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 by Lori Pressman, Mark Planting, Robert Yuskavage, Sumiye Okubo, Carol Moylan, and Jennifer Bond, June 2017

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Acknowledgements: This report and model came into being under the leadership of David Roessner, Professor Emeritus, Georgia Institute of Technology, who had the foresight to draw together people and resources from the Bureau of Economic Analysis at the U.S. Department of Commerce, the National Science Foundation Science & Engineering Indicators Program, and the Association of University Technology Managers (AUTM) to generate a framework for looking at the economic impact of licensed commercialized inventions originating in academic research. The project team gratefully acknowledges the continuing financial support of the Biotechnology Innovation Organization and AUTM. We thank AUTM for supporting the AUTM Survey and the AUTM Survey respondents who provided the data for this report. Special thanks to Hans Sauer and Joe Allen for championing the project.

Contents:

Summary:

Using an input-output "I-O" approach to estimating the economic impact of academic licensing and summing that impact over 20 years of available data for academic U.S. Association of University Technology Managers (AUTM) Survey respondents, the total contribution of these academic licensors to industry gross output ranges from $320 billion to $1.33 trillion, in 2009 U.S. dollars; and contributions to gross domestic product (GDP) range from $148 billion to $591 billion, in 2009 U.S. dollars. Estimates of the total number of person years of employment supported by U.S. universities' and hospitals' and research institutes' licensed-product sales range from 1.268 million to over 4.272 million over the 20-year period. An explanation of the I-O approach is provided, and the assumptions used and the potential effects of the assumptions on the estimates are discussed. AUTM associated contributions to GDP, calculated using the I-O approach, are compared with U.S. GDP as a whole, and to selected industry, as defined by North American Industry Classification System (NAICS) codes, contributions to GDP. Factors affecting the AUTM contributions to GDP appear to differ from those affecting U.S. GDP as a whole, as well as from those affecting selected NAICS industry contributions to GDP.

Introduction and Background:

This June 2017 report, on measures of economic impact of U.S. academic licensing activity, is the third update of a 2009 report[1] and model developed and described[2] by David Roessner, Jennifer Bond, Sumiye Okubo, and Mark Planting for estimating the economic impact of U.S. academic licensing activity. There were also 2015[3] and 2012[4] updates. As in the previous reports, the Leontief input-output "I-O" coefficients[5] are used to estimate i) gross industry output (GO), ii) effects on GDP and iii) person- years of employment supported by academic licensing. Of note, the way the US Bureau of Economic Analysis (BEA) calculated certain input-output coefficients changed in 2014 to better account for the economic effects of research and development (R&D) expenditures. R&D now is treated as investment, creating products for future use rather than current consumption, recognizing that it often provides output and benefits long into the future. This change was reflected, though not highlighted per se in the 2015 report. As in the previous reports, license income data provided by AUTM, in particular License Income Received and Running Royalties[6], are two key inputs.

The report has evolved since its first implementation in 2009, as summarized in Table A below. The 2012 report included AUTM member Hospitals and Research Institutes "HRI's", and included jobs supported by the licensee's sales. The 2015 report was the first report shown in 2009 dollars, and used updated, and increased BEA value added ratios. The 2015 update better reflected the contribution of research expenditures to the U.S. economy, including their contributions

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[1] "The Economic Impact of Licensed Commercialized Inventions Originating in University Research" 1996-2007, September 3, 2009, by David Roessner, Jennifer Bond, Sumiye Okubo, Mark Planting, http://www.bio.org/sites/default/files/BIO_final_report_9_3_09_rev_2_0.pdf accessed June 4, 2017

[2] David Roessner, Jennifer Bond, Sumiye Okubo, Mark Planting, "The Economic Impact of Licensed Commercialized Inventions Originating in University Research" Research Policy, May 26, 2012. 10.1016/j.respol.2012.04.015 .

[3] The Economic Contribution of University/Nonprofit Inventions in the United States: 1996-2013, Prepared for the Biotechnology Industry Organization March 2015 by Lori Pressman, David Roessner, Jennifer Bond, Sumiye Okubo and Mark Planting https://www.bio.org/sites/default/files/files/BIO_2015_Update_of_I-O_Eco_Imp.pdf accessed June 4, 2017

[4] "The Economic Contribution of University/Nonprofit Inventions in the United States: 1996-2010" June 20, 2012, by Lori Pressman, David Roessner, Jennifer Bond, Sumiye Okubo, and Mark Planting, https://www.bio.org/sites/default/files/BIOEconomicImpact2012June20.pdf accessed June 4, 2017

[5] The Nobel Prize was awarded to Wassily Leontief in 1973 "for the development of the input-output method and for its application to important economic problems." http://www.nobelprize.org/nobel_prizes/economics/laureates/1973/press.html

[6] See the 2015 AUTM Survey Instructions and Definitions http://www.autmsurvey.org/id_2015.pdf , and the Glossary of this report for the formal definitions of "License Income Received" and "Running Royalties". License Income Received includes Running Royalties in addition to other license related payments, such as e.g. license issue fees, not tied directly to sale of products.

to growth and productivity similar to other capital goods[7]. This change in the treatment of R&D expenditures is the subject of an upcoming white paper by Carol Moylan and Sumiye Okubo.[8] A fall edition of the 2017 report is planned which will show the results of changing certain assumptions , including that i) the licensee's sales and production is entirely domestic, ii) no sales are final sales, and iii) that the licensees fall entirely within the NAICS codes of industry classes 31-33 "manufacturing".

Table A below summarizes the evolution of these changes. Changes from the prior report are highlighted.

Table A: Evolution of Application of Input Output Model to AUTM License Data

	2009 Report	2012 Report	2013 Research Policy Paper	2015 Report	June 2017 Report	Fall 2017 Report
Years of AUTM Data	1996-2007	1996-2010	1996-2010	1996-2013	1996-2015	1996-2015
Licensees of both HRI's & universities	No	**Yes**	No	Yes	Yes	Yes
Jobs supported by licensee's sales are included in jobs estimate	No	**Yes**	No	Yes	Yes	Yes
Updated BEA value added ratios	No	No	No	**Yes**	Yes	Yes
Base Year for inflation adjusted dollars	2005	2005	2005	**2009**	2009	2009
The licensees' production of Running Royalty generating commodities occurs entirely in the U.S.	Yes	Yes	Yes	Yes	Yes	**Some production is outside the U.S.**
None of the licensees' sales are final sales.	Yes	Yes	Yes	Yes	Yes	**Some sales are final sales**
All of the intermediate inputs to Gross Output are domestic.	Yes	Yes	Yes	Yes	Yes	**Not all intermediate inputs are domestic.**
All licensees are in a subgroup (chemical products (325), plastics and rubber (326), nonmetallic minerals (327), fabricated metals (332), computer and electronics (334), electrical equipment, appliances and components (335), other transportation equipment (3364OT), miscellaneous manufacturing and machinery (339)) of industry classes 31-33: "Manufacturing."	Yes	Yes	Yes	Yes	Yes	**Some licensees are in industry classes 511, 514, 5415, associated with publishing, software and computer systems design and services.**
The deflator is for the U.S. economy as a whole, and not industry specific	U.S. as a whole	U.S. as a whole	U.S. as a whole	U.S. as a whole	U.S. as a whole	**Considered effects of an industry specific deflator**

[7] See R&D in the National Income and Product Accounts: A First Look at Its Effect on GDP, Barbara M. Fraumeni, Sumiye Okubo, August 2005, and Measuring R&D in the National Economic Accounting System, November 2014 by Marissa J. Crawford, Jennifer Lee, John E. Jankowski, and Francisco A. Morris.
[8] 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 non-profits and by general government was reclassified from consumption to investment.

Supplementary Table S-1 displays the 2009, 2012, 2015 and these June 2017 figures for GO, GDP and employment, with notes showing how the application of the I-O model has changed. In 2009, for example, only Universities were included in the calculation, inflation-adjusted estimates were prepared in 2005 dollars, and employment to output multipliers were not applied to the licensees' sales. In 2012, Hospitals and Research Institutes were added to the calculation, and employment to output multipliers were applied to licensees' sales. In 2014, the value-added ratios, which are used to calculate GDP, changed, primarily reflecting the change in the BEA treatment of R&D expenditures. This change, as well as the change to 2009 dollars, resulted in the significant increase in the 2015 values. Supplementary Table S-2 and the accompanying supplementary figure 1 show, and illustrate, respectively, the change in value-added ratios.

Because the main difference of the June 2017 relative to the 2015 report is the addition of two more years, with the other inputs to the calculation, as shown above, remaining essentially constant, it is reasonable to look at a percent increase between the years. The last row of Supplementary table S-1 shows that cumulative GDP, GO and the employment estimates increased by 14%, 14% and 12%, respectively.

Inclusion of Hospitals and Research Institutes that Respond to the AUTM Survey:

In 2001, the NSF issued a Data Brief highlighting the role of nonprofit research organizations[9] as performers of U.S. R&D.[10] The Data Brief lists the "Top 10 nonprofit organization respondents by amount of intramural R&D expenditures, fiscal years 1996-1997" by name.[11] AUTM hospital and research institutes (HRI) respondents include five, and six, respectively of the top ten for 1996,[12] and 1997.[13] A long term trend, seen in Figure 1, is that other nonprofits, as well as universities, are performing a larger share of total U.S. R&D. From 1953-2013, U.S. R&D performed by universities and colleges grew from 5.3% to 14.2% of total U.S. R&D, while the fraction of R&D performed by other nonprofits grew from 2.2% to 4.1 %.[14] From 1996-2013, the period of this economic impact analysis, data available show that U.S. R&D performed at colleges and universities rose from 12.0 % to 14.2% of U.S R&D, and that research performed at other nonprofits rose from 3.1% to 4.1% of U.S. R&D. The overall historical trend notwithstanding, R&D expenditures at Universities, Colleges and Other Nonprofits have fluctuated, as seen qualitatively in Figure 1.

[9] Nonprofit organizations other than universities and federal laboratories

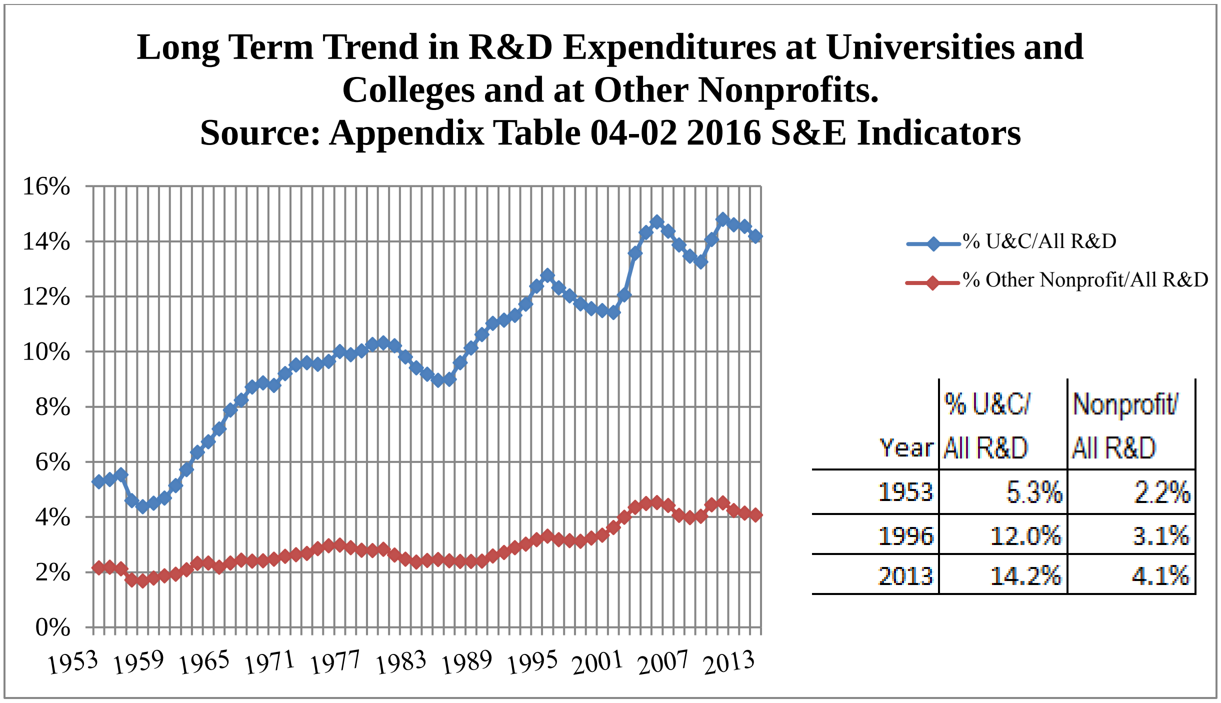
[10] See NSF 01-318, February 15, 2001 by Mary V. Burke "Nonprofit Sector's R&D Grows over Past Quarter Century." https://www.nsf.gov/statistics/databrf/sdb01318.htm Accessed June 5, 2017

[11] Howard Hughes Medical Institute, Mayo Foundation, SRI International, Memorial Sloan Kettering, Research Triangle Institute, Fred Hutchinson Cancer Research Center , SEMATECH, Inc., Dana-Farber Cancer Institute, Brigham and Women's Hospital, Beth Israel Deaconess Medical Center, Inc.

[12] Mayo, SRI, Sloan Kettering, Fred Hutchinson, and Brigham and Women's Hospital

[13] Mayo, Sloan Kettering, Fred Hutchinson, Dana-Farber Cancer Institute, and Brigham and Women's Hospital, Beth Israel Deaconess Medical Center, Inc,

[14] See Appendix Tables 04-02 and 04-03 of the 2016 Science & Engineering Indicators.



Year	% U&C/ All R&D	Nonprofit/ All R&D
1953	5.3%	2.2%
1996	12.0%	3.1%
2013	14.2%	4.1%

Figure 1.

Another factor contributing to the decision to apply the model to Hospitals and Research Institutes is evidence suggesting that the character of the work performed at such institutes is similar to that done at universities and colleges. Figure 2 shows that both Universities and Colleges and Other Nonprofits perform substantially more Basic Research[15] than either business or the federal government. S&E data show that between 1996 and 2013, about two thirds of research expenditures at universities were characterized as Basic Research, reasonably similar to the roughly half of research expenditures at other nonprofit research institutes characterized as Basic Research, and in contrast to the five to six percent of research expenditures in the private sector characterized as Basic Research.[16] Another consideration is that Hospitals and Research Institute AUTM Survey respondents often have close ties to University AUTM Survey respondents and share personnel.[17]

[15] As defined in the Science and Engineering Indicator Glossary https://www.nsf.gov/statistics/2016/nsb20161/#/report/chapter-4/glossary , and excerpted as a convenience in the Glossary and Definition section at the end of this report.

[16] See Appendix Tables 04-02 and 04-03 of the 2016 Science & Engineering Indicators.

[17] For example, all investigators at the Whitehead Institute, which responds to the AUTM survey in the "HRI" category, hold joint appointments in the MIT Department of Biology. Many investigators at the Fred Hutchinson Cancer Research Center, another Hospital and Research Institute which responds to the AUTM survey hold a joint appointment at the University of Washington.

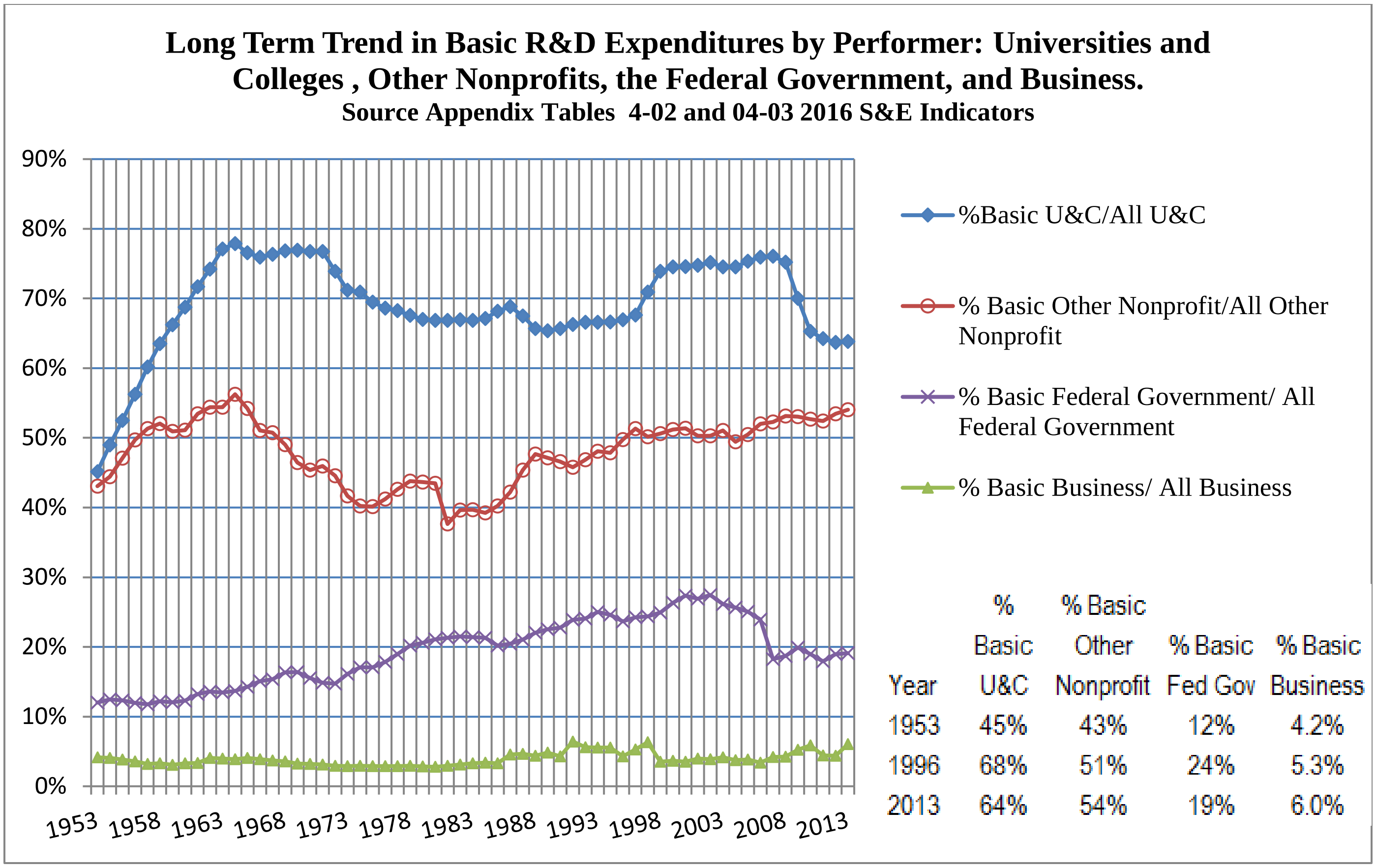


Figure 2.

License Income Received from HRI AUTM Survey respondents over the 20 year period of this report totals $8.33 billion in current dollars, approximately 29% of the $28.61 in current dollars reported by university respondents[18]. Running Royalties reported by HRI AUTM Survey respondents over the 20 year period total $4.79 billion in current dollars, approximately 24% of the $19.66B in current dollars reported by university respondents.[19]

Twenty-six HRI's have responded to the survey in each of 15 years between 1996 and 2010; 28, 32, 30, 26 and 31 responded in 2011, 2012, 2013, 2014, and 2015.respectively. Between 131 to 164 universities responded between 1996 and 2015, and 153-164 between 2002 and 2015. Thus, among institutions that chose to respond to the AUTM Survey, Hospitals and Research Institutions reported, on average, and on a per institution basis, more License Income Received and Running Royalties than universities do.[20] Note that including HRI's also makes this report more heavily weighted toward the economic impact of health technologies, and could introduce a bias toward life science and health technology economic impact.

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[18] License Income Received from HRI AUTM respondents over the 20 year period is also approximately 29% of the License Income Received from University AUTM respondents over the 20 year period in 2009 $. ($8.58 B 2009 $)/($29.71B 2009$) = 29%

[19] Running Royalties reported by HRI AUTM respondents over the 20 year period is also approximately 24% of the Running Royalties reported by University AUTM respondents over the 20 year period in 2009 $. ($4.95 B 2009 $)/($20.42 B 2009$) = 24%

[20] $8.33B /30~ $278M, versus $28.61B/150~$191M. Current, not 2009 U.S. dollars were used for this estimate.

Brief Background on Economic Models Based on the National Input-Output Accounts:

This section provides definitions and concepts underlying the I-O framework[21] to facilitate understanding the assumptions used when applying it to model the economic impact of academic technology licensing. Several paragraphs and sentences, but not all paragraphs and sentences, in this section are taken verbatim from the above noted references. As always, the primary source is the preferred reference.

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

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

The largest single source of U.S. I-O data is the Economic Census, which is conducted once every 5 years by the U.S. Bureau of the Census. The models start with two basic tables, the "make" and "use" table. A make table shows the value of each I-O commodity produced by each industry in a given year. Before such tables can be produced, classifications are needed for "commodities" and "industries."

For the I-O accounts, BEA uses a classification system that is based on the North American Industry Classification System (NAICS). The I-O classification system is consistent with that used by the principal agencies that provide the source data used in the I-O accounts and by the preparers of the national accounts and other economic series that are used for analysis in conjunction with the I-O accounts. In I-O accounting, each industry is associated with a commodity that is considered the primary product of that industry. The 20 major sectors and their two-digit NAICS codes are found in Table S-3.

The coefficients used in this report assume that license income for academic licensors, both universities and HRI's, is in sector 61 "Educational Services," and that the outputs of the technology licensees are in a subgroup of sectors 31-33 "Manufacturing." The subgroups are: chemical products (325), plastics and rubber products (326), nonmetallic mineral products, (327), fabricated metal products (332), machinery (333), computer and electronic products (334), electrical equipment appliances and components (335), other transportation equipment (3364OT), and miscellaneous manufacturing (339).

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[22], and the "use by final users" would be understood in everyday parlance as the sum of purchases

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[21] See BEA (Bureau of Economic Analysis, U.S. Department of Commerce) BRIEFING: A Primer on BEA's Industry Accounts , accessible at http://www.bea.gov/scb/pdf/2009/06%20June/0609_indyaccts_primer_a.pdf : By Mary L. Streitwieser "Concepts and Methods of the Input-Output Accounts," accessible at http://www.bea.gov/papers/pdf/IOmanual_092906.pdf : By Karen J. Horowitz and Mark A. Planting. Chapter 12 discusses Input-Output modeling and applications.

[22] 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.

by persons and by government, business investment, and exports less imports.[23] For the economy as a whole, the total of all final uses of commodities equals the sum of all value added by all industries, or GDP.

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

Table B. The Use of Commodities by Industries, 2007 [Millions of Dollars]

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

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

Note that "total value added" is a measure of the value of factors of production – in textbook economics, land, labor and capital. It is not the same as profit. It includes compensation of employees, taxes on production and imports minus subsidies, and gross operating surplus. This surplus can be used, in the case of industries, to build more capacity, to pay shareholders or owners, for income taxes, or for their own R&D. By definition, this study assumes that all academic license income contributes to GDP. Within the national accounts, all of the output of nonprofits is consumed by persons, and thus is part of GDP.[24] The output of nonprofits is measured as total expenses of the nonprofits. Finally, in this study we assume that the license income revenues are used to fund expenses and all of the revenue adds to output of nonprofits.

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

[23] 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.
[24] In measuring GDP, "persons" include both households and nonprofit institutions serving households.

can be used to show the inputs required by an industry to produce a given output. When only the direct requirements are considered (the inputs needed to produce the inputs are not included), the table is called a "direct requirement" table. When all inputs needed to make the inputs are considered, then the table is called the "total requirements table." The total requirements table accounts for all interactions required by industries to support a given level of final demand. Note that output multipliers can only be used when final demand is known.

Thus, an output multiplier *is* applied to license income received at the academic licensors, since all of their output is consumed by persons, and thus considered, by definition, final demand. In contrast, since there is no information on the fraction of sales of the licensees which is purchased by final users, and thus satisfies a final demand, *no* output multiplier on their sales is applied.

Assumptions used in Applying the I-O Model to Measurements of Economic Impact of U.S. Academic Licensing: See also Appendix A:

General:
i) The academic licensors are in industry class "61," educational services, and their licensees are in a subgroup[25] of industry classes 31-33: "Manufacturing."
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 2009 dollars.
iii) Sales of the licensee's products are estimated using the AUTM reported Running Royalties (earned royalties on product sales) divided by an assumed royalty rate.
iv) All relevant sales are captured by the royalty base.

For the GDP Calculation:
i) 100% of academic institution expenditures contribute to GDP.
ii) 100% of licensee's sales are by domestic producers.

For the Gross Output Calculation:
i) The license revenue (income) received by U.S. academic licensors is all spent in the U.S., and is treated as consumption expenditures. The effect of this revenue on gross output is increased by one iteration of purchases of intermediate inputs, so called "direct requirements."
ii) 100% of licensees' sales are by domestic producers and 100% of the intermediate inputs for this production are also domestic.
iii) Since the fraction of the licensee's sales that are final sales is unknown, no output multipliers are applied. Gross output is simply total licensees' sales.
iv) Though sponsored research to the academic licensors is a result of licensing activity, some licenses include an obligation to fund research as a condition of keeping the license. Since there are no systematic data, it is omitted entirely.

[25] The subgroups are: chemical products, plastics and rubber, nonmetallic minerals, fabricated metals, computer and electronics, electrical equipment, transportation equipment, miscellaneous manufacturing and machinery

The Economic Impact Model using AUTM Data and I-O Coefficients:

GDP:

A: A portion associated with the License Income Received at academic licensors	+	B: A portion associated with the business activity associated with the technology license at the licensees

A_{GDP} = (Licensing Income Received in 2009 dollars) = (Licensing Income Received)[26] / (Price index for GDP, index numbers, 2009 =1.00)[27]

B_{GDP} = ((sales at licensee[28]) x (value-added ratio from U.S. I-0 tables)) / (Price index for GDP, index numbers, 2009 =1.00)

Gross Industry Output:

A: A portion associated with the License Income Received at academic licensors	+	B: A portion associated with the business activity associated with the technology license at the licensees

A_{GO} is made up of two parts, and = $A1_{go}$ + $A2_{go}$
$A1_{GO}$: the effect of the License Income Received at the academic licensor, and $A2_{go}$: the effect outside the licensor when the licensor spends that income.

$A1_{GO}$ = (Licensing Income Received) / (Price index for GDP, index numbers, 2009 =1.00)
$A2_{GO}$ = ((Licensing Income Received in current U.S. dollars) × (output multiplier from U.S. I-O tables)[29]) / Price index for GDP, index numbers, 2009 =1.00)

B_{GO} = (sales at licensee[30])

Employment Supported by Final Purchases Associated with Academic Licensing:

A: A portion associated with the License Income Received at academic licensors	+	B: A portion associated with the business activity associated with the technology license at the licensees

A_{YES} = (employment multiplier for academic licensors) x (current License Income Received)

B_{YES} = (employment to output ratio for manufacturing companies) x (sales at licensee)

[26] License Income Received (as reported in the AUTM Survey). 2015 AUTM Survey Definitions are available here: http://www.autmsurvey.org/id_2015.pdf (accessed June 3, 2017)
[27] The multipliers are applied to current dollar license income. The result is adjusted to 2009 U.S.dollars
[28] (Running Royalties as reported in the AUTM Survey) ÷ (royalty rate)
[29] See Appendix B
[30] (Running Royalties as reported in the AUTM Survey) ÷ (royalty rate)

Comments on Assumptions and Caveats on Accuracy of Estimates:

This report assumes that all of the licensees' sales are commodities produced by domestic producers, and that all intermediate inputs are also domestically produced. These assumptions, in isolation, lead to overestimates; imports are not taken into account.

This report assumes that all sales result from manufacturing activity. To the extent that some important academic licensees are in the service business (Google, for example) this assumption, in isolation could lead to either an over or an underestimate, as value-added ratios, and thus GDP and the output to employment multiplier, and thus the jobs estimate, can be affected differently.

Because the fraction of licensees' sales that are final sales is unknown, this model applies no output multiplier to any portion of these sales. This leads to an underestimate.

Not all licenses contain royalty terms. The license exhibit Google filed with its S-1, for example, contains an equity provision for Stanford, but no apparent running royalty. This phenomenon means that using Running Royalties in isolation, even with an accurate royalty rate, underestimates licensees' sales. Some licenses contain royalties on products, but not on services. [31] Royalty offsets and combination product language[32] through reducing the royalty base, contribute to an effective royalty rate lower than the one apparently specified in the license contract. These factors suggest that estimating licensees' sales by using (Running Royalties as reported in the AUTM Survey) ÷ (an assumed royalty rate) may underestimate licensees' relevant sales, and thus GDP, gross output, and employment.

Patent reimbursement is reported separately from License Income in the AUTM Survey. Review of the data shows patent reimbursement is about 5% of total license income. Adding patent reimbursement would thus increase economic impact estimates, but modestly. License Income Paid to Other Institutions was also not considered and appears also to be roughly 5% of total license income. However, until recently "License Income Paid to Other Institutions" was included in License Income paid to any institution, even one which did not respond to the AUTM Survey. Thus, it is not clear that removing it removes only double counting. Including "License Income Paid to Other Institutions" would subtract from economic impact estimates. These two omissions likely off set each other, and are likely not as large a factor in the accuracy of the overall estimate as other assumptions listed in Appendix A.

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.

Companies highlight their new products, and sometimes they depend on such "substitution" to ensure growth. Frederick J. Palensky, 3M's chief technology officer, was interviewed in the January 9, 2012 Chemical & Engineering News: "New products—five years old or less—accounted for 31% of sales in 2010, and when 2011's new products are included in the tally, they are likely to account for 33% of sales, Palensky says. 3M's goal is for new products to reach 40% of sales. The company's businesses won't grow at all if new product sales don't reach at least 25%, he says, so a high-functioning R&D organization is critical for survival." Since economies grow through renewal and replacement, to assure growth, renewal and replacement must exceed loss. The caveat on product substitution is written as assuming "no detrimental product substitution effects."

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[31] http://www.sec.gov/Archives/edgar/data/1110803/0001012870-00-001863.txt accessed June 5, 2017

[32] https://www.sec.gov/Archives/edgar/data/1424740/000095013508002207/b68098btexv10w1.htm accessed June 5, 2017

Updated Public Information on AUTM Member Royalty Rates:

The model is clearly dependent on the assumed royalty rate. Licensors may be expected to voluntarily publicize higher rates than licensees, and both can be true depending on how the royalty base is defined. The 2009, 2012, and 2015 reports and 2012 Research Policy paper[33] included this table:

Table C: Royalty Rates Used by Selected U.S. Research Universities

University	Life Sciences	Software	Other	Overall
A	4-6%	10-20%	0.5-3%	
B	10%+		.25%	Processes 1-3% composition of matter 4-6%
C				2-3%
D	Devices 5% Therapeutics 1-2%			
E	Devices 4-5% Therapeutics 1-2%	“higher”		
F				8% (health plus IT)
G	4%			3-4% (mostly medical devices)
H				4-5% (mostly life sciences)
I				1-2%
J				About 5%
K				4.4%
L				5-8%

Yet, the AUTM survey reported an average royalty rate of 17% in FY2011 and 1.8% in FY2012.[34] These rates were calculated by asking respondents to report the product sales their licensees provided in royalty reports to AUTM member licensors and the earned royalties AUTM members received[35]:

> “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.”

Table C and the FY2012 AUTM Survey numbers may be internally consistent when combined with royalty offsets and debundling provisions described above, examples of which can be found in template AUTM member license agreements and in numerically, but not structurally, redacted SEC filings.

[33] To develop information about “typical” royalty rates charged by universities on which to base our impact estimates, we enlisted the aid of a number of individual university technology transfer officers from various regions of the country, and current and former members of the AUTM Public Policy Committee. With their help, we obtained royalty rate information from 12 research universities representing a range of sizes, types (public and private), and geo-graphic locations. The following Table 1 summarizes the results of this effort.
[34] Page 40 FY2012 AUTM Survey
[35] 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.

AUTM Data, I-O Coefficients, and Results:

The AUTM respondent data and I-O coefficients are in Appendix B. The GDP, Employment and Gross Output calculations for University AUTM Survey respondents and Hospital and Research Institute AUTM Survey respondents are in Appendices C and D, respectively. Appendix E is a sum of the impacts estimated in Appendices C and D[36].

Since the royalty rate is clearly a key input, the calculations were run for three assumed royalties; 2%, 5%, and 10%. The assumptions that i) all sales are made by domestic producers[37] , ii) the royalty base captures all the relevant sales of the academic licensees, iii) none of the licensees' sales are to final users, iv) the intermediate inputs to the licensees' sales are all produced domestically, and v) all of the licensee's sales are from manufacturing industries captured by NAICS codes 31-33, and not from other sectors, are likely the next largest unknowns which affect the estimates.

Appendix A shows how these and other assumptions affect the estimates, in some cases, leading to overestimates, and in an equal number of cases, leading to underestimates.

Assumptions on whether new products i) displace, and remove from the U.S. economy products which would have been sold absent the new product, or ii) replace existing products , and keep products in the U.S. economy which would otherwise have been lost had not the new product been available to replace a soon-to-be-obsolete product, clearly influence these estimates. Whatever the assumptions on displacement versus replacement, it is known that royalty generating products will evolve away from reportability and visibility under AUTM licenses, as i) market changes remove demand, or ii) the product changes technically so it no longer reads on the licensed intellectual property, or finally, iii) the patent expires.

Since not all sales are captured in the royalty base thereby effectively lowers the royalty rate, and since licensors naturally report higher rates than licensees, estimates at the lower end of the range (2%) are likely more realistic, especially on a weighted average basis.

Summing over the 20 years of available data for academic U.S. AUTM Survey respondents, both U.S. universities and hospitals and research institutes, assuming no detrimental product substitution effects, and all the assumptions listed in Appendix A, then for royalty rates ranging from 2% to 10%, and due to the fact that the impacts are inversely proportional to the estimated average royalty rate; the total contribution of this academic licensing, to gross industry output ranges from $1.33T to $320B in 2009 U.S. dollars and to GDP it ranges from $591B to $148B in 2009 U.S. dollars. Estimates of the total number of person years of employment supported by U.S. universities' and hospitals' and research institutes' licensed-product sales range from 4,272,000 to 1,268,000 over the 20 year period.

[36] The data are calculated to many more significant places than shown in the Appendix Tables. For example, employment supported by University licensing activities from 1996-2013 for a 2% royalty rate is calculated as 3,058,413 jobs. This explains why summing the data in the U table and the HRI table is not always exactly equal to the U+HRI Table.

[37] If all producers are domestic then all sales are domestic even if the buyer takes delivery overseas.

Trends and Observations:

Figure 3 below (data are in Tables S-4 and S-5) shows the normalized, relative to itself in 199***7*,** i) I-O model calculated AUTM respondent contribution to GDP, ii) increase in U.S. GDP for the industry sectors identified by NAICS codes used as the basis of the I-O coefficients in Appendix B[38], and iii) the increase in U.S. GDP as a whole.

Figure 3 suggests that factors different in kind, strength or timing from those that influence U.S. GDP influence AUTM respondent contributions to GDP. Over the twenty-year period, the selected NAICS sectors' contribution to GDP increased by 83%, U.S. GDP as a whole by 55% and AUTM respondents' I-O calculated contributions to GDP increased by a factor of 3.4.Note however, that the absolute I-O calculated AUTM respondent contribution to U.S. GDP is very small. In 1996, it would be roughly a tenth of one percent ($10.8B, assuming a 2% royalty rate, out of $10.6T), and in 2015 a little more than two tenths of a percent ($36.7B, assuming a 2% royalty rate, out of $16.4T).

Selected GDP Trends 1996-2015, Comparison of Normalized: i) US GDP, ii) Industry Specific (selected manufacturing and educational services) contribution to GDP and iii) I-O Model Calculated AUTM Respondent Contribution to US GDP

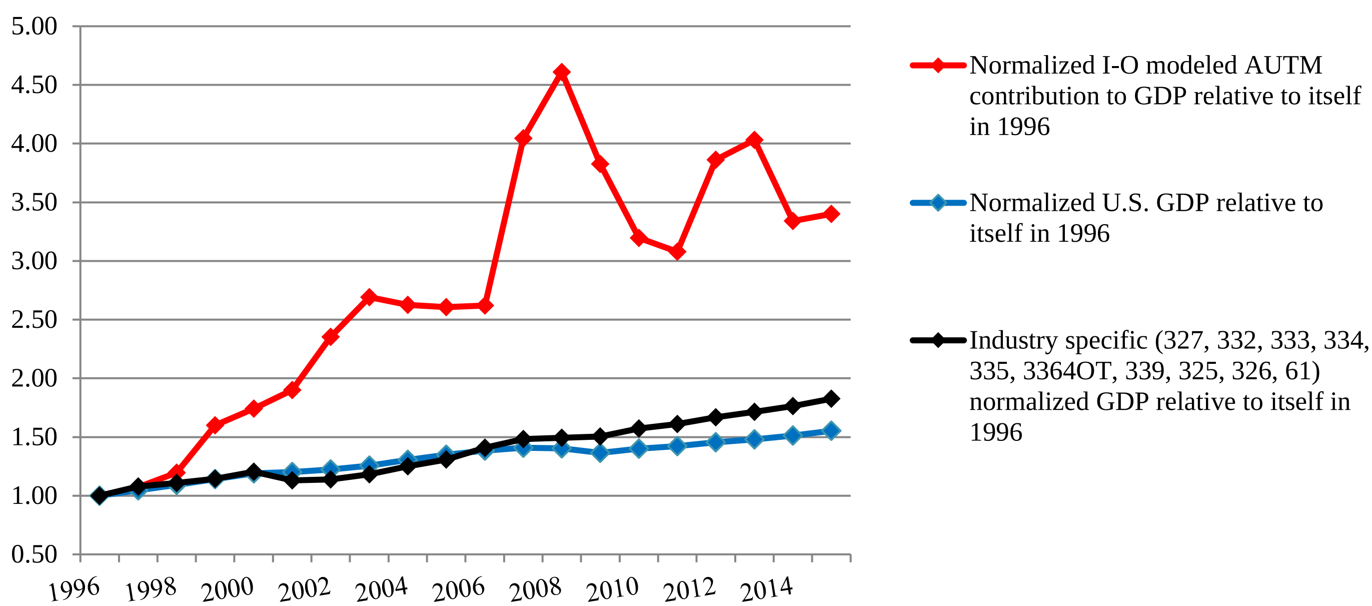

Figure 3.

The comparisons in Figure 3 above suggest that from 1996-2015, factors different in kind, strength or timing from those that influence this selected portion of U.S. GDP influence I-O calculated AUTM respondent contributions to U.S. GDP .

[38] 325 (chemical products), 326 (plastics and rubber products, 327 (nonmetallic mineral products), 332 (fabricated metal products), 333 (machinery), 334 (computer and electronic products), 335 (electrical equipment, appliances, and components), 2264OT (other transportation equipment) 339 (miscellaneous manufacturing), and 61 (educational services).

AUTM tracks many measures of academic licensing activity, including total research expenditures "TOTEXP", new licenses executed "LICEXEC", cumulative total of active licenses "ACTLIC", cumulative total of licenses generating license income "LIGNLI", and cumulative total of licenses generating running royalties "LCGNRR", as well as license income received in a given year "LIRECD" and total running royalties received in a given year "LIRUNR". (LIRECD and LIRUNR are shown in Appendix B, separately for U.S. Universities and Hospitals and Research Institutes). Data on the cumulative number of licenses generating running royalties "LCGNRR" are available only starting in 1999.

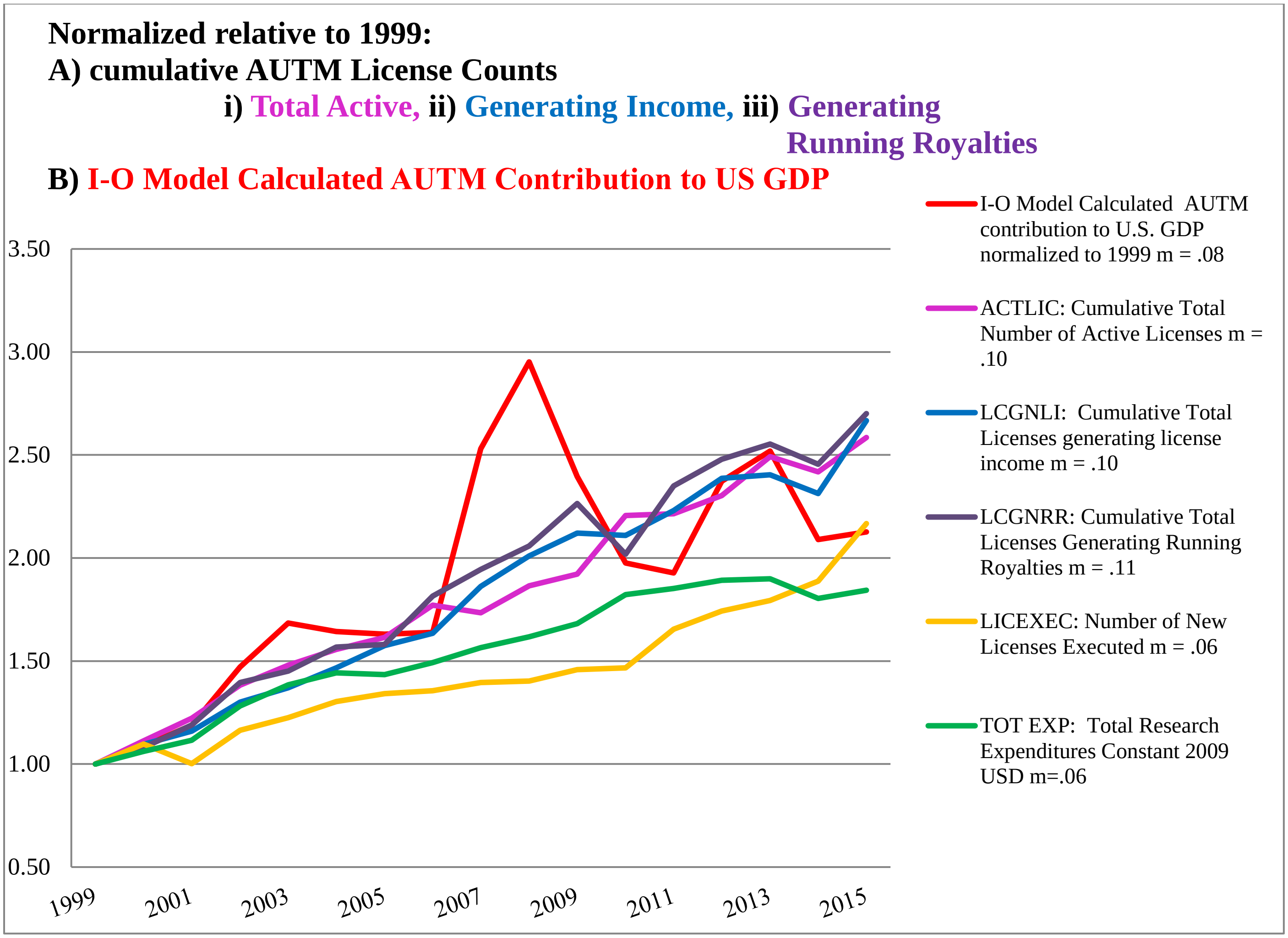

Figure 4.

Figure 4 (data are in Table S-6), above, shows the normalized I-O model derived AUTM respondent contribution to GDP of figure 4 compared with the normalized growth in various AUTM metrics from 1999-2015. Data Table S-6 also provides a slope and correlation coefficient for a linear curve fit, not shown, to the 17 years of normalized data, and displays the actual as well as the normalized data values.

It is interesting to observe, by eye and by calculated slope and correlation coefficients that cumulative active license agreements and cumulative license agreements generating running royalties appear to track with a best fit line to I-O calculated AUTM respondent U.S. GDP contributions. Perhaps because they are by definition cumulative, and thus time averaged, they appear to track more consistently than the single year metrics, such as the number of New Licenses

Executed "LICEXEC" in a given year, or Total Research Expenditures "TOTEXP" in a given year. Sales today are associated with earlier license agreements and even earlier research.

The cumulative license agreement numbers are the result of an inflow and outflow of active license agreements and the subset of active license agreements generating running royalties. Agreements are added as new licenses are signed, or new products start to generate running royalties. Agreements are subtracted as licenses terminate or end for any number of reasons, from i) a discovery that there is no or an inadequate market for the anticipated product, to ii) the product evolving away technically from the patent claims, to iii) patent expiration.

By definition, royalties payable when a product reads on a patent claim end upon patent expiration. Thus, AUTM respondent running royalties are associated with newer or younger products or newer or younger parts of products than U.S. products as a whole. These data support the proposition that new products sustain growth.

For the time period 1999-2015, these data indicate a net addition of active license agreements and license agreements associated with running royalties. It will be interesting to watch these trends as academic licensing continues to mature, patent life is effectively shortened in a now 20-year post GATT world, patent laws continue to evolve, and data and databases, both public and private, play an increasing role in society and the economy.

Appendix A: Assumptions and their Effects

Assumption	Effect of Assumption: + means results in an over estimate relative to the estimates in this report – means results in an under estimate relative to the estimate in this report	Future Work **Updates planned later in 2017**
Relevant sales = (Running Royalties) ÷ royalty rate	+ or - Total impact is a function of royalty rate - Since not all sales generate Running Royalties, this assumption leads to an underestimate. Impact overall would increase if this could be adjusted accurately.	Acquire data Ongoing
The licensees' production of Running Royalty generating commodities occurs entirely in the U.S.	+ Impact overall would decrease.	Model the effect of changing this assumption. **Yes**
None of the licensees' sales are final sales.	- Gross output: If a fraction of the licensees' sales are final sales, then it is appropriate to apply an output multiplier to that fraction, thus increasing the gross output estimate. - Employment: If gross output increases, then employment Increases.	Model the effect of changing this assumption. **Yes**
All of the intermediate inputs to gross output are domestic.	+ Gross output: If a fraction of the intermediate inputs to production are not domestically produced, then gross output should be reduced. + Employment: If gross output is reduced, then Employment is reduced	Model the effect of changing this assumption. **Yes**
All licensees are in a subgroup (chemical products (325), plastics and rubber (326), nonmetallic minerals (327), fabricated metals (332), computer and electronics (334), electrical equipment, appliances and components (335), other transportation equipment (3364OT), miscellaneous manufacturing and machinery (339)) of industry classes 31-33: "Manufacturing."	- GDP: value added ratios are generally higher for service providers than for manufacturers, so the GDP estimate would increase. -Employment: Employment multipliers are generally higher for service providers than for manufacturers, so the employment estimate would increase. + Gross output: The output multipliers for service providers are generally lower than for manufacturers, however in this June 2017 report, they are applied only to license income to the AUTM Survey respondents, and thus any effect is small.	Model the effect of changing this assumption. **Yes** **Include: Publishing industries, except internet (includes software) (511), Data processing, internet publishing, and other information services (514), Computer systems design and related services (5415).**
The economy-wide GDP deflator is appropriate for the selected industries	+ if industry-specific deflators increase more slowly than the GDP deflator - if industry- specific deflators increase faster than the GDP deflator	**Evaluated in the fall 2017 report**
Sponsored research to the academic licensor associated with the license = 0	- Impact would increase. The assumption was forced, as there are no reliable data	Acquire data
Substitution effects	+ To the extent a new product actually displaces a current product, unaccounted for substitution effect will result in an overestimate. To the extent it keeps in the U.S. economy activity which would otherwise have been lost, then not a factor	Case by case considerations
Impact ends when Running Royalty payments end.	- Likely results in an underestimate of impact.	Studies of product lifetimes, relative to license duration.
No Patent Reimbursement and no License Income Paid to Other Institutions	Likely cancel each other out	Look at in more detail

Appendix B: AUTM Data and I-O Multipliers

Source of data	AUTM	AUTM	AUTM	AUTM	BEA I-O tables	BEA I-O tables	BEA I-O tables	BEA I-O tables	BEA
Year	Current Dollar University Total License Income	Current Dollar University Running Royalties	Current Dollar HRI License Income	Current Dollar HRI Running Royalties	Value added ratio for selected industries[39]	Output multiplier for Total License Income) [40]	Employment to output ratio for Academic Institutions[41]	Employment to output ratio for Manufacturers (Licensees) [42]	Price index for GDP, 2009=100
1996	$365	$282	$135	$84	0.43	0.73	0.020	0.0046	76.767
1997	$483	$315	$129	$81	0.43	0.73	0.020	0.0046	78.088
1998	$614	$390	$113	$60	0.42	0.76	0.020	0.0046	78.935
1999	$675	$475	$152	$139	0.42	0.77	0.019	0.0045	80.065
2000	$1,100	$559	$132	$111	0.42	0.81	0.018	0.0043	81.89
2001	$868	$637	$171	$131	0.42	0.81	0.018	0.0044	83.755
2002	$998	$787	$259	$151	0.43	0.76	0.017	0.0041	85.04
2003	$1,032	$829	$314	$249	0.44	0.74	0.016	0.0039	86.735
2004	$1,088	$810	$346	$277	0.44	0.69	0.016	0.0036	89.118
2005	$1,775	$856	$346	$278	0.42	0.74	0.015	0.0033	91.985
2006	$1,512	$969	$653	$198	0.42	0.75	0.015	0.0031	94.812
2007	$2,099	$1,807	$576	$125	0.41	0.75	0.014	0.0029	97.34
2008	$2,397	$1,946	$1,037	$351	0.41	0.77	0.013	0.0028	99.218
2009	$1,782	$1,351	$525	$257	0.48	0.68	0.013	0.0029	100
2010	$1,790	$1,092	$587	$276	0.47	0.74	0.012	0.0027	101.226
2011	$1,814	$1,097	$620	$333	0.45	0.76	0.012	0.0025	103.315
2012	$1,955	$1,306	$638	$555	0.43	0.73	0.012	0.0024	105.214
2013	$2,090	$1,426	$627	$554	0.44	0.73	0.012	0.0024	106.913
2014	$2,223	$1,358	$460	$294	0.44	0.73	0.012	0.0024	108.828
2015	$1,946	$1,371	$513	$288	0.46	0.70	0.012	0.0024	109.998

[39] This applies to the licensees' sales only. Recall that 100% of license income received by the academic licensors contributes to GDP.
[40] This is applied to the License Income Received by the academic licensors only, and is effectively (1+.71, 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. Gross output = 1 x (licensees' sales)
[41] The number of employees required in all industries to meet the academic institutions' level of final demand.
[42] For manufacturers in the subgroup of manufacturers identified previously.

Appendix C: GDP, Employment and Gross Output Calculations for U.S. University AUTM Survey Respondents

	University Contribution to GDP, 2% Running Royalties	University Contribution to GDP, 5% Running Royalties	University Contribution to GDP, 10 % Running Royalties	University Contribution to Person Years of Employment Supported , 2% Run Royalties	University Contribution to Person Years of Employment Supported, 5% Run Royalties	University Contribution to Person Years of Employment Supported, 10 % Run Royalties	University Contribution to Gross Output, *Output Multiplier = 1*, 2% Run Royalties	University Contribution to Gross Output, *Output Multiplier = 1*, 5% Run Royalties	University Contribution to Gross Output, *Output Multiplier = 1*, 10 % Run Royalties
	2009 Dollars	2009 Dollars	2009 Dollars	Person Yrs of Employment	Person Yrs of Employment	Person Yrs of Employment	2009 Dollars	2009 Dollars	2009 Dollars
Year	Millions	Millions	Millions	Thousands	Thousands	Thousands	Millions	millions	millions
1996	$8,291	$3,602	$2,039	73	33	20	$19,196	$8,172	$4,497
1997	$9,191	$4,047	$2,333	83	39	24	$21,222	$9,130	$5,099
1998	$11,182	$4,939	$2,858	103	48	30	$26,095	$11,261	$6,316
1999	$13,388	$5,862	$3,353	119	55	34	$31,156	$13,357	$7,423
2000	$15,759	$7,110	$4,226	139	68	44	$36,560	$16,083	$9,257
2001	$16,986	$7,417	$4,227	154	71	43	$39,882	$17,081	$9,481
2002	$21,217	$9,191	$5,182	180	82	50	$48,323	$20,568	$11,317
2003	$22,317	$9,641	$5,415	177	81	49	$49,872	$21,190	$11,629
2004	$21,132	$9,185	$5,203	163	75	46	$47,522	$20,250	$11,159
2005	$21,423	$9,727	$5,828	169	83	55	$49,877	$21,961	$12,656
2006	$23,161	$10,221	$5,908	173	82	52	$53,866	$23,219	$13,003
2007	$40,379	$17,445	$9,801	288	133	81	$96,580	$40,890	$22,326
2008	$42,600	$18,490	$10,453	305	141	87	$102,354	$43,510	$23,896
2009	$34,539	$14,885	$8,333	222	102	63	$70,555	$30,018	$16,505
2010	$27,088	$11,896	$6,832	167	80	51	$56,996	$24,641	$13,856
2011	$25,439	$11,229	$6,492	161	77	50	$56,175	$24,323	$13,706
2012	$28,838	$12,650	$7,254	182	87	55	$65,272	$28,038	$15,626
2013	$31,410	$13,737	$7,846	196	93	59	$70,101	$30,073	$16,731
2014	$29,641	$13,082	$7,563	188	91	58	$65,940	$28,492	$16,009
2015	$30,234	$13,155	$7,462	187	88	56	$65,326	$27,940	$15,477
Total	$474,217	$207,511	$118,609	3,428	1,612	1,007	$1,072,871	$460,194	$255,969

Appendix D: GDP, Employment and Gross Output Calculation for U.S. Hospital and Research Institute AUTM Survey Respondents

	HRI Contribution to GDP, 2% Running Royalties	HRI Contribution to GDP, 5% Running Royalties	HRI Contribution to GDP, 10 % Running Royalties or	HRI Contribution to Person Years of Employment Supported , 2% Run Royalties	HRI Contribution to Person Years of Employment Supported, 5% Run Royalties	HRI Contribution to Person Years of Employment Supported, 10 % Run Royalties	HRI Contribution to Gross Output, Output Multiplier = 1, 2% Run Royalties	HRI Contribution to Gross Output, Output Multiplier = 1, 5% Run Royalties	HRI Contribution to Gross Output, Output Multiplier = 1, 10 % Ru Royalties
	2009 Dollars	2009 Dollars	2009 Dollars	Person Yrs of Employment	Person Yrs of Employment	Person Yrs of Employment	2009 Dollars	2009 Dollars	2009 Dollars
Year	Millions	Millions	Millions	Thousands	Thousands	Thousands	Millions	Millions	Millions
1996	$2,495	$1,104	$640	22	10	7	$5,756	$2,485	$1,394
1997	$2,382	$1,052	$609	21	10	6	$5,496	$2,370	$1,328
1998	$1,730	$777	$460	16	8	5	$4,023	$1,760	$1,006
1999	$3,853	$1,655	$922	34	15	9	$8,998	$3,800	$2,067
2000	$3,017	$1,304	$732	26	12	7	$7,052	$2,996	$1,644
2001	$3,499	$1,522	$863	32	15	9	$8,220	$3,510	$1,940
2002	$4,150	$1,843	$1,074	36	17	11	$9,410	$4,086	$2,311
2003	$6,712	$2,902	$1,632	53	24	15	$14,997	$6,376	$3,503
2004	$7,197	$3,112	$1,750	55	25	15	$16,202	$6,875	$3,766
2005	$6,697	$2,905	$1,641	51	24	14	$15,739	$6,688	$3,671
2006	$5,100	$2,453	$1,571	40	22	16	$11,651	$5,383	$3,294
2007	$3,243	$1,653	$1,122	26	15	12	$7,471	$3,608	$2,321
2008	$8,291	$3,943	$2,494	63	34	24	$19,536	$8,925	$5,388
2009	$6,761	$3,019	$1,772	45	22	14	$13,743	$6,026	$3,453
2010	$6,976	$3,138	$1,859	44	22	15	$14,629	$6,455	$3,731
2011	$7,782	$3,473	$2,037	50	24	16	$17,155	$7,496	$4,276
2012	$12,078	$5,195	$2,901	75	35	21	$27,436	$11,604	$6,327
2013	$12,033	$5,165	$2,876	74	34	21	$26,942	$11,387	$6,202
2014	$6,392	$2,810	$1,617	40	19	12	$14,229	$6,130	$3,430
2015	$6,438	$2,855	$1,660	40	20	13	$13,868	$6,024	$3,409
Total	$116,826	$51,880	$30,231	844	407	261	$262,554	$113,985	$64,461

Appendix E: Sum of University and HRI AUTM Survey Respondent Contribution to GDP, Employment and Gross Output

	U +HRI Contribution to GDP, 2% Running Royalties	U + HRI Contribution to GDP, 5% Running Royalties	U+ HRI Contribution to GDP, 10 % Running Royalties	U + HRI Contribution to Person Years of Employment Supported , 2% Run Royalties	U + HRI Contribution to Person Years of Employment Supported, 5% Run Royalties	U + HRI Contribution to Person Years of Employment Supported, 10 % Run Royalties	U + HRI Contribution to Gross Output, Output Multiplier = 1, 2% Run Royalties	U + HRI Contribution to Gross Output, Output Multiplier = 1, 5% Run Royalties	U+ HRI Contribution to Gross Output, Output Multiplier = 1, 10 % Run Royalties
	2009 Dollars	2009 Dollars	2009 Dollars	Person Yrs of Employment	Person Yrs of Employment	Person Yrs of Employment	2009 Dollars	2009 Dollars	2009 Dollars
Year	Millions	Millions	Millions	Thousands	Thousands	Thousands	Millions	Millions	Millions
1996	$10,786	$4,706	$2,679	95	44	27	$24,953	$10,657	$5,891
1997	$11,572	$5,099	$2,942	104	49	31	$26,718	$11,500	$6,427
1998	$12,912	$5,717	$3,318	119	56	35	$30,118	$13,021	$7,321
1999	$17,241	$7,516	$4,275	153	71	43	$40,154	$17,156	$9,491
2000	$18,776	$8,413	$4,959	165	80	51	$43,612	$19,079	$10,901
2001	$20,485	$8,939	$5,090	186	86	52	$48,102	$20,591	$11,421
2002	$25,366	$11,033	$6,256	216	99	60	$57,733	$24,654	$13,628
2003	$29,029	$12,543	$7,047	230	105	64	$64,870	$27,566	$15,132
2004	$28,329	$12,297	$6,953	218	101	62	$63,724	$27,125	$14,925
2005	$28,120	$12,632	$7,469	220	107	70	$65,616	$28,649	$16,327
2006	$28,261	$12,674	$7,479	213	104	68	$65,517	$28,602	$16,297
2007	$43,622	$19,098	$10,923	314	148	92	$104,051	$44,498	$24,647
2008	$50,891	$22,433	$12,947	368	175	110	$121,890	$52,436	$29,284
2009	$41,300	$17,904	$10,105	266	124	77	$84,298	$36,044	$19,959
2010	$34,064	$15,034	$8,691	211	102	66	$71,625	$31,096	$17,587
2011	$33,221	$14,702	$8,529	210	102	66	$73,330	$31,819	$17,982
2012	$40,916	$17,845	$10,155	257	121	76	$92,708	$39,642	$21,953
2013	$43,444	$18,902	$10,722	271	127	79	$97,043	$41,460	$22,933
2014	$36,033	$15,893	$9,179	228	110	71	$80,169	$34,621	$19,439
2015	$36,672	$16,010	$9,123	227	108	68	$79,194	$33,963	$18,886
Total	$591,042	$259,391	$148,840	4,272	2,019	1,268	$1,335,425	$574,179	$320,430

Supplementary Tables and Figures:

Table S-1: Comparisons of 2009, 2012, 2015, and June 2017 Economic Impact Reports

Year of Report Years of data Year of currency value R&D capitalized? Industries of the licensees	GDP U 2% RR	GDP HRI 2% RR	GDP U + HRI 2% RR	Gross Output U 2% RR	Gross Output HRI 2% RR	Gross Output U + HRI 2% RR	Jobs: Person years of employ ment supported U 2% RR	Jobs: Person years of employ ment supported HRI 2% RR	Jobs: Person years of employ ment Supported U + HRI 2% RR
2009 12 years of AUTM data 1996-2008 2005 dollars R&D not capitalized 9 manufacturing industries **Licensee's sales not included in jobs calculation**	$187B			$457B			277,000		
2012 15 years of AUTM data 1996-2010 2005 dollars R&D not capitalized 9 manufacturing industries	$278B	$61B	$339B	$687B	$149B	$836B	2,586,000	579,000	3,165,000
2015 18 years of AUTM data 1996-2013 2009 dollars **R&D capitalized** 9 manufacturing industries	$414B	$104B	$519B	$941B	$234B	$1,176B	3,058,000	765,000	3,824,000
June 2017 20 years of AUTM data 1996-2015 2009 dollars **R&D capitalized** 9 manufacturing industries	$474B	$116B	$591B	$1,072B	$262B	$1,335B	3,428,000	844,000	4,272,000
% change of 2017 relative to 2015 (2017 -2015)/ 2015	14%	12%	**14%**	14%	12%	**14%**	12%	10%	**12%**

Table S-2: Value added ratios in prior and this I-O report on the economic impact of nonprofit inventions.

Year	2009 report (9[43] industries)	2012 report (9 industries)	2013 Res Policy Paper (9 industries)	2015 report (9 industries, R&D considered in Value Added Ratios[44])	June 2017 report (9 industries R&D considered in Value Added Ratios)
1996	0.39	0.39	0.39	0.43	0.43
1997	0.39	0.39	0.39	0.43	0.43
1998	0.4	0.39	0.39	0.42	0.42
1999	0.4	0.39	0.39	0.42	0.42
2000	0.4	0.39	0.39	0.42	0.42
2001	0.4	0.38	0.38	0.42	0.42
2002	0.41	0.40	0.40	0.43	0.43
2003	0.4	0.40	0.40	0.44	0.44
2004	0.4	0.40	0.40	0.44	0.44
2005	0.39	0.39	0.39	0.42	0.42
2006	0.4	0.40	0.40	0.42	0.42
2007	0.41	0.39	0.39	0.41	0.41
2008		0.38	0.38	0.41	0.41
2009		0.42	0.42	0.48	0.48
2010		0.42	0.42	0.47	0.47
2011				0.45	0.45
2012				0.44	0.43
2013				0.44	0.44
2014					0.44
2015					0.46

[43] Industries which make up the licensees are in a subgroup (chemical products (325), plastics and rubber (326), nonmetallic minerals (327), fabricated metals (332), computer and electronics (334), electrical equipment, appliances and components (335), other transportation equipment (3364OT), miscellaneous manufacturing and machinery (339)) of industry classes 31-33: "Manufacturing."

[44] Measuring R&D in the National Economic Accounting System, Marissa J. Crawford, Jennifer Lee, John E. Jankowski, and Francisco A. Moris, *Survey of Current Business*, November 2014 https://www.bea.gov/scb/pdf/2014/11%20November/1114_measuring_r&d_in_the_national_economic_accounting_system.pdf

Supplementary Figure 1.

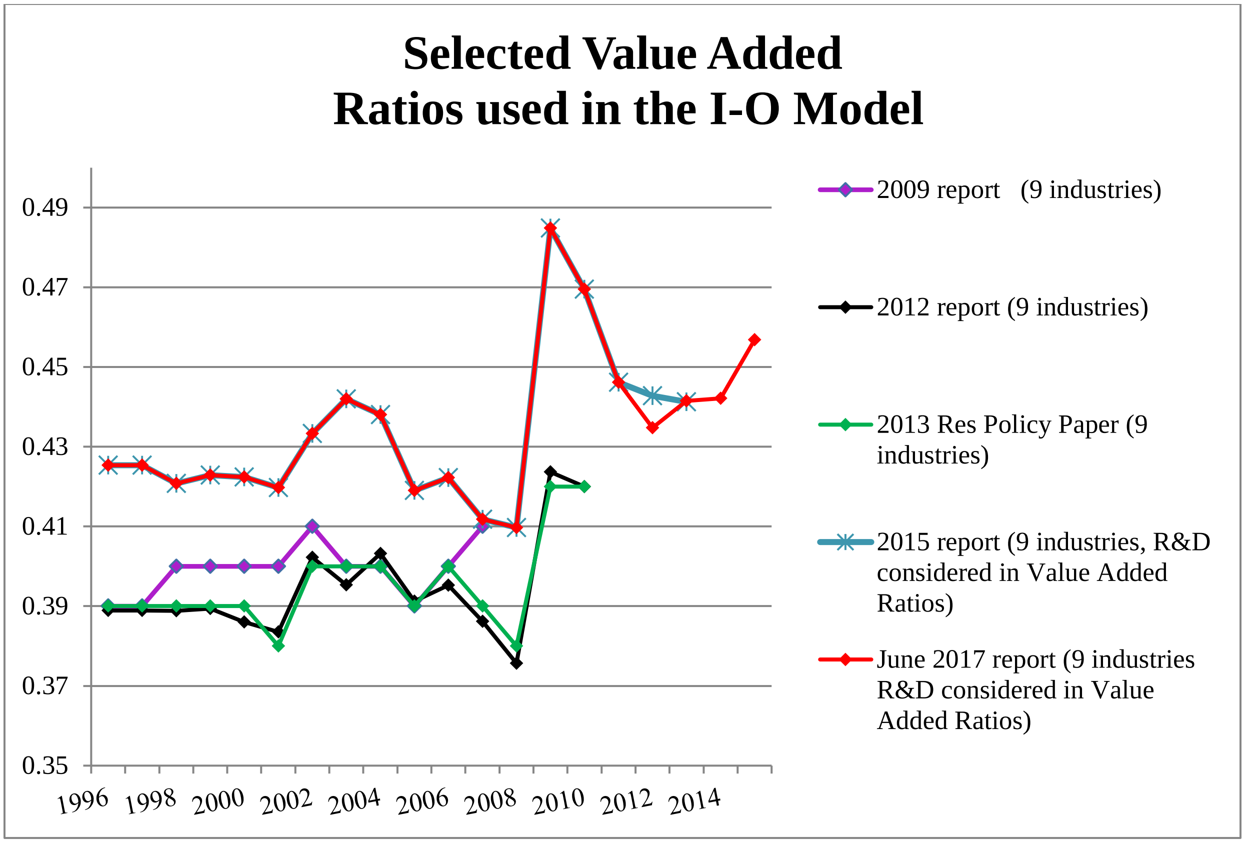

Table S-3: A list of the 20 major sectors and their two-digit NAICS codes.

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-4. Data in Figure 3.

Year	U +HRI Contribution to GDP, 2% Running Royalties , in millions of 2009 dollars	Normalized I-O modeled AUTM contribution to GDP relative to itself in 1996	BEA Table 1.1.6. Real Gross Domestic Product, billions of chained 2009 dollars	Normalized U.S. GDP relative to itself in 1996	GDP in billions of 2009 dollars Selected Manufacturing industries(327, 332, 333, 334, 335, 3364OT, 339, 325, 326, 61)	Industry specific (327, 332, 333, 334, 335, 3364OT, 339, 325, 326, 61) normalized GDP relative to itself in 1996
1996	10,786	1.00	10,561.0	1.00	848.6	1.00
1997	11,572	1.07	11,034.9	1.04	916.4	1.08
1998	12,912	1.20	11,525.9	1.09	940.6	1.11
1999	17,241	1.60	12,065.9	1.14	970.9	1.14
2000	18,776	1.74	12,559.7	1.19	1,021.0	1.20
2001	20,485	1.90	12,682.2	1.20	959.8	1.13
2002	25,366	2.35	12,908.8	1.22	967.2	1.14
2003	29,029	2.69	13,271.1	1.26	1,004.0	1.18
2004	28,329	2.63	13,773.5	1.30	1,060.3	1.25
2005	28,120	2.61	14,234.2	1.35	1,109.0	1.31
2006	28,261	2.62	14,613.8	1.38	1,196.2	1.41
2007	43,622	4.04	14,873.7	1.41	1,257.2	1.48
2008	49,736	4.61	14,830.4	1.40	1,267.9	1.49
2009	41,276	3.83	14,418.7	1.37	1,276.8	1.50
2010	34,464	3.20	14,783.8	1.40	1,334.4	1.57
2011	33,221	3.08	15,020.6	1.42	1,367.3	1.61
2012	41,644	3.86	15,354.6	1.45	1,411.1	1.67
2013	43,494	4.03	15,612.2	1.48	1,439.9	1.72
2014	36,033	3.34	15,982.3	1.51	1,497.5	1.76
2015	36,672	3.40	16,397.2	1.55	1,549.4	1.83

Table S-5

Value Added by Industry (GDP by Industry)												
[Billions of dollars]												
Bureau of Economic Analysis												
Release Date November 13, 2014												
NAICS Code	327	332	333	334	335	3364OT	339	325	326	61		
Year	Nonmetallic mineral products	Fabricated metal products	Machinery	Computer and electronic products	Electrical equipment, appliances, and components	Other transportation equipment	Miscellaneous manufacturing	Chemical products	Plastics and rubber products	Educational services	Total	Total, Normalized to itself in 1996
1996	34.6	107.3	100.1	165.5	46.6	60.6	49.5	165.9	55.5	63.1	848.6	1
1997	40	110.5	102.6	196.3	47.1	62.7	52.5	174.9	58	71.8	916.3	1.08
1998	40.9	112	114	192.2	40.6	66.9	55.4	182	62.1	74.5	940.8	1.11
1999	43.3	116.4	111.3	186.9	44.7	74	57.8	189.8	66.3	80.4	970.9	1.14
2000	42.7	121.7	113.3	225.9	45.8	71.2	59.4	189	65.9	86.1	1,020.90	1.2
2001	41.5	111.5	105.8	173	44.3	77	57.5	193.4	64.1	91.7	959.7	1.13
2002	42	106.6	99.3	172.4	43.7	73	61	207.1	63.5	98.6	967.1	1.14
2003	42.2	109	97.8	193.3	45.6	72.7	62.1	211.5	63.3	106.5	1,004.00	1.18
2004	45.6	115.3	104.7	201.5	42.1	76	63.9	230.1	64.4	116.7	1,060.20	1.25
2005	49.1	122.9	114.9	211	43.2	89.9	66.2	227.3	63.5	121	1,109.10	1.31
2006	50.6	127.1	122.3	223.4	51.4	96.3	70.2	260.6	64.4	129.9	1,196.30	1.41
2007	50.3	135.1	129.7	227.2	50.2	114	71.9	276.4	63.7	138.7	1,257.20	1.48
2008	43.8	133	129.7	234.1	55.1	111.6	74.9	280.1	56.3	149.3	1,267.90	1.49
2009	37.3	117.9	115.6	228.9	50.2	111.9	80.2	310.3	61.5	163	1,276.80	1.5
2010	36.2	120.3	122.1	249	50	112.2	81.2	330.8	63.3	169.3	1,334.30	1.57
2011	36.1	127.4	136.7	248.9	47.4	115.4	78.1	337.2	64.6	175.5	1,367.20	1.61
2012	38.7	138.5	143.1	256.8	51	114.1	78.7	341.9	70.1	183	1,415.90	1.67
2013	43.4	141.7	146.8	261.2	54.4	119.1	77.5	355.1	70.8	185.6	1,455.50	1.72
2014	45.9	146.2	152.2	266.3	55.4	126	79.2	364.6	66.6	195.1	1,497.50	1.76
2015	48	149.2	153.1	278.2	56.3	131.1	83.1	377.3	70.8	202.3	1,549.40	1.83

Table S-6. Data in Figure 4.

Year	TOT EXP: total research expenditures 2009 $B	TOT EXP: normalized to 1999	LCEXEC: number of new licenses executed	LICEXEC: normalized to 1999	ACTLIC: cumulative total number of active licenses	ACTLIC: normalized to 1999	LCGNLI: cumulative total number of licenses generating license income	LCGNLI: normalized to 1999	LCGNRR: cumulative total number of licenses generating running royalties	LCGNRR: normalized to 1999	LIRECD: License Income Received 2009 $M	LIRECD: normalized to 1999	LIRUNR : License Income Received characterized as Running Royalties, 2009 $M	LIRUNR: normalized to 1999	U +HRI Contribution to GDP, assuming 2% Running Royalties 2009 $B	I-O Model Calculated AUTM contribution to U.S. GDP normalized to 1999
1999	32.07	1.00	3650	1.00	17370	1.00	7620	1.00	3878	1.00	$1,033	1.00	767	1.00	$17,241	1.00
2000	34.04	1.06	4004	1.10	19337	1.11	8352	1.10	4188	1.08	$1,505	1.46	818	1.07	$18,776	1.09
2001	35.77	1.12	3657	1.00	21236	1.22	8839	1.16	4614	1.19	$1,241	1.20	917	1.20	$20,485	1.19
2002	41.12	1.28	4247	1.16	24034	1.38	9906	1.30	5412	1.40	$1,478	1.43	1,103	1.44	$25,366	1.47
2003	44.42	1.39	4473	1.23	25694	1.48	10442	1.37	5627	1.45	$1,551	1.50	1,243	1.62	$29,029	1.68
2004	46.28	1.44	4758	1.30	27025	1.56	11181	1.47	6080	1.57	$1,609	1.56	1,220	1.59	$28,329	1.64
2005	45.99	1.43	4897	1.34	28049	1.61	11998	1.57	6130	1.58	$2,306	2.23	1,232	1.61	$28,120	1.63
2006	47.85	1.49	4947	1.36	30777	1.77	12452	1.63	7037	1.81	$2,283	2.21	1,231	1.61	$28,261	1.64
2007	50.18	1.56	5094	1.40	30132	1.73	14194	1.86	7541	1.94	$2,748	2.66	1,985	2.59	$43,622	2.53
2008	51.87	1.62	5123	1.40	32399	1.87	15316	2.01	7982	2.06	$3,461	3.35	2,315	3.02	$50,891	2.95
2009	53.95	1.68	5321	1.46	33381	1.92	16162	2.12	8782	2.26	$2,307	2.23	1,608	2.10	$41,300	2.40
2010	58.42	1.82	5356	1.47	38328	2.21	16080	2.11	7828	2.02	$2,348	2.27	1,351	1.76	$34,064	1.98
2011	59.39	1.85	6037	1.65	38477	2.22	16997	2.23	9113	2.35	$2,356	2.28	1,384	1.81	$33,221	1.93
2012	60.70	1.89	6360	1.74	40006	2.30	18189	2.39	9613	2.48	$2,465	2.39	1,769	2.31	$40,916	2.37
2013	60.90	1.90	6549	1.79	43295	2.49	18318	2.40	9901	2.55	$2,541	2.46	1,853	2.42	$43,444	2.52
2014	57.85	1.80	6892	1.89	42011	2.42	17626	2.31	9521	2.46	$2,466	2.39	1,518	1.98	$36,033	2.09
2015	59.13	1.84	7910	2.17	44899	2.58	20320	2.67	10474	2.70	$2,235	2.16	1,508	1.97	$36,672	2.13

Table S-6, continued

Year	TOT EXP: total research expenditures 2009 $B	TOT EXP: normalized to 1999	LCEXEC: number of new licenses executed	LICEXEC: normalized to 1999	ACTLIC: cumulative total number of active licenses	ACTLIC: normalized to 1999	LCGNLI: cumulative total number of licenses generating license income	LCGNLI: normalized to 1999	LCGNRR: cumulative total number of licenses generating running royalties	LCGNRR: normalized to 1999	LIRECD: License Income Received 2009 $M	LIRECD: normalized to 1999	LIRUNR : License Income Received characterized as Running Royalties 2009 $M	LIRUNR: normalized to 1999	U +HRI Contribution to GDP, assuming 2% Running Royalties 2009 $B	I-O Model Calculated AUTM contribution to U.S. GDP normalized to 1999
Slope		0.06		0.06		0.10		0.10		0.11		0.08		0.07		0.08
rsq		0.93		0.92		0.99		0.98		0.97		0.51		0.45		0.56

Most consistent multiyear tracking to a linear fit to I-O mode calculated GDP growth, by eye, slope and r2 :
Slope = m in a y =mx+b in a linear model
Rsq = Pearson’s correlation coefficient

Glossaries and Definitions:

Selected defined terms and field names in the AUTM Survey and STATT database
These excerpts are provided as a convenience. The 2015 AUTM Survey Instructions and Definitions can be found here: http://www.autmsurvey.org/id_2015.pdf

Active Licenses/Options [ACTLIC]: The cumulative number of Licenses/Options, over all years, that had not terminated by the end of the Survey's year requested.

License/Option Agreements [LICEXEC] = the sum of License Agreements + Option Agreements
A License Agreement formalizes the transfer of Technology between two parties, where the owner of the Technology (licensor) permits the other party (licensee) to share the rights to use the Technology.

An Option Agreement grants the potential licensee a time period during which it may evaluate the Technology and negotiate the terms of a License Agreement..

License Income Paid to Other Institutions [LIPDIN]: License Income Paid To Other Institutions is the amount paid to other institutions under inter-institutional agreements. The Survey subtracts it from the Total License Income of your institution to avoid double counting License Income when the receiving institution reports it to the Survey.

License Income Received[LIRECD]: License Income Received includes: license issue fees, payments under options, annual minimums, running royalties, termination payments, the amount of equity received when cashed-in, and software and biological material end-user license fees equal to $1,000 or more, but not research funding, patent expense reimbursement, a valuation of equity not cashed-in, software and biological material end-user license fees less than $1,000, or trademark licensing royalties from university insignia. License Income also does not include income received in support of the cost to make and transfer materials under Material Transfer Agreements.

Licenses/Options Yielding License Income: [LIGNLI] The number of Licenses/Options that generated License Income Received in the year requested.

Licenses/Options Yielding Running Royalties: [LICRUNR] The number of Licenses/Options that generated Running Royalties in the year requested.

Running Royalties[LIRUNR]: For the purposes of this Survey, Running Royalties are defined as royalties earned on and tied to the sale of products. Excluded from this number are license issue fees, payments under options, termination payments, and the amount of annual minimums not supported by sales. Also excluded from this amount is Cashed-In Equity, which should be reported separately.

Total Research Expenditures [TOTEXP]: Total Research Expenditures include expenditures (not new awards) made by the institution in in support of its research activities that are funded by all sources including the federal government, local government, industry, foundations, voluntary health organizations (i.e., AHA, ACS, etc.), and other nonprofit organizations.

Selected defined terms from the Science & Engineering Indicators

These excerpts are provided as a convenience. The 2016 Science & Engineering Indicators can be found here: https://www.nsf.gov/statistics/2016/nsb20161/#/report/chapter-4/glossary

Applied research: The objective of applied research is to gain knowledge or understanding to meet a specific, recognized need. In industry, applied research includes investigations to discover new scientific knowledge that has specific commercial objectives with respect to products, processes, or services.

Basic research: The objective of basic research is to gain more comprehensive knowledge or understanding of the subject under study without specific applications in mind. Although basic research may not have specific applications as its goal, it can be directed in fields of present or potential interest. This is often the case with basic research performed by industry or mission-driven federal agencies.

Development: The systematic use of the knowledge or understanding gained from research directed toward the production of useful materials, devices, systems, or methods, including the design and development of prototypes and processes.