Economic Contributions of University/Nonprofit Inventions in the United States: 1996–2020

Prepared for the Biotechnology Innovation Organization (BIO) and AUTM
by Lori Pressman, Mark Planting, Carol Moylan and Jennifer Bond.

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Transforming Ideas into Opportunities

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June 14, 2022

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Acknowledgments This model came into being more than 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 and the Science and Engineering Indicators Program at the National Science Foundation. We thank Sumiye Okubo, former Associate Director for Industry Accounts at the Bureau of Economic Analysis, for her contributions to the earlier reports. We thank Robert Yuskavage, former Associate Director for International Economics at the Bureau of Economic Analysis, for his contributions to modeling non-U.S. production. We thank Raymond Wolfe and Mark Boroush at the National Center for Science and Engineering Statistics for helpful consultations. We are grateful to the Biotechnology Innovation Organization, AUTM, and the National Institute of Standards and Technology for their cumulative support. This report would not have been possible without the decades of insights and data gathered by the U.S. Census Bureau, the National Science Foundation, the Bureau of Labor Statistics, and the Bureau of Economic Analysis. Many of these analyses would not have been possible without the data provided by institutions choosing to respond to the AUTM Survey.

Contents

Summary

Using AUTM data from 1996-2020, the updated Input-Output modeled economic impact of academic licensing, assuming no detrimental product substitution effects, and summing that impact over 25 years of available data from academic U.S. AUTM Survey respondents:

- Contributions of academic licensors to industry gross output range from $631 billion to $1.9 trillion, in 2012 U.S. dollars; and
- Contributions to gross domestic product (GDP) range from $333 billion to $1 trillion, in 2012 U.S. dollars; and
- Estimates of the total number of person years of employment supported by licensed-product sales range from 2.356 million to 6.499 million over the 25-year period.

The high end of the range, in particular the $1.9 trillion contribution to gross output, $1 trillion contribution to GDP, and providing support for 6.499 million jobs over the 25-year period, assumes a 2% weighted average running royalty rate on licensees' reported product sales, and a higher domestic production factor.

The low end of the range, in particular the $631 billion contribution to gross output, $333 billion contribution to GDP, and providing support for 2.356 million jobs over the 25-year period, assumes a 5% weighted average running royalty rate on licensees' reported product sales and a lower domestic production factor.

An overview of the intent to capitalize and eventual realization of capitalizing business research expenditures in the national accounts is provided, along with a discussion of how this change altered the implementation of this model. An explanation of how the domestic production factor used in this report is calculated is provided.

These findings help document the importance of basic and blended research to the U.S. economy as well as the demand for public-private partnerships.

Motives for understanding the impacts of research expenditures

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 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.

It is generally accepted that research expenditures contribute to the growth and productivity of an economy, yet a close look[1] suggests that the type of research and the interface between innovators and implementers matter greatly. Using a novel macroeconomic approach which leverages the nature (to an academic publication or to another patent) and country of authorship (to a publication in the same country or a different country) of front-page citations on issued patents to distinguish the benefits of basic and more applied research to a country's economy, a noteworthy 2021 International Monetary Fund (IMF) report concludes that basic scientific research is a key driver of productivity and is currently underfunded in advanced economies.

A bill to fund innovation and foster U.S. competitiveness is currently under discussion by the U.S. Congress. The United States Innovation and Competition Act: S.1260[2] and H.R. 4521[3] would authorize funds both for research and for technology transfer, and calls for "metrics related to commercialization" (aka the practical interface between lab and market).

In addition, the Foundations for Evidence-Based Policymaking Act of 2018,[4] Public Law No. 115-435 draws attention to the need for empirical studies to inform approaches to public policy in general.

Some impacts occur close in time and place to when and where the research was performed. A single project in a single organization might be evaluated using a classic net present value approach. Did, for example, a new process improve the yield or profit margin for that product line? How much, and how long did it take before the project paid for itself?

Other impacts occur far removed in time and far away geographically from where the research was first done. The 2021 IMF report looks at the entire world, and makes general conclusions about productivity, the ability of an economy to produce more outputs with fewer inputs, where various types of research are treated as inputs, albeit intangible ones, akin to the more tangible and familiar inputs, such as labor, capital equipment, and materials. The IMF report also considers impacts on countries that did not perform the research.

[1] International Monetary Fund. October 2021. World Economic Outlook: Chapter 3
[2] https://www.congress.gov/bill/117th-congress/senate-bill/1260/text
[3] https://www.congress.gov/bill/117th-congress/house-bill/4521/text
[4] 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.

This report is about more than one project, but unlike the IMF report, it is place and time limited. It is about research done at U.S. academic institutions and at other nonprofits, subsequently licensed to the private sector, and the 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. Visibility under this model depends on AUTM Survey respondents choosing to report license income, and then choosing to categorize some fraction of that license income as running royalties. Visibility under this model depends on knowing that there are licensed product sales and having quantitative information about them. This approach provides an important, but place and time limited, look at what happens after the transfer from U.S. academic innovators to commercial implementers. Because of these limitations, these estimates are an underestimate of total impact.

The Input-Output model for estimating economic impact of university/nonprofit inventions

Nobel Prize-winning Wassily Leontief is credited with developing the Input-Output quantitative economic model that represents the interdependencies between different sectors of a national economy or different regional economies. In the case of this particular anlysis and report, the model takes microeconomic data, that is, the license income and running royalty income reported in the annual AUTM (formerly the Association of University Technology Managers) survey ("AUTM Survey"[5]) 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 these macroeconomic empirical generalizations, it is necessary to make assumptions[6] about the types of products made and sold by AUTM licensees, where the products are made and how they are subsequently used or transferred.

Because the model relies primarily on impacts arising from sales of licensed products[7], it is necessary to estimate these sales. Royalties earned on products sales are reported in the AUTM Survey, but not the sales themselves. Thus, by assuming a weighted average running royalty rate, and using the available running royalty[8] information, it is possible to estimate the dollar value of licensees' product sales.

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[5] The FY2020 Survey is here: https://autm.net/AUTM/media/Surveys-Tools/Documents/FY20-Licensing-Survey-Questionnaire-FNL.pdf .

[6] See Table A-1 on the assumptions and their effects.

[7] Products made by the companies that license AUTM Survey respondent intellectual property

[8] "Earned royalty" and "running royalty" are used interchangeably in this report. Earned royalties are metered by product sales. Not all license income is metered by product sales. A license issue fee, e.g., is associated with signing the license, and not directly with the sale of a product. A license issue fee still falls in the category of "License Income". See the AUTM Survey Instructions and Definitions document for more information on the breakout of income types. https://autm.net/AUTM/media/Surveys-Tools/Documents/FY20-Licensing-Survey-Definitions-Instructions-FNL.pdf

The nonprofit licensing data used in this study were gathered by AUTM members initially for internal office management and benchmarking, and only later used to help describe the impact of their technology transfer activities outside their home institutions. This effort started in 1995[9] using a practitioner-generated survey instrument known as the AUTM Survey.

In 1998, AUTM began soliciting product commercialization narratives, now called the Better World Project[10] to illustrate societal impacts. AUTM also tracks start-ups formed and operational and new licensed technologies that became available to the public.[11] In the mid-1990s, AUTM developed its own impact model that included measures of preproduction impact,[12] [13] using i) running royalties and an assumed royalty rate[14] 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's 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 and the series of reports described in Table A-2 and Supplement 1 are based on that model, first published in a 2009.[15] report, and then in the peer-reviewed journal *Research Policy* in 2013.[16]

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9 The data collected were from 1991–95 in the first survey.

10 https://autm.net/about-tech-transfer/better-world-project

11 See AUTM Survey definitions and instructions re definitions of start-ups, start-ups operational and licensed technologies available.

12 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.

13 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.

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

15 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 https://www.bio.org/sites/default/files/legacy/bioorg/docs/files/BIO_final_report_9_3_09_rev_2_0.pdf

16 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, https://doi.org/10.1016/j.respol.2012.04.015

Background on the national accounts, input-output models and how they are used in this model

The national accounts track and record transactions among businesses, individuals, and governments for an entire country and their transactions with the rest of the world[17]. They are well suited to studying the dynamics of an economy, and how changes in one part of the economy, such as research expenditures and technology transfer activities, affect others. The input-output model gets its name because the same marketable item can be output to one party, and input for another. The system of national accounts tracks the item from both perspectives, checking that the reported inputs and outputs are internally consistent.

Implementing a system of national accounts necessarily required defining and naming categories of things to count. The consensus structure for these accounts is called the System for National Accounts "SNA", and traces its origin to a 1947 report[18] by a sub-committee on National Income Statistics of the League of Nations that called for the creation of such a consensus reference document. It can be seen as a Linnaean classification system for economists and is used to track commodities (in the sense of any marketable good or service, not a product sold without differentiation, such as the generic "salt") and the industries that make them.

For the I-O accounts, the BEA uses a classification system that is based on the North American Industry Classification System (NAICS), (not Carolus Linnaeus). 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-7.

The terms "input" and "output," but not "cost" and "revenue," are used, 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 "(domestic) final user" in I-O terms. 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. This is a reason the I-O model for nonprofit technology transfer impact started in 2009 with the conservative assumption that none of the licensees' products are satisfying final demand, i.e., are the last sale in a value chain.

[17] Measuring the Nation's Economy: An Industry Perspective. A Primer on BEA's Industry Accounts, Gary Locke, Rebecca M. Blank, J Steven Landefield, Brian C. Moyer. https://www.bea.gov/sites/default/files/methodologies/industry_primer.pdf

[18] United Nations 1947. *Measurement of National Income and Construction of Social Accounts* Geneva: United Nations

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. 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,[19] and the "use by final users" means the sum of purchases by persons and by government, business investment, and exports less imports.[20] 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.

The coefficients used in this report assume the AUTM licensors are in industry class 61, "educational services." We selected "educational services" from the input-output accounts as the industry most likely to include university research. For hospitals we also chose educational services believing that research activities there are more closely aligned in terms of inputs and outputs with university research than with operations of hospitals.

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). These industries were selected because of data on research investment at businesses, which makes it possible to identify research-intensive industries. See BEA Table 5.6.5. Private Fixed Investment in Intellectual Property Products by Type.

Note that "total value added" is a measure of the value of factors of production — in textbook economics, land, labor and capital. It is different from 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. Within the national accounts, the output of nonprofits is measured as expenses and all of output is added to GDP. Thus, this study assumes that all AUTM Survey respondent license income contributes to GDP through its use to fund operating expenses.

[19] 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.
[20] 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.

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 industry-appropriate 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 make and use 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 our 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.

Multigenerational process leading to capitalizing research in the system of national accounts

As early as the 1953 SNA[21], economists took note that some expenses clearly lead to future benefits. Nonetheless they elected to treat research expenditures as not leading to capital formation *[emphasis added]*.

> “*Capital formation is confined to tangible assets in national accounting*. …. Expenditures by business the benefits from which may be expected to accrue in the future but which are not embodied in tangible assets, *for example expenditures on an advertising campaign or that associated with long-term research and development, are conventionally excluded from capital formation.”*

A similar concern was expressed in the 1968 SNA[22], and characterized as “an area in urgent need of clarification”. An excerpt is provided below *[emphasis added]:*

“(h) The boundary between current and capital expenditure

[21] United Nations. 1953. A system of National Accounts and Supporting Tables. New York: United Nations. Quote from pages 8-9

[22] United Nations. 1968. System of National Accounts, Revision. New York: United Nations. Quote from page 15.

1.95 Although there are no substantial changes in the concept of capital expenditure in the new SNA, various suggestions for extending the coverage of this concept were considered. ... *Second, there is the question of expenditure on research and development, to which reference has already been made. This is an area in urgent need of clarification, but this can only be done based on experience, which, through growing is not yet very great."*

The full multi-decade process leading to the practical implementation of this change in 2013 in the U.S. National Accounts is beyond the scope of this report. See Moylan and Okubo "The Evolving Treatment of R&D in the U.S. National Economic Accounts" BEA 2020[23] and Supplement 1 for more information on the U.S. process. The international consensus that it was finally time to do so occurred in 2008[24].

Treating business R&D as a depreciable asset and not as an expense in the national accounts[25] also added to GDP, and thus the value-added multipliers. Consequently, starting in 2015, the I-O calculations done in this series of reports received a few percent boost from this change alone.

The 2022 application of the I-O model to nonprofit licensing activity

Prior reports explored the effects of the assumptions listed in Appendix A-1, from the weighted average royalty rates to the industries of the licensees[26], to the location of production of licensed products and their place in a value chain. See Tables A-2, A-3, and Supplement 1 for an overview of this series of reports, and how they have evolved. This 2022 report continues the practice of exploring the effects of varying the assumptions needed to run the calculation.

Because the location of production is a key input when modeling gross *domestic* (emphasis added) product, it was decided to run the model under two scenarios;

The first scenario, as in the 2019 report, assumed that i) half the reported sales of licensed products were made by large entities, ii) the ratio of domestic employment of U.S. majority owned multinationals in a particular industry to the global employment of firms in the same industry is a proxy for domestic production of large entities in that industry, iii) half the product sales of licensed products that generate running royalties are made by small[27] companies, and iv) 100% of these small company licensees' sales are produced domestically.

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[23] https://www.bea.gov/system/files/2020-04/the-evolving-treatment-of-rd-in-the-us-national-economic-accounts.pdf

[24] https://unstats.un.org/unsd/nationalaccount/docs/sna2008.pdf See p 666 ""Broadening the fixed asset boundary to include other intellectual property assets"

[25] For a glimpse into the historical treatment of research expenditures by financial accountants see Nix, Paul E, Nix, David E., "A Historical Review of the Accounting Treatment of Research and Development Costs", The Accounting Historians Journal, Vol 19, No. 1 June 1992 51-78

[26] Rev 2 in the NIST report, as in this 2022 update, considered some non-domestic 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. The manufacturing industries used in the earlier reports, the Rev 2 NIST industries and the research intensive industries overlap but are not the same. See Table A-3, which shows how the industries overlap and differ among the reports.

[27] Small in this case means companies employing fewer than 500 employees.

The second scenario assumes that i) all the reported sales were made by large entities, and ii) the ratio of domestic employment of U.S. majority owned multinationals in a particular industry to the global employment of firms in the same industry is a proxy for domestic production of large entities in that industry. See Table A-4 and Figure A-4 for additional information on the calculation of the domestic production factor.

Reasons for changing the industries to research-intensive industries and using a more complex model

AUTM member institutions typically license early-stage technology requiring significant additional 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 running royalty income received in the year ending June 30, 1989, against the year in which an invention accounting for that income was received, showing that 95% of this type of income is generated by inventions reported eight years before or earlier.[28] Data on the timing of licensees' product sales relative to license execution were presented by a team from MIT at the 2000 American Association for the Advancement of Science meeting.[29] 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,"[30] which shows commercialization timelines of products covered by patents having DNA sequences in their claims. This group of patents was studied because of 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.

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[28] 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.

[29] See Lori Pressman and Don Kaiser, "Measuring Product Development Outcomes of Patent Licensing at M.I.T.," AAAS Annual Meeting, February 7, 2000, Washington, D.C. ; Slide 3, available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.198.3934&rep=rep1&type=pdf .

[30] 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

Commercialization timelines and costs in the biological sciences

Many nonprofit licenses are to life science companies. AUTM data from 1996 and 1997[31] suggest that for Universities, about 80% of the income is from licenses in the life sciences. For the category 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 timelines[32] 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. A report released in February 2021 "Clinical Development Success Rates and Contributing Factors 2011-2020" reports an average of 10.5 years for a drug to successfully progress from Phase I to regulatory approval.[33] Note that pre-clinical research precedes Phase I clinical trials.

Complementary cultures

Research is characterized by how directed it is to practical applications, and is divided into three types: Basic Research, Applied Research, and Experimental Development. Basic research is done to expand knowledge or understanding of observable phenomena and undertaken without a practical goal in mind. Applied research has a practical goal in view, but not a defined product. Experimental development is undertaken with a particular new product in mind, or to improve an existing product. See Supplement 2 for a discussion of types of research, and the subjective element involved in characterizing the research expenditures reported to statistical agencies.

In addition to tracking research by the character of the work, government statistical agencies also track research by the types of organizations that perform and fund it. The categories include the Federal Government, Nonfederal Government[34], Higher Ed, Nonprofit Organization, and Business. The Universities are in the "Higher Ed" category,[35] and the Hospital and Research Institutes are in the "Nonprofit Organization" category.[36]

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[31] FY1996 AUTM Survey, pp 9–10, and FY 1997 AUTM Survey, p. 10. Also Table S-3 and S-4 of the 2019 report.

[32] 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.

[33] David Thomas, Daniel Chancellor, Amanda Micklus, Sara LaFaver, Michael Hay, Shomesh Chauduri, Andrew Bowden, Andrew W. Lo,"Clinical Development Success Rates and Contributing Factors" February 2021 https://go.bio.org/rs/490-EHZ-999/images/ClinicalDevelopmentSuccessRates2011_2020.pdf

[34] Nonfederal government is a small, though growing share of the total, and for simplicity is omitted in this discussion and graphs.

[35] "Higher Ed" includes university AUTM Survey respondents. "NPO" or Nonprofit Organization includes hospital AUTM Survey Respondents.

[36] The National Science Foundation conducts survey of the nonprofit research activities that include hospital research institutes and other nonprofit foundations. 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.

Figure 1 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 2 shows that 70% to 80% of Basic Research in the U.S. is performed by non-business entities.

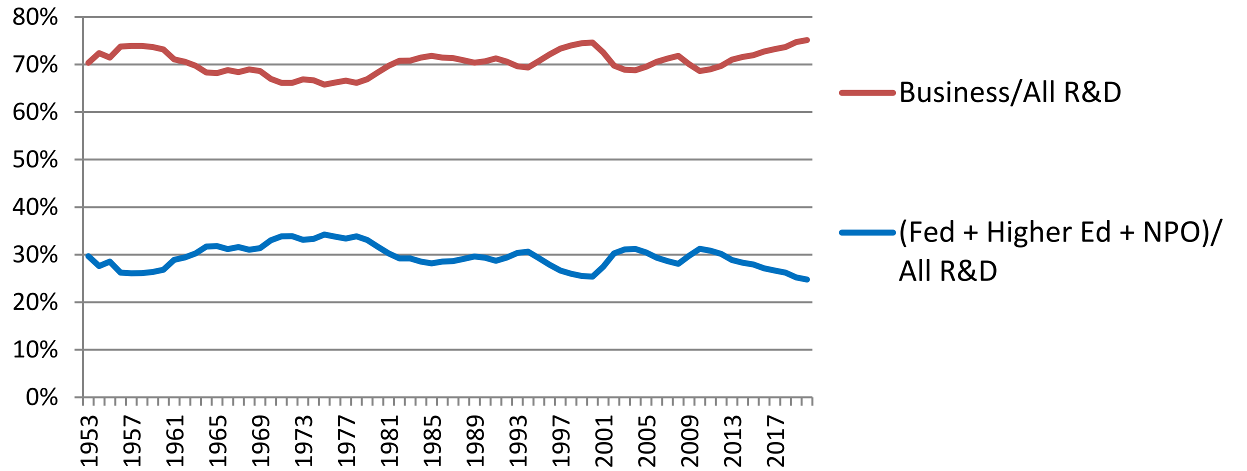


Figure 1: R&D Expenditures *as a % of the Total R&D Expenditures* Grouped by Nonbusiness (Fed + Higher Ed + Nonprofit Organizations) and Business

Source: Table 2 2020 NCSES

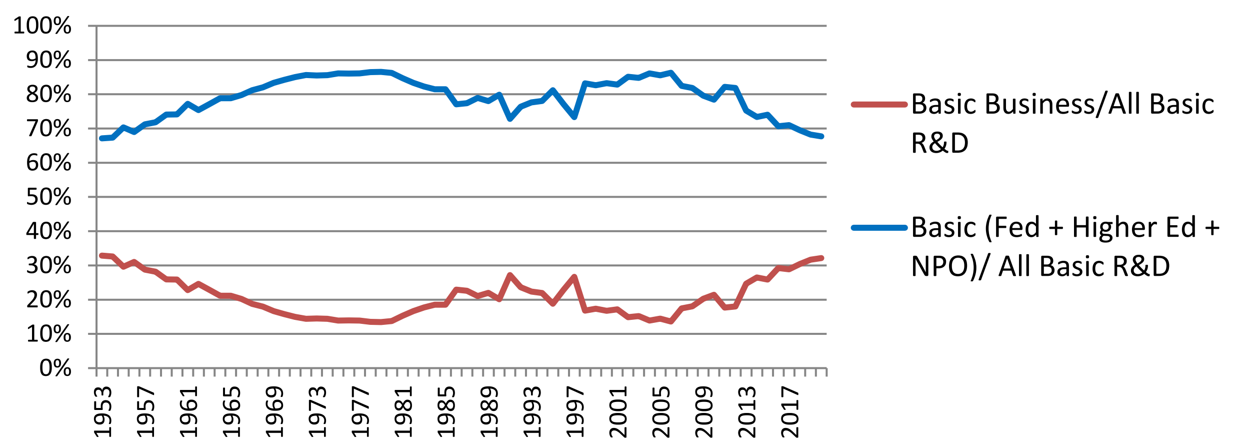


Figure 2: Basic R&D Expenditures as a *% of Total Basic R&D* Grouped by Nonbusiness (Fed + Higher Ed + Nonprofit Organizations) and Business

Source: Table 3 2020 NCSES

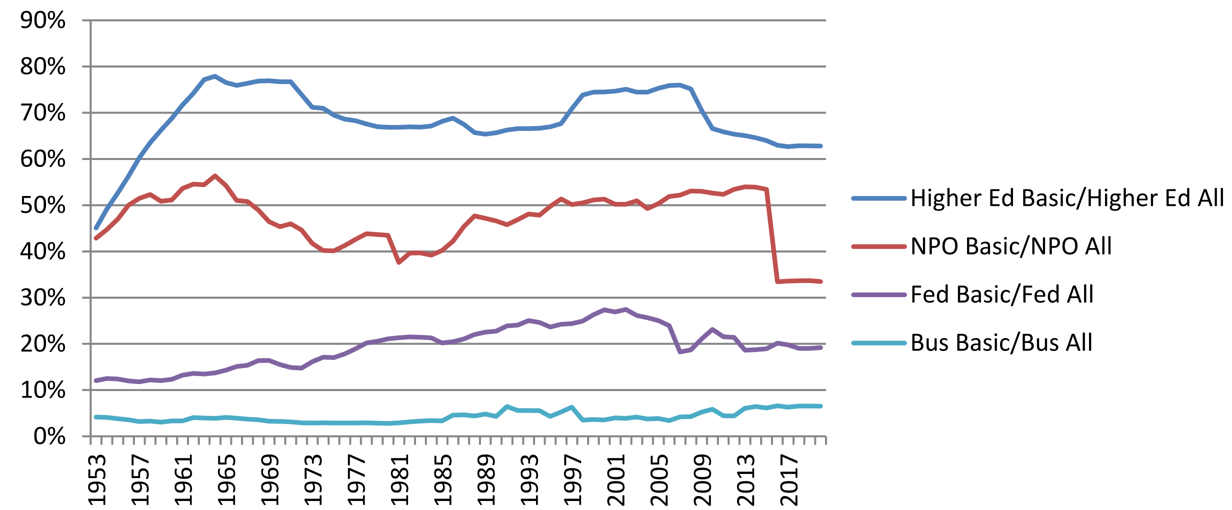
Basic and blended research in Higher Ed and Nonprofit Organizations

Figure 3 shows that universities do predominately basic research, though the amount of basic research relative to all research may be trending down in recent years. Nonprofit organizations, which include hospitals and research institute respondents to the AUTM Survey may be doing a greater mix of types of research than previously. The apparent discontinuous drop in reported basic research was discussed with NCSES and is not explained by a change in their survey instrument or in the institutions surveyed.

The figures on Supplement 3 show that a fraction of federally funded research done by AUTM Survey respondents appears to be trending down, consistent with proportionally less basic research being done by Higher Ed and Nonprofit Organizations as perceived in national data. Perhaps increased emphasis by decision makers about the importance of showing relevance and economic and social outcomes of research has led some in Higher Ed and Nonprofit Organizations to try to mature their technologies a little more to facilitate technology transfer. Another possible explanation is a changing perception of the character of research they perform by the nonprofit organizations receiving the questionnaire.

Figure 3: Basic R&D Expenditures *By % by Performer*: Higher Ed, Nonprofit Organization, Federal, and Business.

Source NCSES 2020 National Patterns of R&D resources tabs 002 and 003



This data support the assumption that distribution and commercialization of early-stage academic technology occurs outside of academia by industry partners willing and able to perform 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 has identified, studied, and tracked such "research intensive" industries. See Robbins and Moylan 2007.[37] Their papers show that about three-quarters of U.S. business research is done by an identifiable group of industries, the same ones used in this report.

Patterns of research expenditures by character of work and by performer, combined with long product development timelines, are the basis for assuming that the licensees of nonprofit inventions are predominantly in these research-intensive industries. Every iteration of this report starts by first confirming the research expenditures by industry[38] data to have the most up-to-date information on which industries are research-intensive.

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 professionals 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.

[37] 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.
[38] BEA Table 5.6.5. Private Fixed Investment in Intellectual Property Products by Type

Assumptions used in the 2019 and 2022 models

Table A: Assumptions used in the two estimates, and in the 2019 report for comparison

	Complex Model **Seven Research-Intensive Industries for Universities** **Two Research Intensive Industries for Hospitals**		
Years of AUTM Data	1996–2017	1996–2020	1996–2020
Report Year	2019 Report	2022 Report	2022 Report
Base Year for Inflation Adjusted Dollars	**2012**	**2012**	**2012**
Location of the Licensee's production of products reported under the license	**Half** of the licensees' sales are made by companies employing > 500 people, which are modeled as U.S. majority owned multinational enterprises (MNE's). BEA and Census Bureau data on the location of the employees of U.S. majority owned MNEs are used to estimate U.S. production. **The domestic production factor is the same for universities as for hospitals.** See Table S-6 of the 2019 Report	**Half** of the licensees' sales are made by companies employing > 500 people, which are modeled as U.S. majority owned multinational enterprises (MNE's). BEA and Census Bureau data on the location of the employees of U.S. majority owned MNEs are used to estimate U.S. production. **The domestic production factor is calculated separately for universities and for hospitals.** See Table A-4 of the 2022 Report.	**All** the licensees' sales are made by companies employing > 500 people, which are modeled as U.S. majority owned multinational enterprises (MNE's). BEA and Census Bureau data on the location of the employees of U.S. majority owned MNEs are used to estimate U.S. production. **The domestic production factor is calculated separately for universities and for hospitals.** See Table A-4 of the 2022 Report.
Fraction of the licensees sales that are final sales	BEA industry-specific patterns on the fraction of sales that are final sales are used.	BEA industry-specific patterns on the fraction of sales that are final sales are used.	BEA industry-specific patterns on the fraction of sales that are final sales are used.
Location of production of intermediate inputs	Not all intermediate inputs are domestic. The domestic requirements tables are used.	Not all intermediate inputs are domestic. The domestic requirements tables are used.	Not all intermediate inputs are domestic. The domestic requirements tables are used.
Industries of the licensees	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))		

2022 model assumption, Two Variations

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 the last row of Table A.

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.

Variation One

Half of the product sales that generate running royalties are made by large companies (companies employing 500 or more people), which, for the purpose of calculating a domestic production factor are assumed to be U.S. majority owned multi-national enterprises "MNE's". The fraction of products made domestically is inferred from BEA data on foreign employment by industry combined with Census Bureau data on the domestic employment of the same research-intensive industry. Other product sales that generate running royalties are made by small companies (companies employing fewer than 500 people), and 100% of these small company licensees' sales are modeled as being produced domestically.

Variation Two

All of the product sales that generate running royalties are made by large companies (companies employing 500 or more people), which, for the purpose of calculating a domestic production factor are assumed to be U.S. majority owned multi-national enterprises "MNE's". The fraction of products made domestically is inferred from BEA data on foreign employment by industry for such U.S. majority owned MNE's, combined with Census Bureau data on the domestic employment of the same research-intensive industry. No product sales that generate running royalties are made by small companies (companies employing fewer than 500 people).

For the GDP calculation

i) 100% of licensors' expenditures contribute to GDP.

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 the gross output of all industries after adjusting for imports is to increase the production of other industries.

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 each year based on the data from the annual input-output accounts. For the basket of research-intensive industries it is approximately 50%.

2022 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)[39] / (price index for GDP, index numbers, 2012 = 1.00)[40]

B_{GDP} = ((modeled domestically produced sales by licensees[41]) 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[42]) + (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

A_{YES} = (ratio of employment to output 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 (ratio of employment to output for research intensive industries))

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[39] Total license income received (as reported).

[40] The multipliers are applied to current dollar license income and current dollar modeled sales. The result is adjusted to 2012 U.S. dollars.

[41] ((Earned royalty income as reported) ÷ (royalty rate)) x (an industry and year specific fraction, from .82 to .75)

[42] ((ERI as reported) ÷ (royalty rate)) x (an industry and year specific fraction, from .82 to .75)

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.[43] 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."[44]

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." 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. In 2019 the name of the Survey was changed to Business Enterprise Research and Development Survey, "BERD" [45].

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[43] 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.

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

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

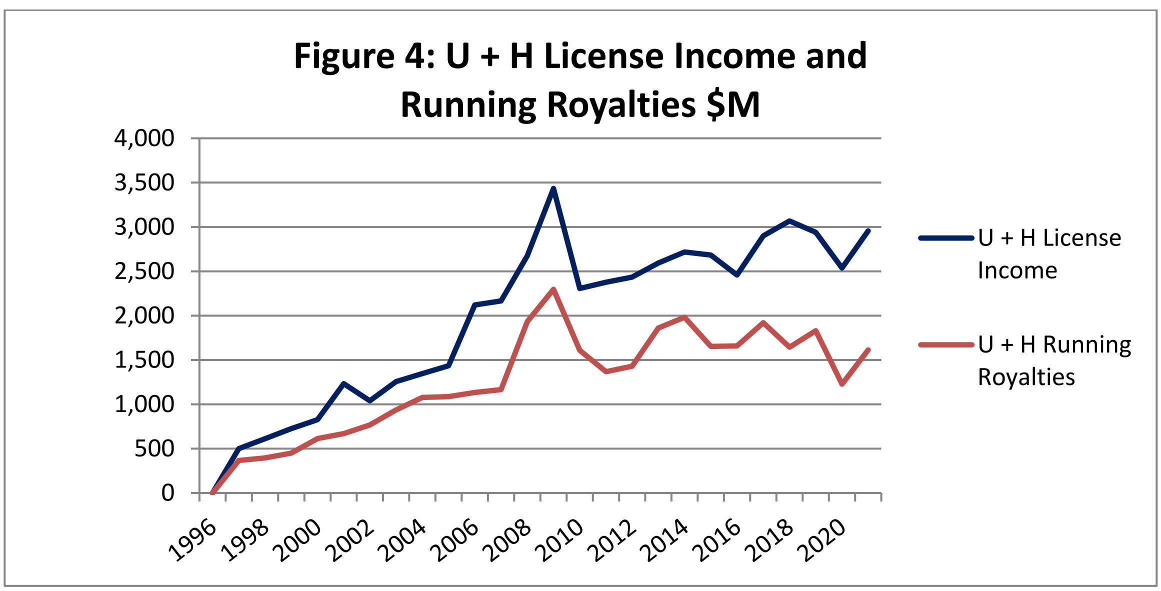
AUTM data

AUTM's Statistics Access for Technology Transfer (STATT) database, a multi-institution, multiyear database, is available to subscribers. STATT is the online compilation of 30 years of annual AUTM Licensing Activity Surveys. 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 Survey typically collects approximately forty data elements, with some changes from year to year. Not all respondents answer every question every year. A response to a relatively small number, six to seven, of core questions is required to be considered a respondent. Thus, "recurrent respondent" without further qualification, as used in this report, means an organization responding to the survey every year from1996-2020. While as many as 31 hospitals and as many as 167 universities have responded in any one year, there are only 8 and 58, respectively, recurrent respondents between 1996 and 2020.

To confirm interesting 25-year trends observed in the data, it was deemed important to consider recurrent respondents *to specific questions*, which is a somewhat smaller group than the 8 and 58, recurrent hospital and university recurrent respondents, respectively. The number of question-specific recurrent respondents is provided when appropriate.

The 2020 AUTM Survey summary[46] reports that 312 institutions were invited to participate in the 2020 AUTM Survey. AUTM received 197 completed surveys, for a response rate of 63 percent. The remarks in this section use this visible-to-subscriber information and information easily findable by internet searching. The AUTM data are in Table S-8.

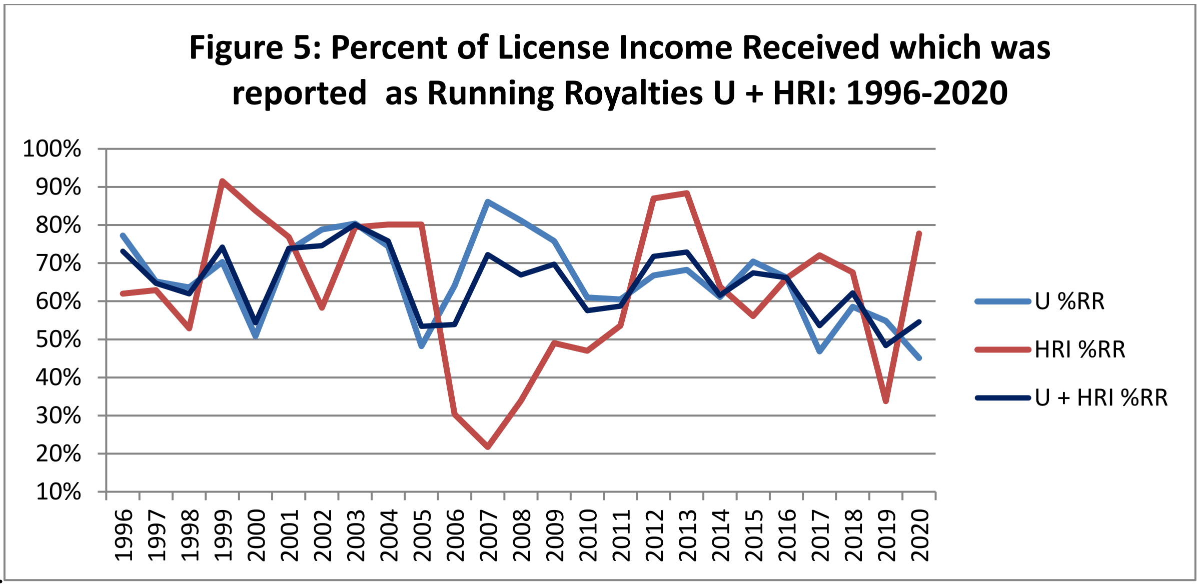
Figure 4 shows the trends in license income received, and in the fraction of this income the survey respondents elected to characterize as running royalties.



[46] https://autm.net/AUTM/media/SurveyReportsPDF/FY20-US-Licensing-Survey-FNL.pdf

The data fluctuate considerably. License income reported as running royalties appears to be flat. The flattening persists for the recurrent respondents. See Figure A-5.

The fraction of license income reported as running royalties appears to be drifting down, see Figure 5 below.

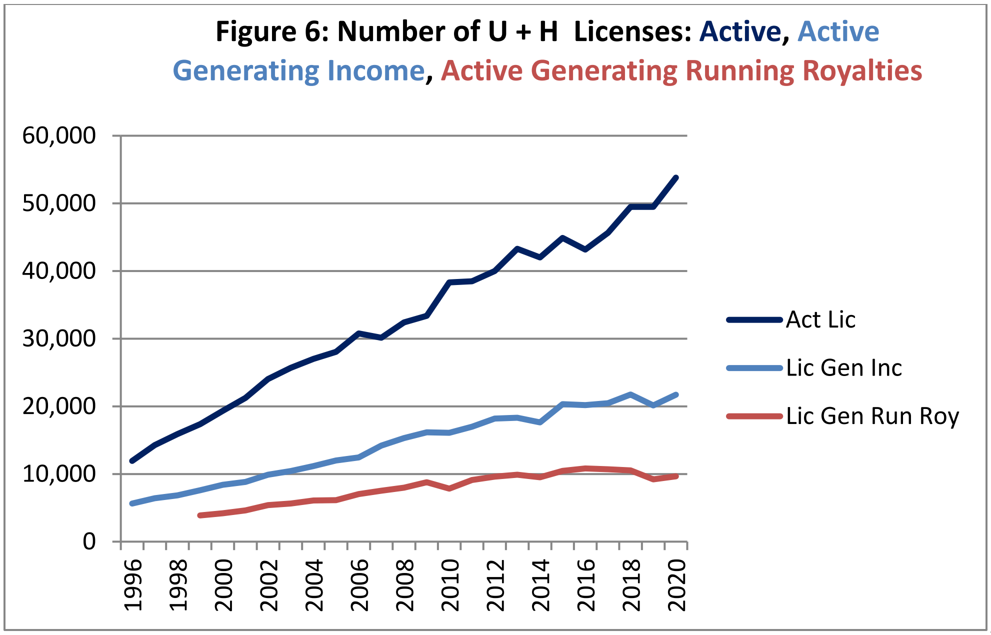


This drift is not seen for the recurrent respondents. Rather, the fraction of license income received in the form of running royalties appears erratic. See Figure A-6.

Of interest, the number of active license agreements continues to increase, showing a steady and increasing demand for public-private partnerships. See Figure 6 below. Parenthetically, Supplement 4 on a sample of clinical trials also illustrates the demand for public-private[47] partnerships, and the important role of industry as products move closer to the market.

Figure 6 also suggests that the number of license agreements producing license income is increasing more slowly, and appears to be flattening, and the number of license agreements associated with reported product sales and running royalties seems to be flat in recent years. This analysis, because it was deemed an important finding, was repeated for the 66 recurrent respondents to the Survey in general, and a smaller group of recurrent respondents to all three license-count questions and persists. See Figures A-7 and A-8.

[47] See Supplement 4; AUTM member institutions are among the organizations classified as "Other" in the data available for download from the ClinicalTrials.gov website.



Intermittent responses

When some frequent survey responders drop out, either selectively on a question-by-question basis, or completely, it is possible to infer[48] the order of magnitude of missing license income or running royalty income. There could be inferable missing income on the order of a hundred million to a few hundreds of millions of dollars in some years. Sometimes frequent survey responders opt out of reporting when there is a large, public financial event, such as a royalty buyout, or legal settlement. This suggests that the impacts in this report are underestimated.

Partial responses

In addition to lack of response by institutions in certain years, not all institutions respond to the running royalties question in every year, even when there is no singular event, yet still report the more general category of license income. This may be in part due to AUTM's decision to emphasize a small number of data elements, which do not include running royalties on product sales. Electing not to characterize "license income"[49] by type of income results in zero being recorded in the running royalties category. Since most of the impact of the model derives from the licensees' product sales as estimated from reported running royalties and not from the more general category "license income", this will also reduce the estimates.

[48] 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. Sometimes the missing number can be seen by "Googling" the name of the institution and the year.

[49] 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.

The partial responses for both universities and hospitals were tabulated. For the entire 25-year period, $2,334,105,597 in uncharacterized license income was reported by universities and $1,844,491,179 in uncharacterized license income was reported by hospitals. If half of this license income were characterized as running royalties, it would add $1,167,052,799 for university respondents over the 25-year period, and $922,245,590 for hospital respondents over the 25-year period. This is about 4.7% and 12%, respectively of the 25-year totals of university and hospital reported running royalty income, respectively, likely contributing to an underestimate.

Inconsistently categorized data

There are no explicit survey instructions or recommendations on how to categorize either royalty buyouts or legal settlements, though they reasonably fall into the category "Other Income", and indeed they appear to be frequently, but not always[50] categorized as "Other Income". When buyouts are reported as "Running Royalties", they add more to the macroeconomic impact model than if they are reported as "Other Income". While buyouts are probably associated with products, unless the buyout was only for a fraction of the royalty stream, there is no further visibility into product sales. If, on the other hand, it was a partial buyout, such an event provides support for using lower weighted average royalty rates.

Legal settlements pursuant to patent enforcement litigation are characterized, as far as there is visibility into these settlements, as "Other Income"[51] . This label raises the same question. Does the settlement amount represent evidence that licensed products were sold, and what, if anything, can be inferred about the sales from the settlement amount? Is the royalty higher than if the party paying the settlement had licensed the invention before a first sale, or lower? 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 of demand for the innovative product.

Licenses with no royalty terms: Licenses with no royalty terms are not uncommon and are often associated with the IT sector. Google and Akamai are examples where the licenses, as visible in SEC filings, had only equity terms. There are also open-source agreements[52], where managing liability and subsequent user rights and obligations are the key elements. This suggests that visibility into IT technology transfer activities may be less achievable using this product sales I-O approach than visibility into health technologies.

[50] Sometimes there are very visible public events and it is straightforward to find a public number on some buyout or settlement, and match it to an entry in the Survey .

[51] Similar "method" as for buyouts. Sometimes there are very visible public events and it is straightforward to see how and if the academic organization chose to report this event to the Survey.

[52] https://www.cmu.edu/cttec/forms/opensourcelicensegridv1.pdf

Inferences on royalty rates

The AUTM Survey reported an average royalty rate of 1.7% in FY2011 and 1.8% in FY2012.[53] These rates were calculated by asking respondents to report the product sales their licensees provided in royalty reports to AUTM member licensors and the running royalties AUTM members received:[54]

> "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 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[55] posted information obtained from Securities and Exchange Commission filings on effective royalty rates by tiers of product sales volumes. 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. More recent information from BioSciBD Advisors[56] on monetizations of academic royalty streams was presented at BIO 2017.

The above noted weighted average royalty rate numbers from AUTM and Exhibit A of the 2018 NIST report may be consistent with the 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.[57, 58] 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 parse by nonprofit and for-profit licensees show that the nonprofit licenses have lower rates. On balance 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 the 2009-2017 reports using AUTM data. When and if academic institutions license more mature technology, it may be reasonable to revisit this decision.

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[53] FY2012 AUTM Survey, page 40.

[54] 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.

[55] https://bioscibd.com/effective-royalty-rates

[56] https://bioscibd.com/dawn-of-post-venture-era/BIO_2017_Funding_Translational_Research.pdf

[57] https://www.sec.gov/Archives/edgar/data/0001693415/000119312518181734/d523294dex102.htm .

[58] https://www.sec.gov/Archives/edgar/data/1424740/000095013508002207/b68098btexv10w1.htm,

Discussion of assumptions used in the I-O estimates and their effects

Table A-1 summarizes certain key assumptions and their effects. All implementations of this I-O approach depend on either knowing or modeling the licensees' sales of licensed products.

As stated previously, 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 running royalty. The MIT license to Akamai, per its S-1, similarly had an equity provision for MIT and no running royalty. Some licenses contain royalties on tangible products, but not on services.[59] 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 running 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.

Incomplete and missing data also lead to underestimating impact as noted in the section "AUTM Data."

The multipliers (output, value added, employment) vary 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 Table S-9, which shows changing only the industries changes the various I-O multipliers and ratios.

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,[60] could cause either an over- or an under-estimate. Currently, as discussed earlier in this 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.

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[59] http://www.sec.gov/Archives/edgar/data/1110803/0001012870-00-001863.txt,

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

Since our 2019 report, the model uses a domestic production factor (see Table A-4). 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 data about foreign employment by industry for U.S. majority owned multinational enterprises[61]. Understandably, there are no equivalent data for non-U.S. majority owned multinational enterprises, as the U.S. Census Bureau and the BEA do not ask non-U.S. companies about their employment outside the U.S. The BEA has the non-domestic employment data for U.S. majority owned multinational enterprises by industry. The Census Bureau has total domestic employment for U.S. enterprises by firm size and by industry. The domestic production factor calculated in this and the 2019 report is one minus the non-domestic employment of such industries divided by total employment (domestic plus non-domestic) for the same industries.

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.[62] A domestic production factor was derived for AUTM member licensees assuming; i) a fraction (half, and then all, in this 2022 report) were large entities[63] at the time the royalties were received, and that the domestic production of large entity academic licensees can be modeled by knowing the non-domestic employment of U.S. majority owned multinational enterprises and the global employment of the matching industries and ii) other product sales that generate running royalties are made by small companies (companies employing fewer than 500 people), and 100% of these small company licensees' sales are modeled as being produced domestically.

In the 2019 implementation of the model, the same domestic production factor was used for both Universities and for Hospitals and Research Institutes. In this 2022 implementation, the domestic production factor was calculated separately for universities and for hospitals and research institutes. 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. See Table 12 from the BERD Survey [64] on sales by company size for research intensive industries.

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."

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[61] A multinational enterprise, abbreviated as MNE is an enterprise producing goods or delivering services in more than one country.

[62] Between 1996 and 2020, 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 2020, 16% to 21% of the licenses/options were options.

[63] Companies employing five hundred or more people

[64] Table 12, Worldwide, domestic, and foreign sales for companies located in the United States that performed or funded R&D by industry and company size 2019 . Business Enterprise Research and Development Survey, 2019. See Table S-10 of this report for an excerpt.

I-O coefficients and results

The AUTM license data and price index deflator are in Table S-8. Selected I-O coefficients are in Table S-9. The calculations were run for two assumed running royalty rates, 2% and 5%, and for both domestic production factors shown in Table A. The results by year, for both models, both royalty rates, for Universities and HRIs separately and then together, are in Tables S-1 though S-6. 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 non-domestic 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.

Empirical information on (i) the licensees' industries and (ii) where the licensed products are made and their position in a value chain would improve the estimates. It is also important to have systematic weighted average royalty rate information so running royalty income can reliably be used to estimate sales, or actual product sales information. More complete license income of all types will also be helpful.

Using the updated I-O approach to estimating the economic impact of academic licensing, assuming no detrimental product substitution effects, and summing that impact over 25 years of available data for academic U.S. AUTM Survey respondents, the total contribution of these academic licensors to industry gross output ranges contribution of these academic licensors to industry gross output ranges from $631 billion to $1.9 trillion, in 2012 U.S. dollars; contributions to gross domestic product (GDP) range from $333 billion to $1 trillion, 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 2.356 million to 6.499 million over the 25-year period.

The high end of the range, in particular the $1.9 trillion contribution to gross output, $1 trillion contribution to GDP, and providing support for 6.499 million jobs over the 25-year period, is based on an assumption of a 2% weighted average running royalty rate on licensees' product sales, and that half the licensees are large entities (the domestic production of which can be modeled according to the process described in this report) at the time the products they report are sold, and that half the licensees are small companies, the production of which is entirely domestic.

The low end of the range, in particular the $631 billion contribution to gross output, $333 billion contribution to GDP, and providing support for 2.356 million jobs over the 25-year period, assumes a 5% weighted average running royalty rate on licensees' product sales, and that all the licensees are large entities (the domestic production of which can be modeled according to the process described in this report) at the time the products they report are sold.

The 25-year cumulative data for the four, total, combinations of assumptions on weighted average running royalty rate and whether half, or all the licensees are large entities at the time the licensed products were sold are shown in table B below. The 2019 results are included for comparison. Conveniently, all results remain in $2012 dollars, as the BEA has not yet updated their multipliers and ratios to more recent inflation adjusted dollars.

Table B: Cumulative GO, GDP, and Jobs under various conditions and assumptions. All numbers in thousands.

	Set of Conditions U + H		GO 2%	GO 5%	GDP 2%	GDP5 %	Jobs 2%	Jobs 5%
1	.5 MNE 2019	96-17 U+H	$1,698,823	$722,539	$865,058	$373,688	5,883	2,676
2	.5 MNE 2022	96-17 U+H	$1,723,940	$733,284	$878,773	$379,734	5,753	2,634
3	.5 MNE 2022	96-20 U+H	$1,949,832	$829,718	$1,005,803	$434,749	6,499	2,981
4	All MNE 2022	96-20 U +H	$1,452,955	$630,986	$750,973	$332,721	4,944	2,356
	Δ new BEA ratios and multipliers		1.5%	1.5%	1.6%	1.6%	-2.2%	-1.6%
	Δ +3 years years data (.5MNE)		13%	13%	14%	14%	13%	13%
	Δ all production by MNEs/ lrg ent.		-25%	-24%	-25%	-23%	-24%	-21%

	Set of Conditions U only		GO 2%	GO 5%	GDP 2%	GDP 5%	Jobs 2%	Jobs 5%
1	5 NME 2019	96-17 U	$1,367,704	$579,959	$687,740	$296,281	4,751	2,149
2	.5 NME 2022	96-17 U	$1,391,379	$589,632	$700,097	$301,221	4,615	2,094
3	.5 MNE 2022	96-20 U	$1,535,257	$651,698	$780,417	$336,345	5,085	2,315
4	All MNE 2022	96-20 U	$1,145,652	$495,856	$583,357	$257,521	3,874	1,830
	Δ new BEA ratios and multipliers		1.73%	1.67%	1.80%	1.67%	-2.87%	-2.53%
	Δ +3 years years data (.5MNE)		10%	11%	11%	12%	10%	11%
	Δ all production by MNEs/ lrg		-25%	-24%	-25%	-23%	-24%	-21%

	Set of Conditions H only		GO 2%	GO 5%	GDP 2%	GDP 5%	Jobs 2%	Jobs 5%
1	.5 MNE 2019	96-17 H	$331,119	$142,579	$177,318	$77,407	1,132	527
2	.5 MNE 2022	96-17 H	$332,562	$143,652	$178,675	$78,513	1138	540
3	.5 MNE 2022	96-20 H	$414,575	$178,019	$225,386	$98,404	1,413	666
4	All MNE 2022	96-20 H	$307,303	$135,130	$167,615	$75,200	1,070	526
	Δ new BEA ratios and multipliers		0.44%	0.75%	0.77%	1.43%	0.50%	2.42%
	Δ +3 years years data (.5MNE)		25%	24%	26%	25%	24%	23%
	Δ all production by MNEs/ lrg		-26%	-24%	-26%	-24%	-24%	-21%

The routine adjustments to BEA ratios and multipliers during three years between the 2019 and 2022 report change cumulative impact by a few percent. Compare line 1 with line 2 which both show cumulative impact from 1996-2017; however, line 2 uses the most recent BEA figures.

It is not surprising that the cumulative numbers for the same method used previously are higher than in the 2019 report, as there are three more years of data. Compare line 2 with line 3, which shows cumulative impact from 1996-2017 and from 1996-2020, respectively.

If all the companies paying running royalties on product sales were large entities (companies employing 500 or more people), the domestic production of which can be modeled by the method described in this report, the cumulative U.S. GO, GDP, and jobs figures would be reduced by about twenty five percent. Compare line 3 with line 4. Non-domestic impact, whatever its size, may under certain circumstances be considered a contribution to global well-being, consistent with AUTM's impact narratives: "The Better World Project".

Discussion

Cumulative impact is considerable. Better estimates using this approach require more certain and complete knowledge of product sales. Better information on the actual industries of the licensed products and where they are made and for what use would also be helpful.

Depending on the language in the patent claims and the license, sales of products not made domestically can 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[65] 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 Outsde U.S. (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."[66] 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."[67]

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

[66] 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.

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

Year to year, the AUTM data, and thus, the modeled impact fluctuate considerably. Scherer and Harhoff,[68] 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 stakeholders who trust the long-term benefits of academic research and are not counting on any particular outcome in any particular year. It also emphasizes the importance of multi-decade commitments to data collection and management, which then enable studies of trends in our innovation ecosystem.

Demand for public-private partnerships

Income fluctuations aside, there is a marked strong demand for public-private partnerships, as seen in the apparently linear increase in the number of active license agreements, to over fifty thousand such agreements. By definition, royalties payable on a patented product end upon expiration of the licensed patent. Licenses to intellectual property other than patents are also finite. Therefore, 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. Thus, there is strong demand for public-partnerships supporting development of new and improved products.

The number of license contracts generating running royalty income appears to be flat, as does the license income fraction received as running royalties. This can be for many reasons, each worth considering.

In times of unpredictable scope[69] and strength of patents, prudent licensees and licensors may opt for royalty buyouts. In times of unpredictable pricing for products, including most visibly health care products, prudent licensees and licensors may also opt for royalty buyouts. These buyouts may produce peaks, or not be reported at all. Both a reported and an unreported buyout result in an end to a royalty stream, and thus visibility under this report, though the former may show up as "other income." To the extent that the lump sums from buyouts are reinvested in research, they add to GDP.

There may also be a trend toward doing more fully paid-up licenses, or subscription licenses as is common for software. Perhaps AUTM members are doing considerably more software, data and IT related technology transfer than previously. Subscriptions, unless they are metered by use, would generate periodic fees which would likely be reported as "other income". Thus, neither a subscription type of license nor a fully paid-up license would contribute significantly to an I-O model based largely on visibility into licensees' product sales.

[68] F.M. Scherer and Dietmar Harhoff, 2000, "Technology Policy for a World of Skew-Distributed Outcomes," *Research Policy* 29: 559–566.
[69] Karshtedt, Dmitry , Mark A. Lemley, Sean B "The Death of the Genus Claim" 35 Harv. J.L. & Tech. 1 (Fall 2021). Available at http://dx.doi.org/10.2139/ssrn.3668014

Whether money changes hands or not, once, never, or periodically, every active license contract is an indication of an agreement on the part of an academic institution to transfer and on the part of a company to receive technology. Erik Iverson, CEOof the Wisconsin Alumni Research Foundation (WARF), who previously was associate general counsel for the Gates Foundation said:

> "In my experience, everything, certainly in global health matters, revolves around public-private partnerships. There isn't a single product I know of that doesn't get to the marketplace without industrial involvement."

This report is not about one project or one public-private partnership. It is about the 53,000 active license agreements representing 53,000 active public-private partnerships. It is about thousands of innovators and implementers and contract negotiators. It is about the 9,664 public-private partnerships we know are associated with products because royalties have been reported on them. Next year, there will be more newly visible evidence of the fruit of public-private partnerships in the form of new running royalty streams. Next year, other products will age out of reportability and no longer be visible using this model. This does not mean that these products are not there; it is only a limitation of the model.

Next year, there will be innovations which do not and will not produce visible royalty streams. This does not mean that they have no impact on well-being, economic and otherwise.

In the fullness of time, visibility into the far-reaching benefits of research may be possible with an IMF like approach. Productivity will be correlated with research investment and the ease with which all innovations are moved from lab to market.

Meanwhile, be practical. Invest in the research collaborations of tomorrow.

Table A-1: 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 = (Running 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. Explain result of omitting ERI.
Inconsistently reported data or mischaracterized data	+/– Underestimate or overestimate, 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.	Acquire data on the actual industries.
The licensees' production of ERI generating commodities is modeled by industry and by assuming that half (all) the royalty-generating products are sold by large companies, and then by using what can be inferred about the 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.[70]
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 running royalty payments end.	– Underestimate of impact.	Studies of product lifetimes, relative to license duration. IMF like approach

[70] See text of report.

Table A-2 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	AUTM 2022 Report
Years	1996–2007	1996–2010	1996–2010	1996–2013	1996–2015	2008–2015	1996–2017	1996-2020
Licensees of both HRIs and Universities	No →	Yes	No	Yes	Yes	NA: 11 Agencies[71]	Yes	Yes
Licensees' sales used in job estimate	No →	Yes	No	Yes	Yes	Yes	Yes	Yes
Updated BEA value added ratios	No	No	No →	Yes	Yes	Yes	Yes	Yes
Base year for inflation adj $	2005	2005	2005 →	2009	2009	2009 →	2012	2012
Industries			A[72]		→	B[73] →	**C[74]**	C
The licensees' production of running royalty bearing products occurs entirely in the U.S.	Yes	Yes	Yes		Yes →	i) Yes, **A** ii) No, **B** → →	Yes, "**A**" Yes, "**C**" No, "**C**"	No, **C**
The companies reporting product sales are multinational entitles "MNE's"			NA: see above assumption that all production occurs in the U.S.			A: NA B: half are MNE's	**A:** NA C: half are MNE's →	C: i) half are MNE's ii) **All MNE's**
None of the licensees' sales are final sales.	Yes	Yes	Yes	Yes	Yes →	i) Yes, **A** ii) No, **B** → →	Yes, "**A**" Yes, "**C**" No, "**C**"	No, **C**
All of the intermediate inputs to gross output are domestic.	Yes	Yes	Yes	Yes	Yes →	i) Yes, A ii) No, B: → →	Yes, "A" Yes, "C" No "C"	No, **C**

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

[72] **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).

[73] **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).

[74] **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).

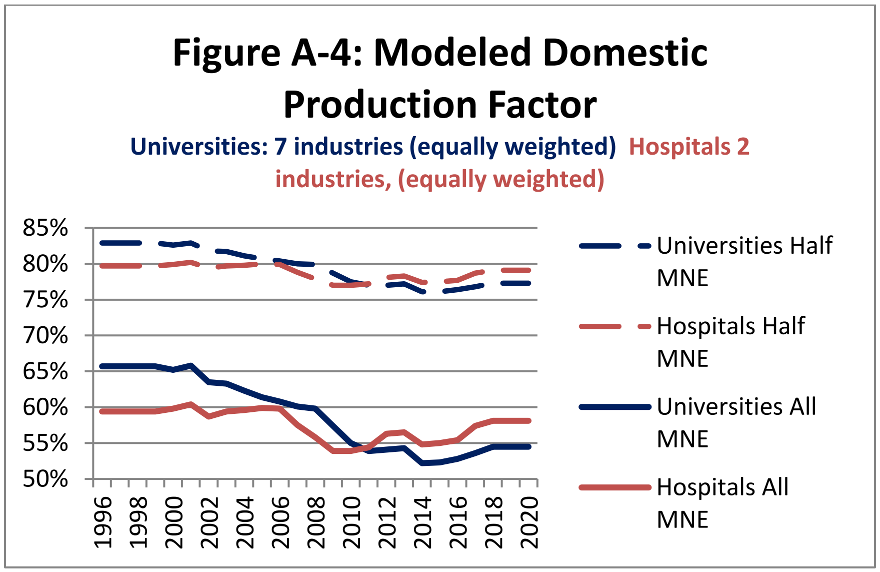
Table A-3: Industries used in various implementations of the I-O model to nonprofit licensing

	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 2022 report and the 2019 report for AUTM: Universities 7 industries	This 2022 report and the 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 A-4: and Figure A-4: Domestic production factor

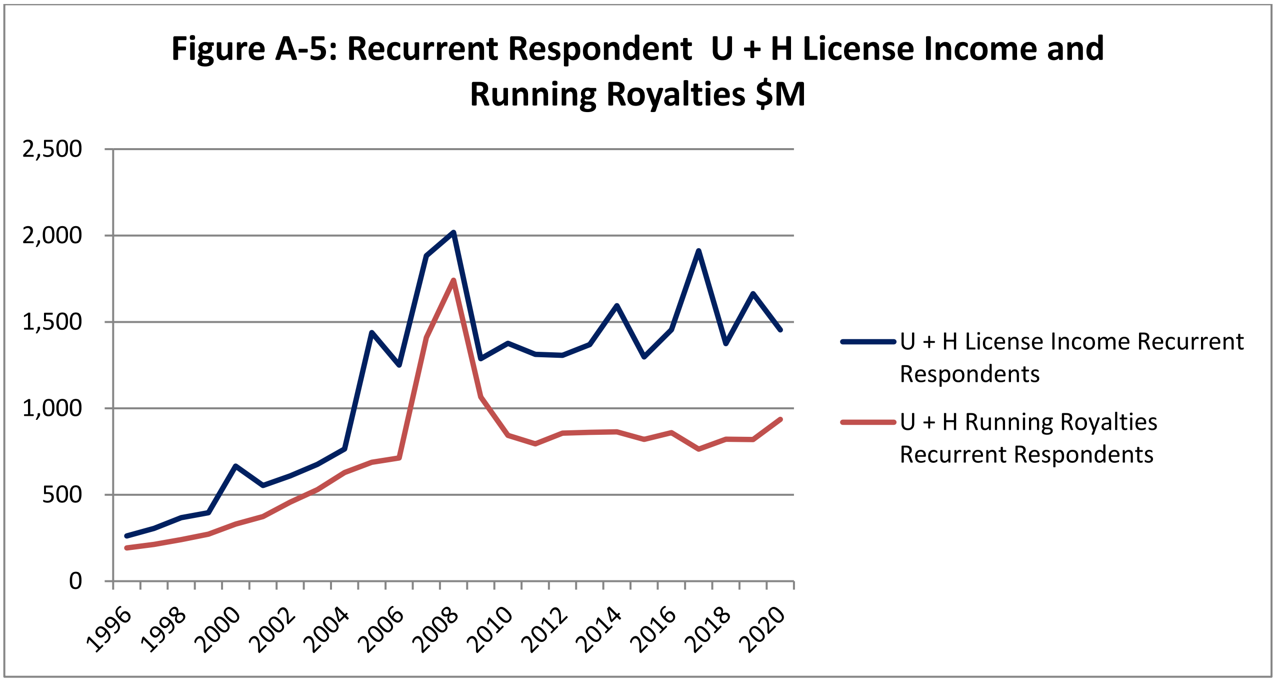
Modeled from BEA and Census Bureau observed employment patterns for U.S. majority owned multinationals for a) the 7 research intensive industries which, per the model are the industries of licensees of the Universities, and: b) for the 2 research intensive industries which, per the model, are the industries of the licensees of the Hospitals and Research Institutes.

Method: In each case, the model assumes that i) (a) half, and then (b) all the production is by large entities, and that ii) the domestic production of large entities can be modeled by i) knowing the non-domestic employment of U.S. majority owned multinational enterprises by industry, and ii) the total employment of enterprises in the same industries. The domestic production factor is one minus the non-domestic employment of such industries divided by total global employment for the same industries.



	Modeled Domestic Production Factor Universities Half MNE	Modeled Domestic Production Factor Universities All MNE	Modeled Domestic Production Factor Hospitals Half MNE	Modeled Domestic Production Factor Hospitals All MNE
1996	0.829	0.657	0.797	0.594
1997	0.829	0.657	0.797	0.594
1998	0.829	0.657	0.797	0.594
1999	0.829	0.657	0.797	0.594
2000	0.826	0.652	0.799	0.598
2001	0.829	0.658	0.802	0.604
2002	0.818	0.635	0.794	0.587
2003	0.817	0.633	0.797	0.594
2004	0.811	0.623	0.798	0.596
2005	0.807	0.614	0.800	0.599
2006	0.804	0.608	0.799	0.598
2007	0.800	0.601	0.788	0.575
2008	0.799	0.598	0.779	0.558
2009	0.787	0.574	0.770	0.539
2010	0.775	0.550	0.770	0.539
2011	0.770	0.539	0.772	0.544
2012	0.770	0.541	0.781	0.563
2013	0.772	0.543	0.783	0.565
2014	0.761	0.522	0.774	0.548
2015	0.761	0.523	0.775	0.550
2016	0.764	0.528	0.777	0.554
2017	0.768	0.536	0.787	0.574
2018	0.773	0.545	0.791	0.581
2019	0.773	0.545	0.791	0.581
2020	0.773	0.545	0.791	0.581

Other Appendix Figures



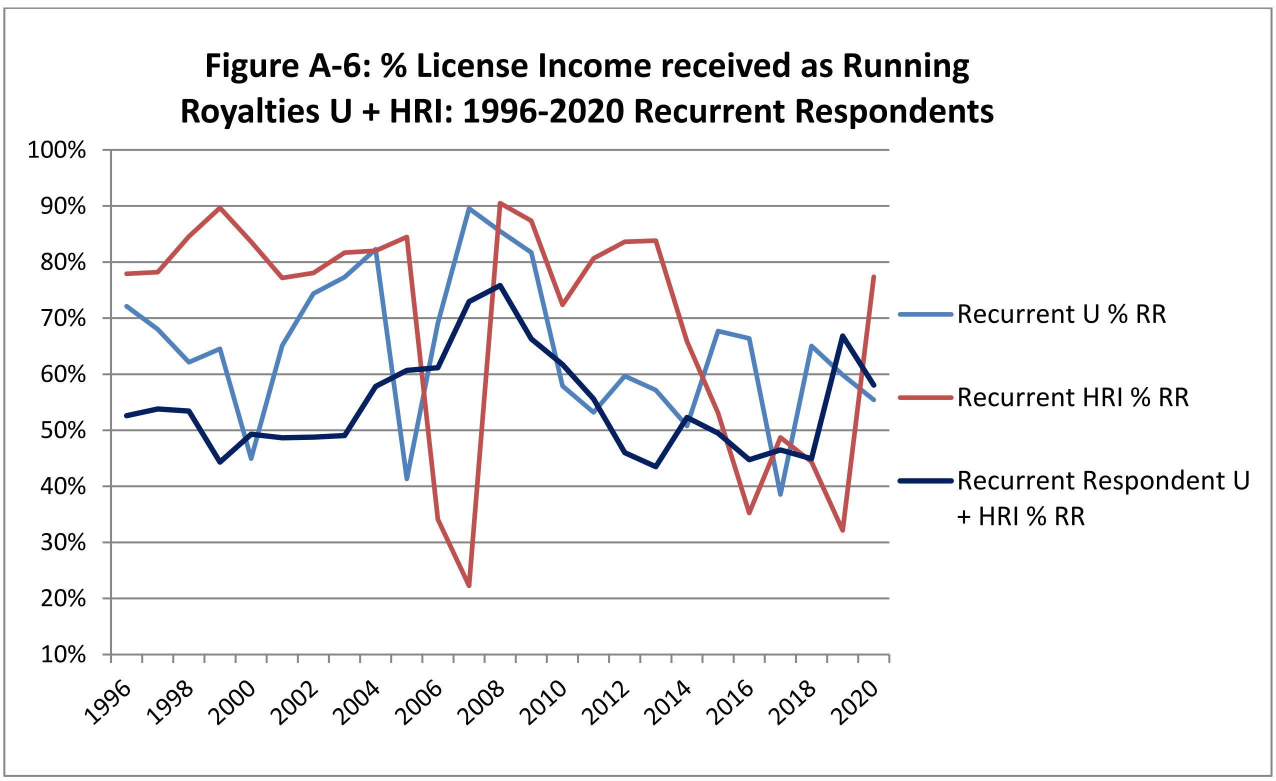


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Figure A-7: #'s of Active Licenses, Licenses Generating Income, Licenses Generating Running Royalties.

U+ H: recurrent 1996-2020, the 66 responding to at least one question

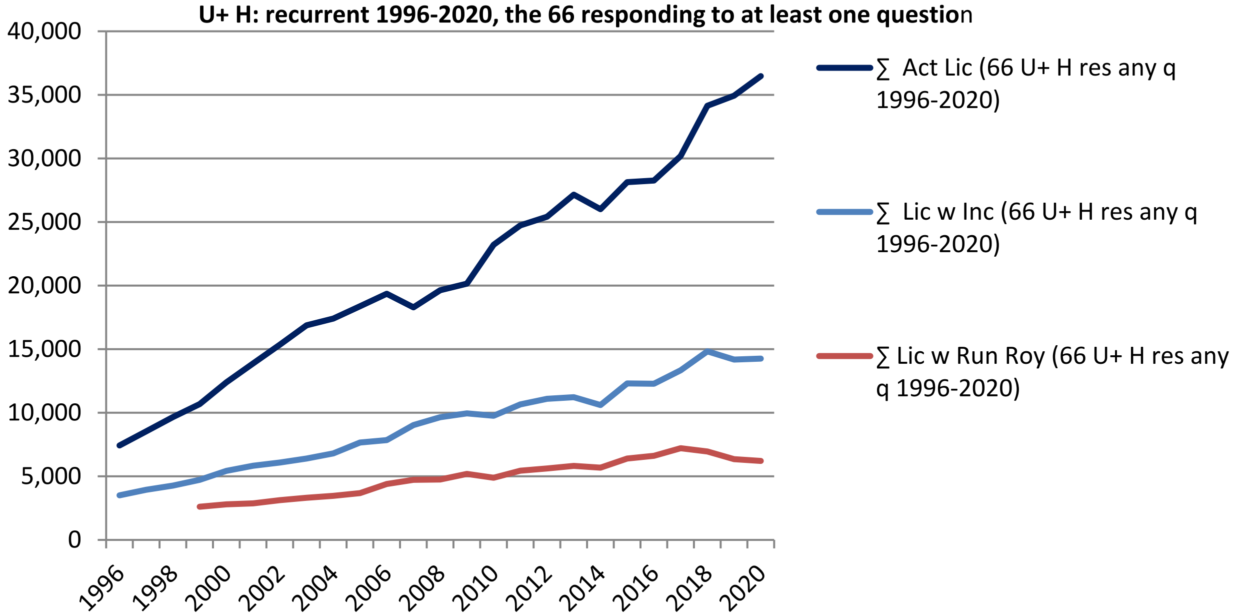
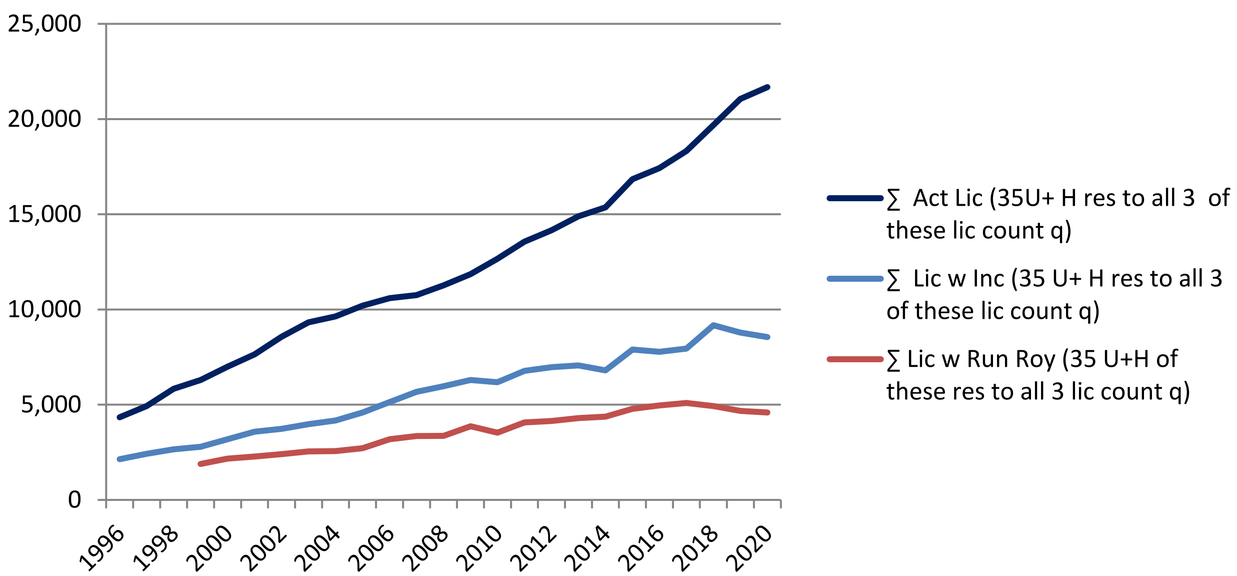


Figure A-8: #'s of Active Licenses, Licenses Generating Income, Licenses Generating Running Royalties.

U+H: recurrent 1996-2020, the 35 responding to all three of the noted license count questions



Glossary: Definitions and Abbreviations

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 running royalty generating licensed products occurs outside the United States.

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

GDP: Gross domestic product is the market value of goods and services produced by labor and property in the United States, regardless of nationality.

GO: Gross output is the value of the goods and services produced by the nation's economy. It is principally measured using industry sales or receipts, including sales to final users (GDP) and sales to other industries (intermediate inputs).

Hospitals: 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.

NCSES: National Center for Science and Engineering Statistics www.nsf.gov/statistics/

NPO: A nonprofit organization, the same category as "Other Nonprofit" in prior reports.

Small company: As used in this report, a company employing fewer than 500 people.

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

Definitions from the AUTM 2020 Survey:

https://autm.net/AUTM/media/Surveys-Tools/Documents/FY20-Licensing-Survey-Definitions-Instructions-FNL.pdf

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Supplements to Economic Contributions of University/ Nonprofit Inventions in the United States: 1996–2020

Prepared for the Biotechnology Innovation Organization (BIO) and AUTM
by Lori Pressman, Mark Planting, Carol Moylan and Jennifer Bond.

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Transforming Ideas into Opportunities

Supplements to Economic Contributions to University/Nonprofit Inventions in the United States: 1996-2020

Lori Pressman, Mark Planting, Carol Moylan and Jennifer Bond

June 14, 2020

Contents

Supplement 1:

Implementation of the I-O model 2009-2022

This report is the eighth calculation and evolution of the original model. Refer to Appendix A-2, and Appendix A-3 for quick guides on the change in the model and the industries used to model the industries of the licensees.

The initial 2009 report only used the data provided by university AUTM Survey respondents and omitted the responses by hospitals and research institutes. The 2009 report modeled all the licensed products as being made by companies in manufacturing industries 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.

The 2012 report1 included AUTM member hospitals and research institutes (HRIs) and for the first time, included jobs supported by the licensees' sales. The 2009 report and the 2013 Research Policy paper included only universities and omitted jobs supported by the licensees' product sales2.

The 2015 report3 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 contribution of research expenditures to the U.S. economy, including their contributions to growth and productivity similar to other capital goods.4 This change in the treatment of R&D expenditures is the subject of a review paper5 by Carol Moylan and Sumiye Okubo and was the fruit of many decades of international 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. One of the methods developed6 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.

[1] 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

[2] Jobs at the universities supported by license income received by the universities were included.

[3] 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

[4] 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.

[5] Carol E. Moylan and Sumiye Okubo "The Evolving Treatment of R&D in the U.S. National Economic Accounts", BEA 2020 https://www.bea.gov/system/files/2020-04/the-evolving-treatment-of-rd-in-the-us-national-economic-accounts.pdf

[6] 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.

The 2017 report[7] 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[8] prepared for 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.

The 2019 estimate is built 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, the 2019 report changed the industries used to model the products sold by the licensees to research-intensive industries[9] identified and studied by the BEA[10] in preparation for treating research as a capital expenditure in the national accounts. The research-intensive industries overlap with, but are not identical to, i) the manufacturing industries used in the earlier reports and ii) the industries used in "Rev 2" of the NIST report. The various sets of industries used in the full series of reports are described in Table A-3 in the main report.

To better reflect a more globally integrated economy, and again by using empirically gathered data on industry specific patterns (not actual information about where the licensees' products are made), starting in 2019, and continuing in this 2022 report, the location of manufacturing of the licensed products, and their position in a value chain is modeled based on BEA and Census Bureau documented industry specific patterns of employment, inputs and outputs.

Starting in 2019, and again continuing in this report, 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.[11] In 2019, this distinct treatment applied to the value-added ratios, output multipliers, and employment to output multipliers, but not to the calculation of the domestic production factor which was calculated solely for the basket of seven research-intensive industries used to model the production of the university licensees, and not separately for the two research-intensive industries used to model the production of the hospital licensees.

Starting in 2022, for the first time, the domestic production factor is calculated separately for a basket of seven research-intensive industries of the university licensees and the subset of two research-intensive industries of the hospital licensees. The domestic production factor appears to decrease from 1996 through 2010 for hospitals and from 1996 through 2014 for universities, and then appears to start increasing. These trends have been called "off shoring", and "re-shoring" and are shown in Fig A-4 next to Table A-4 in the main report.

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[7] 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.

[8] 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.

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

[10] 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.

[11] 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."

Supplement 2:

Types of research: how it is defined and identified

The international consensus definitions of the types of research have changed little over the past 59 years. In 1963, the OECD released the first edition of what became known as the Frascati Manual on proposed methods for studying research activities. Per the Frascati Manual, research must be novel, creative, reproducible, undertaken systematically, and have an uncertain outcome. It is the uncertainty that distinguishes research from routine work and at the same time makes it difficult to value. Table S-2.1 below shows the Frascati Manual 1963 and 2015 definitions of types of research.

Table S-2.1: Frascati Manual Definitions of R&D in 1963 and 2015	
1963	**2015**
Fundamental Research: Work undertaken primarily for the advancement of scientific knowledge, without a specific practical application in view.	**Basic research** is 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: The same, but with a specific practical aim in view.	**Applied research** is original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective.
Development: The use of the results of fundamental and applied research directed to the introduction of useful materials, devices, products, systems, and processes, or the improvement of existing ones.	**Experimental development** is 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.

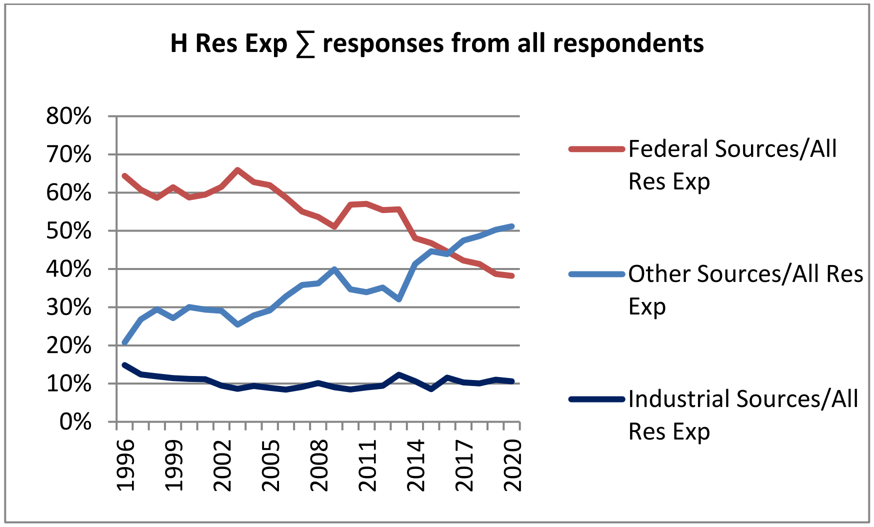
NSF questionnaires sent to organizations, which perform and fund research use these definitions and provide illustrative examples to help the respondents characterize the research they do and fund. Here is an example from a questionnaire https://www.nsf.gov/statistics/srvynpra/surveys/2020-npra-survey.pdf sent to Nonprofit Organizations.

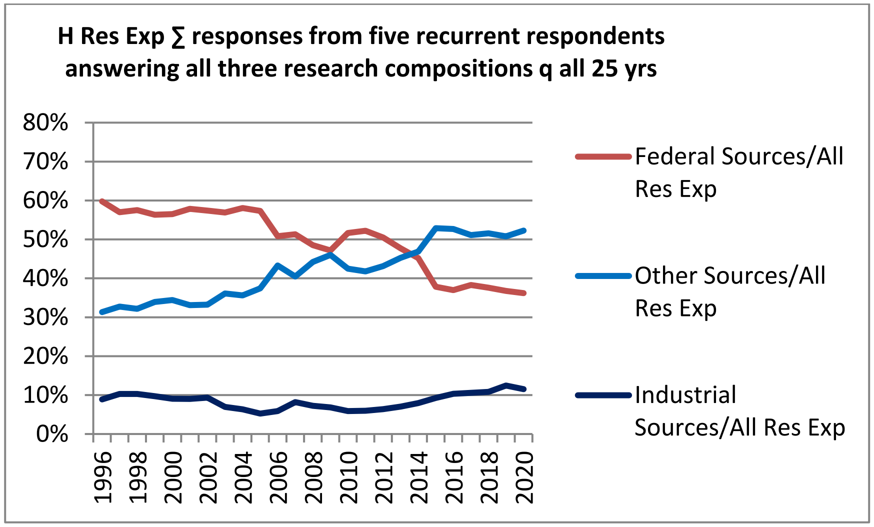
Basic research	Applied research	Experimental development
A researcher is studying the properties of human blood to determine what affects coagulation.	A researcher is conducting research on how a new chicken pox vaccine affects blood coagulation.	A researcher is conducting clinical trials to test a newly developed chicken pox vaccine for young children.
A researcher is studying the properties of molecules under various heat and cold conditions.	A researcher is investigating the properties of particular substances under various heat and cold conditions with the objective of finding longer lasting components for highway pavement.	A researcher is working with state transportation officials to conduct tests of a newly developed highway pavement under various types of heat and cold conditions.
A researcher is investigating the effect of different types of manipulatives on the way first graders learn mathematical strategy by changing manipulatives and then measuring what students have learned through standardized instruments.	A researcher is studying the implementation of a specific math curriculum to determine what teachers need to know to implement the curriculum successfully.	A researcher is developing and testing software and support tools, based on field work, to improve mathematics cognition for student special education.

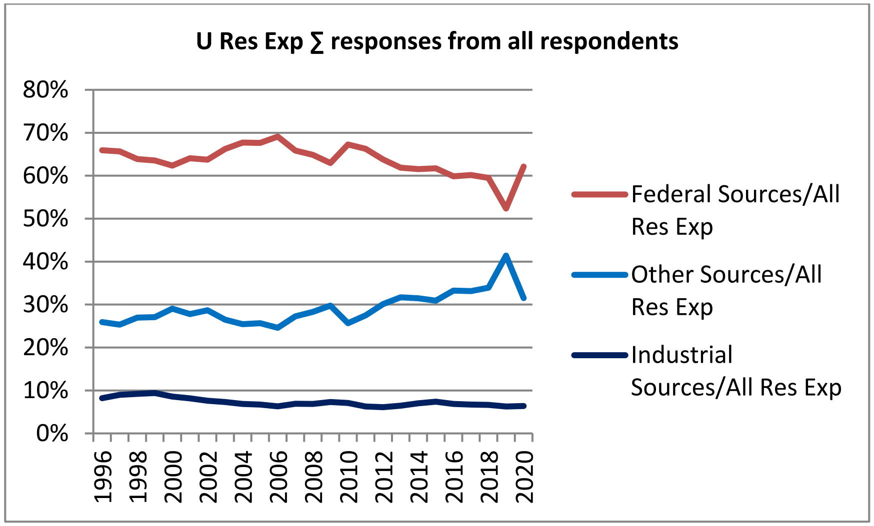
Thus, characterization of the type of research is necessarily more subjective than providing the amount of research expenditures either performed or funded.

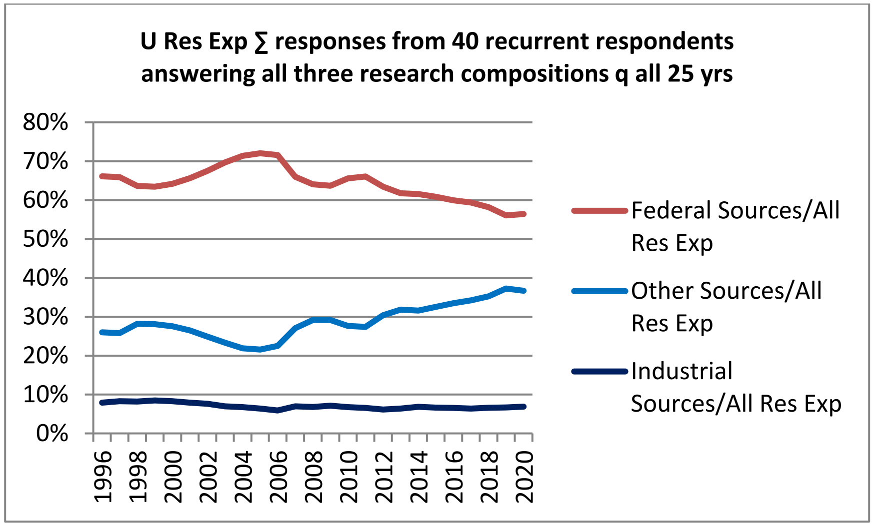
Supplement 3:

Research funding patterns, disaggregated by university and hospital and research institute respondents









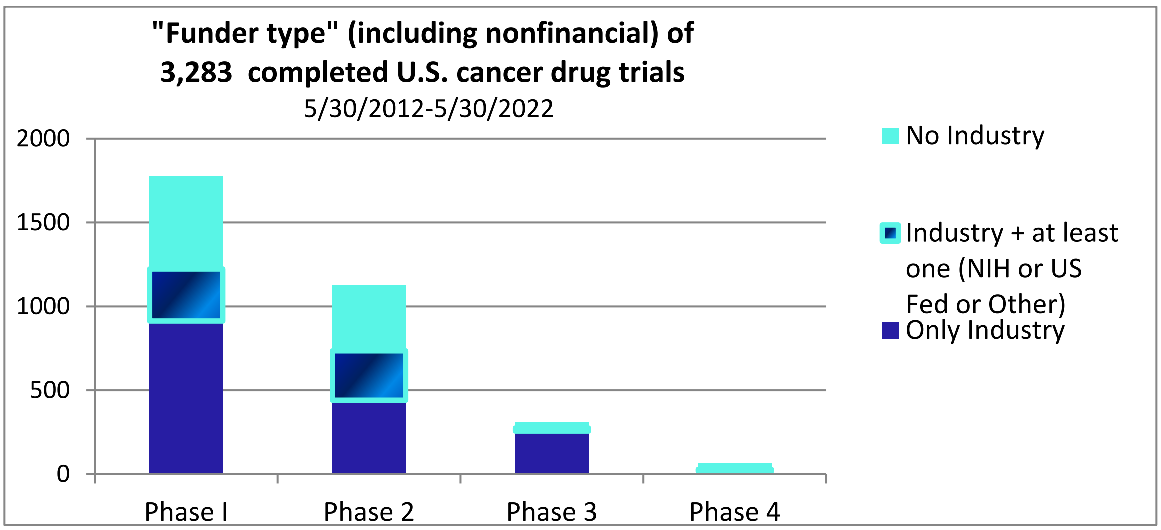
Supplement 4:

Collaboration patterns in U.S. completed cancer drug clinical trials

Funder type https://clinicaltrials.gov/ct2/about-studies/glossary Describes the organization that provides funding or support for a clinical study. **This support may include activities related to funding, design, implementation, data analysis, or reporting.** Organizations listed as sponsors and collaborators for a study are considered the funders of the study. ClinicalTrials.gov refers to four types of funders:

- •U.S. National Institutes of Health
- •Other U.S. Federal agencies (for example, Food and Drug Administration, Centers for Disease Control and Prevention, or U.S. Department of Veterans Affairs)
- •Industry (for example: pharmaceutical and device companies)
- •All others (including individuals, universities, and community-based organizations)

Search string, run 6/2/2022: Completed Studies | Interventional Studies | Cancer | Drug | United States | Phase Early Phase 1, 1, 2, 3, 4 | Start date from 05/30/2012 to 05/30/2022



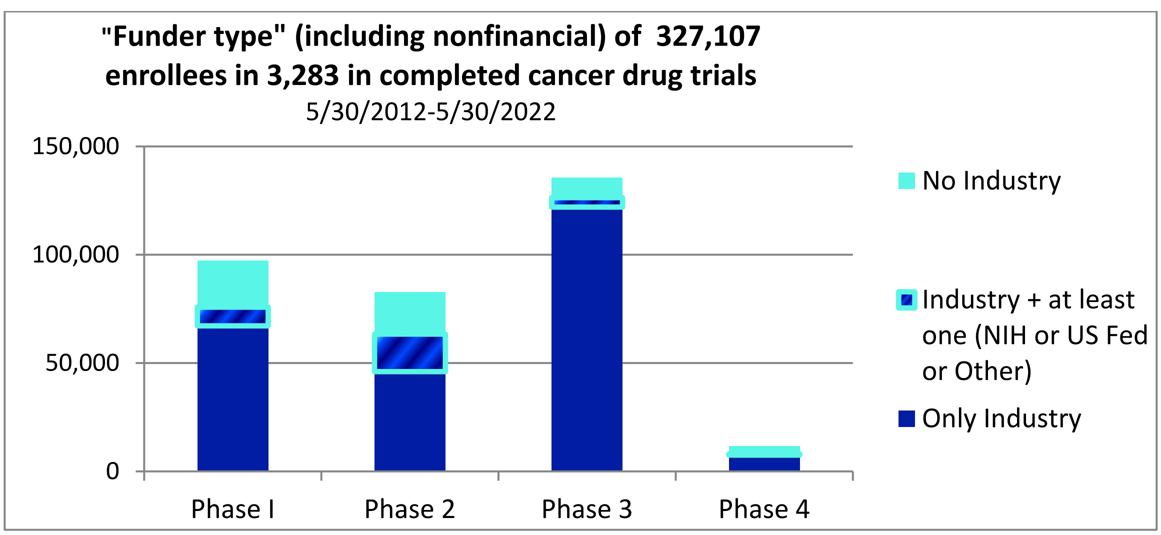


Table S-1: Universities 1996–2020 contribution to: GDP, employment, and gross output: 2% ERI, half, and then all sales by large entities, adjusted per the domestic production factor of A-4. seven research-intensive industries.

	University Contribution to GDP 2% ERI Half MNE	University Contribution to GDP 2% ERI All MNE	University Contribution to Person Years of Employment 2 % ERI Half MNE	University Contribution to Person Years of Employment 2 % ERI All MNE	University Contribution to Gross Output 2 % ERI Half MNE	University Contribution to Gross Output 2 % ERI All MNE
Year	**2012 Dollars (Millions)**	**2012 Dollars (Millions)**	**Person Years of Employment (Thousands)**	**Person Years of Employment (Thousands)**	**2012 Dollars (Millions)**	**2012 Dollars (Millions)**
1996	$11,435	$9,171	91	73	$24,481	$19,575
1997	$12,616	$10,140	103	83	$27,008	$21,628
1998	$15,637	$12,570	125	101	$33,168	$26,576
1999	$18,538	$14,885	145	118	$39,615	$31,705
2000	$21,765	$17,472	175	142	$46,276	$36,995
2001	$24,144	$19,390	194	157	$51,347	$41,123
2002	$29,307	$23,047	217	172	$59,850	$46,955
2003	$30,383	$23,844	213	169	$60,950	$47,715
2004	$28,400	$22,095	193	152	$57,421	$44,529
2005	$29,199	$22,704	202	160	$59,931	$46,362
2006	$31,651	$24,350	215	167	$64,840	$49,695
2007	$56,220	$42,772	368	283	$115,941	$87,955
2008	$59,714	$45,315	387	297	$121,043	$91,579
2009	$42,977	$31,843	271	203	$80,813	$59,689
2010	$33,644	$24,412	200	148	$63,779	$46,079
2011	$32,262	$23,162	193	141	$62,649	$44,757
2012	$37,800	$27,117	225	164	$72,698	$51,917
2013	$40,414	$29,060	242	177	$78,316	$56,073
2014	$37,497	$26,402	226	162	$72,796	$50,982
2015	$37,988	$26,660	225	161	$71,468	$49,958
2016	$39,058	$27,604	231	166	$72,398	$50,965
2017	$29,450	$21,192	176	130	$54,592	$39,091
2018	$27,873	$20,136	163	120	$51,132	$36,798
2019	$26,235	$18,974	153	113	$47,052	$33,894
2020	$26,211	$19,040	154	115	$45,694	$33,055
Total	$780,417	$583,357	5,085	3,874	$1,535,257	$1,145,652

Table S-2: Universities 1996–2020 contribution to: GDP, employment, and gross output: 5% ERI, half, and then all sales by large entities, adjusted per the domestic production factor of A-4. seven research-intensive industries.

	University Contribution to GDP 5% ERI Half MNE	University Contribution to GDP 5% ERI All MNE	University Contribution to Person Years of Employment 5 % ERI Half MNE	University Contribution to Person Years of Employment 5 % ERI All MNE	University Contribution to Gross Output 5 % ERI Half MNE	University Contribution to Gross Output 5 % ERI All MNE
Year	**2012 Dollars (Millions)**	**2012 Dollars (Millions)**	**Person Years of Employment (Thousands)**	**Person Years of Employment (Thousands)**	**2012 Dollars (Millions)**	**2012 Dollars (Millions)**
1996	$4,873	$3,968	40	34	$10,260	$8,298
1997	$5,436	$4,445	47	39	$11,411	$9,259
1998	$6,744	$5,517	57	48	$14,055	$11,418
1999	$7,947	$6,485	66	55	$16,682	$13,518
2000	$9,552	$7,835	82	68	$19,872	$16,160
2001	$10,310	$8,409	86	71	$21,594	$17,504
2002	$12,462	$9,958	96	79	$25,154	$19,996
2003	$12,902	$10,287	95	77	$25,570	$20,276
2004	$12,130	$9,608	87	70	$24,150	$18,993
2005	$12,897	$10,299	96	79	$25,875	$20,448
2006	$13,666	$10,746	98	79	$27,530	$21,472
2007	$23,847	$18,468	163	129	$48,572	$37,378
2008	$25,409	$19,649	172	136	$50,842	$39,056
2009	$18,316	$13,862	121	94	$34,026	$25,577
2010	$14,574	$10,882	92	71	$27,218	$20,139
2011	$14,014	$10,373	89	68	$26,771	$19,614
2012	$16,293	$12,020	102	78	$30,862	$22,550
2013	$17,398	$12,856	110	84	$33,224	$24,327
2014	$16,286	$11,848	104	79	$31,093	$22,368
2015	$16,311	$11,779	102	76	$30,305	$21,701
2016	$16,824	$12,243	105	79	$30,792	$22,219
2017	$13,031	$9,728	84	65	$23,772	$17,572
2018	$12,101	$9,006	75	58	$21,910	$16,177
2019	$11,432	$8,528	71	55	$20,228	$14,964
2020	$11,591	$8,723	74	58	$19,929	$14,873
Total	$336,345	$257,521	2,315	1,830	$651,698	$495,856

Table S-3: HRI 1996–2020L contribution to: GDP, employment, and gross output: 2% ERI, half, and then all sales by large entities, adjusted per the domestic production factor of A-4. two research-intensive industries

Year	HRI Contribution to GDP 2% ERI Half MNE 2012 Dollars (Millions)	HRI Contribution to GDP 2% ERI All MNE 2012 Dollars (Millions)	HRI Contribution to Person Years of Employment 2 % ERI Half MNE Person Years of Employment (Thousands)	HRI Contribution to Person Years of Employment 2 % ERI All MNE Person Years of Employment (Thousands)	HRI Contribution to Gross Output 2 % ERI Half MNE 2012 Dollars (Millions)	HRI Contribution to Gross Output 2 % ERI All MNE 2012 Dollars (Millions)
1996	$3,233	$2,437	24	18	$6,118	$4,596
1997	$3,063	$2,326	23	18	$5,796	$4,388
1998	$2,253	$1,717	18	14	$4,247	$3,226
1999	$5,120	$3,866	38	29	$9,535	$7,184
2000	$3,949	$2,999	29	22	$7,559	$5,728
2001	$4,768	$3,645	35	27	$8,878	$6,773
2002	$5,488	$4,144	38	29	$9,910	$7,469
2003	$8,712	$6,589	59	45	$16,021	$12,093
2004	$9,282	$7,037	61	47	$17,433	$13,182
2005	$8,718	$6,631	58	45	$17,137	$12,995
2006	$6,573	$5,104	46	36	$12,602	$9,724
2007	$4,123	$3,179	29	23	$8,003	$6,116
2008	$10,709	$7,982	70	54	$20,571	$15,231
2009	$8,010	$5,777	49	36	$14,208	$10,205
2010	$8,311	$6,005	49	37	$15,168	$10,904
2011	$9,498	$6,878	57	42	$17,956	$12,939
2012	$15,418	$11,280	90	67	$29,146	$21,258
2013	$15,112	$11,088	89	66	$28,603	$20,927
2014	$8,004	$5,797	48	35	$14,982	$10,806
2015	$8,008	$5,823	48	35	$14,413	$10,443
2016	$14,261	$10,376	85	63	$25,426	$18,444
2017	$16,063	$11,923	95	71	$28,850	$21,363
2018	$21,608	$16,172	127	97	$38,542	$28,775
2019	$7,403	$5,627	45	35	$12,857	$9,728
2020	$17,699	$13,213	103	78	$30,614	$22,807
Total	$225,386	$167,615	1,413	1,070	$414,575	$307,303

Table S-4: HRI 1996–2020 contribution to: GDP, employment, and gross output: 5% ERI, half, and then all sales by large entities, adjusted per the domestic production factor of A-4. two research-intensive industries

Year	HRI Contribution to GDP 5% ERI Half MNE 2012 Dollars (Millions)	HRI Contribution to GDP 5% ERI All MNE 2012 Dollars (Millions)	HRI Contribution to Person Years of Employment 5 % ERI Half MNE Person Years of Employment (Thousands)	HRI Contribution to Person Years of Employment 5 % ERI All MNE Person Years of Employment (Thousands)	HRI Contribution to Gross Output 5 % ERI Half MNE 2012 Dollars (Millions)	HRI Contribution to Gross Output 5 % ERI All MNE 2012 Dollars (Millions)
1996	$1,444	$1,123	11	9	$2,682	$2,072
1997	$1,377	$1,071	11	9	$2,559	$1,976
1998	$1,024	$801	9	7	$1,897	$1,475
1999	$2,200	$1,690	17	13	$4,046	$3,094
2000	$1,777	$1,373	14	11	$3,352	$2,578
2001	$2,152	$1,674	17	13	$3,956	$3,065
2002	$2,485	$1,922	19	15	$4,432	$3,416
2003	$3,804	$2,931	27	22	$6,896	$5,293
2004	$4,022	$3,108	28	22	$7,428	$5,708
2005	$3,768	$2,922	27	21	$7,271	$5,603
2006	$3,137	$2,531	24	20	$5,833	$4,656
2007	$2,024	$1,646	16	14	$3,799	$3,046
2008	$4,999	$3,892	36	30	$9,355	$7,196
2009	$3,570	$2,666	24	19	$6,224	$4,611
2010	$3,712	$2,783	24	19	$6,637	$4,928
2011	$4,193	$3,141	27	21	$7,768	$5,761
2012	$6,537	$4,885	41	31	$12,183	$9,044
2013	$6,399	$4,794	40	31	$11,950	$8,897
2014	$3,463	$2,581	22	17	$6,369	$4,708
2015	$3,481	$2,611	23	17	$6,168	$4,594
2016	$6,125	$4,578	39	30	$10,759	$7,992
2017	$6,820	$5,181	43	34	$12,088	$9,137
2018	$9,143	$7,008	58	45	$16,072	$12,255
2019	$3,312	$2,619	22	18	$5,626	$4,412
2020	$7,437	$5,668	46	36	$12,669	$9,613
Total	$98,404	$75,200	666	526	$178,019	$135,130

Table S-5: University + HRI 1996–2020: contribution to: GDP, employment, and gross output: 2% ERI, half, and then all sales by large entities, adjusted by the domestic production factor of A-4. (Sum of tables S-1+S-3)

	U + HRI Contribution to GDP 2% ERI Half MNE	U + HRI Contribution to GDP 2% ERI All MNE	U + HRI Contribution to Person Years of Employment 2 % ERI Half MNE	U + HRI Contribution to Person Years of Employment 2 % ERI All MNE	U + HRI Contribution to Gross Output 2 % ERI Half MNE	U + HRI Contribution to Gross Output 2 % ERI All MNE
Year	2012 Dollars (Millions)	2012 Dollars (Millions)	Person Years of Employment (Thousands)	Person Years of Employment (Thousands)	2012 Dollars (Millions)	2012 Dollars (Millions)
1996	$14,668	$11,609	115	92	$30,599	$24,172
1997	$15,679	$12,466	126	101	$32,804	$26,016
1998	$17,890	$14,286	142	115	$37,415	$29,801
1999	$23,659	$18,751	183	147	$49,150	$38,889
2000	$25,714	$20,472	205	165	$53,836	$42,724
2001	$28,912	$23,035	229	184	$60,225	$47,895
2002	$34,795	$27,191	255	201	$69,759	$54,424
2003	$39,095	$30,433	272	214	$76,971	$59,808
2004	$37,681	$29,132	254	199	$74,854	$57,711
2005	$37,917	$29,335	261	205	$77,068	$59,357
2006	$38,224	$29,454	260	204	$77,442	$59,420
2007	$60,343	$45,951	397	306	$123,943	$94,070
2008	$70,423	$53,298	458	351	$141,615	$106,809
2009	$50,986	$37,620	320	239	$95,020	$69,894
2010	$41,955	$30,416	249	184	$78,946	$56,983
2011	$41,760	$30,040	249	183	$80,605	$57,696
2012	$53,218	$38,397	315	231	$101,844	$73,175
2013	$55,526	$40,148	332	243	$106,919	$77,000
2014	$45,501	$32,199	274	197	$87,778	$61,789
2015	$45,996	$32,483	273	196	$85,881	$60,401
2016	$53,319	$37,980	315	229	$97,824	$69,410
2017	$45,513	$33,115	271	201	$83,441	$60,455
2018	$49,481	$36,309	290	216	$89,675	$65,573
2019	$33,638	$24,601	198	148	$59,909	$43,622
2020	$43,911	$32,253	258	193	$76,308	$55,862
Total	$1,005,803	$750,973	6,499	4,944	$1,949,832	$1,452,955

Table S-6: University + HRI 1996–2020: contribution to: GDP, employment, and gross output: 5% ERI, half, and then all sales by large entities, adjusted per the domestic production factor of A-4 (Sum of tables S-2+S-4)

	U + HRI Contribution to GDP 5 % ERI Half MNE	U + HRI Contribution to GDP 5% ERI All MNE	U + HRI Contribution to Person Years of Employment 5 % ERI Half MNE	U + HRI Contribution to Person Years of Employment 5 % ERI All MNE	U + HRI Contribution to Gross Output 5 % ERI Half MNE	U + HRI Contribution to Gross Output 5 % ERI All MNE
Year	2012 Dollars (Millions)	2012 Dollars (Millions)	Person Years of Employment (Thousands)	Person Years of Employment (Thousands)	2012 Dollars (Millions)	2012 Dollars (Millions)
1996	$6,318	$5,091	52	43	$12,942	$10,370
1997	$6,813	$5,516	58	48	$13,970	$11,235
1998	$7,768	$6,318	66	55	$15,952	$12,893
1999	$10,147	$8,175	83	68	$20,728	$16,612
2000	$11,329	$9,208	96	80	$23,224	$18,738
2001	$12,462	$10,083	103	85	$25,550	$20,569
2002	$14,947	$11,879	115	94	$29,585	$23,412
2003	$16,706	$13,218	122	99	$32,466	$25,569
2004	$16,152	$12,716	115	93	$31,579	$24,701
2005	$16,665	$13,221	123	101	$33,146	$26,051
2006	$16,803	$13,277	123	100	$33,364	$26,129
2007	$25,871	$20,114	180	143	$52,371	$40,424
2008	$30,408	$23,542	209	166	$60,197	$46,253
2009	$21,886	$16,529	144	112	$40,250	$30,188
2010	$18,286	$13,665	116	90	$33,855	$25,067
2011	$18,207	$13,514	116	89	$34,539	$25,375
2012	$22,830	$16,905	143	109	$43,045	$31,594
2013	$23,797	$17,650	150	115	$45,175	$33,224
2014	$19,748	$14,429	126	96	$37,462	$27,076
2015	$19,791	$14,391	124	94	$36,473	$26,296
2016	$22,949	$16,821	144	109	$41,551	$30,211
2017	$19,851	$14,909	127	99	$35,860	$26,708
2018	$21,243	$16,013	133	104	$37,983	$28,431
2019	$14,745	$11,147	94	73	$25,854	$19,377
2020	$19,028	$14,390	120	94	$32,598	$24,486
Total	$434,749	$332,721	2981	2,356	$829,718	$630,986

Table S-7:

The 20 major industry classes and 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-8:

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	73.138
1997	$483	$315	$129	$81	74.399
1998	$614	$390	$113	$60	75.236
1999	$675	$475	$152	$139	76.296
2000	$1,100	$559	$132	$111	78.025
2001	$868	$637	$171	$131	79.783
2002	$998	$787	$259	$151	81.026
2003	$1,032	$829	$314	$249	82.625
2004	$1,088	$810	$346	$277	84.843
2005	$1,775	$856	$346	$278	87.504
2006	$1,512	$969	$653	$198	90.204
2007	$2,099	$1,807	$576	$125	92.642
2008	$2,397	$1,946	$1,037	$351	94.419
2009	$1,782	$1,351	$525	$257	95.024
2010	$1,790	$1,092	$587	$276	96.166
2011	$1,814	$1,097	$620	$333	98.164
2012	$1,955	$1,306	$638	$555	100
2013	$2,090	$1,426	$627	$554	101.751
2014	$2,223	$1,358	$460	$294	103.654
2015	$1,946	$1,371	$513	$288	104.691
2016	$2,117	$1,402	$784	$518	105.74
2017	$2,246	$1,052	$822	$592	107.747
2018	$1,749	$1,024	$1,191	$805	110.321
2019	$1,757	$964	$781	$264	112.294
2020	$2,097	$946	$859	$668	113.648

Table S-9:

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
Year	Value added ratio for **seven research-intensive industries**	Value added ratio for **two research-intensive industries**	Output multiplier for Total Lic Inc **educational services,** 1 ind [12]	Employment to output ratio **for educational services**, 1 ind [13]	Employment to output ratio **for seven research-intensive industries**	Employment to output ratio **for two research-intensive industries**
1996	0.450	0.526	0.562	0.019	0.0043	0.0046
1997	0.449	0.526	0.562	0.019	0.0043	0.0046
1998	0.455	0.528	0.610	0.019	0.0041	0.0048
1999	0.451	0.539	0.573	0.018	0.0040	0.0048
2000	0.454	0.528	0.610	0.017	0.0041	0.0046
2001	0.454	0.543	0.615	0.017	0.0041	0.0046
2002	0.480	0.561	0.643	0.016	0.0039	0.0044
2003	0.491	0.547	0.588	0.016	0.0037	0.0042
2004	0.487	0.534	0.535	0.015	0.0035	0.0039
2005	0.478	0.507	0.564	0.014	0.0033	0.0037
2006	0.482	0.517	0.586	0.014	0.0033	0.0035
2007	0.482	0.503	0.616	0.013	0.0031	0.0033
2008	0.496	0.519	0.592	0.012	0.0031	0.0033
2009	0.535	0.566	0.512	0.012	0.0032	0.0034
2010	0.533	0.551	0.528	0.011	0.0030	0.0031
2011	0.521	0.532	0.544	0.011	0.0028	0.0030
2012	0.528	0.536	0.520	0.011	0.0028	0.0030
2013	0.522	0.533	0.540	0.011	0.0028	0.0030
2014	0.521	0.539	0.534	0.010	0.0027	0.0029
2015	0.540	0.559	0.541	0.010	0.0028	0.0030
2016	0.548	0.565	0.526	0.010	0.0028	0.0030
2017	0.546	0.561	0.547	0.010	0.0027	0.0029
2018	0.557	0.567	0.532	0.010	0.0027	0.0029
2019	0.569	0.578	0.499	0.009	0.0027	0.0029

[12] 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).

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

Table S-10: Excerpt from table 12 of BERD 2019, with selected subtotals

Table 12 Business Enterprise Research and Development Survey, 2019.
Worldwide, domestic, and foreign sales for companies located in the United States that performed or funded R&D, by industry and company size: 2019 (Millions of U.S. dollars)
ww = worldwide dom= domestic

Industry and company size	Sales						Selected subtotals by authors			
	R&D performers or funders[a]			Domestic R&D performers[b]						
	Worldwide	Domestic	Foreign	Worldwide	Domestic	Foreign				
All companies (number of domestic employees)	14,897,629	11,180,864	3,716,765	14,253,081	10,627,588	3,625,493				
Small companies							∑ small ww	∑ small dom	∑ < 500 ww	∑ < 500 dom
10–19c	22,697	22,272	426	22,225	21,822	403				
20–49	114,158	108,914	5,244	111,381	107,012	4,369	0.919%	1.17%		
Medium companies							∑ medium ww	∑ medium dom		
50–99	126,146	120,557	5,589	121,993	118,064	3,930				
100–249	324,503	267,171	57,332	289,065	264,042	25,023	3.02%	3.47%		
Large companies							∑ large ww	∑ large dom		
250–499	338,682	300,032	38,651	330,756	294,480	36,277			6.22%	7.32%
500–999	440,795	371,248	69,547	435,634	366,154	69,480			∑ 500 or more ww	∑ 500 or more dom
1,000–4,999	1,945,194	1,475,601	469,594	1,923,534	1,455,656	467,878				
5,000–9,999	1,498,357	1,141,851	356,506	1,451,157	1,101,217	349,940				
10,000–24,999	3,108,788	2,115,325	993,464	3,051,470	2,058,006	993,464				
25,000 or more	6,978,308	5,257,895	1,720,413	6,515,865	4,841,134	1,674,731	96.1%	95.4%	93.78%	92.68%

i = > 50% of the estimate is a combination of imputation and reweighting to account for nonresponse.
NAICS = 2012 North American Industry Classification System.

[a] Statistics are representative of companies located in the United States that performed or funded R&D.
[b] Statistics are representative of companies located in the United States that performed R&D.
[c] Business Enterprise Research and Development Survey does not include companies with fewer than 10 domestic employees