CONCEPT TO COMMERCIALIZATION

The Best Universities for Technology Transfer

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EXECUTIVE SUMMARY

Innovative activities – and their commercial applications – are driving long-term economic growth in America. While industry energizes innovation through research and development (R&D) initiatives, the main catalyst that fuels knowledge-based growth once again lies where it started: the American research university. As new, bi-directional information exchanges open up between academic and industry researchers – as opposed to past linear models – more commercially attuned knowledge exchange is shared, leading to a rise in entrepreneurial success and economic impact.

In the 21st century, public and private research universities are the seed capital for creating knowledge that fosters scientific- and technology-based economic development. Yet there are key underpinnings required to promote success in knowledge-based economic development: creating the highly-trained human capital that industry requires; and capitalizing on research by converting it for private-sector application. Creating human capital and conducting research, along with its efficiency as measured by output (patents, licenses executed, licensing income, and startups) relative to input (research expenditures), depict the production of good universities delivering on their mission.

TECHNOLOGY TRANSFER, COMMERCIALIZATION PROCESS, AND REGIONAL ECONOMIES

The dissemination of university-developed intellectual property (IP) occurs through a variety of complex channels. In this study we focus on the primary channels of research conversion to IP as measured by patenting and licensing activity, which, in turn, leads to either academic start-ups or externally-formed entrepreneurial entities, along with the income that accrues to a university from licensing its IP. There are many other potential metrics for evaluating the success of university IP dissemination to the marketplace. However, inconsistent availability of information across universities preclude including other measures.

Most major U.S. research universities support a Technology Transfer Office (TTO) that actively seeks, registers, and patents IP, and manages the commercialization of their discoveries. Professional TTO staff regularly engages with university researchers to assess whether there is potential commercial merit to early-stage research.

The majority of these knowledge spillovers are highly localized. In a 2015 study, the Milken Institute described and documented this process as the supplier network, including research universities and government labs, that commercialize research in the form of spinout firms or via licensing to established firms.[1]

THE UNIVERSITY TECHNOLOGY TRANSFER AND COMMERCIALIZATION INDEX

Development of an aggregate ranking of university technology transfer and commercialization success is fraught with challenges; nevertheless, metrics-based benchmarking is helpful in assessing the relative position among peers and in recognizing best practices.

The University Technology Transfer and Commercialization Index (Index) is based on data collected by the Association of University Technology Managers (AUTM) via the AUTM's Annual Licensing Activity Survey. Four-year averages (2012-15) for four key indicators of technology transfer success are included in the Index: patents issued, licenses issued, licensing income, and start-ups formed. These were normalized based on a four-year average of research dollars received by each university to yield four additional variables, for a total of eight measures.

The University of Utah is first in our University Technology Transfer and Commercialization Index (an index score of 100), up from 14th in our original ranking released in 2006. The institution has quietly evolved into one of the most prestigious research universities in the United States with a strong emphasis on commercializing its research.

Columbia University is second on the Index. Columbia was not included in the original 2006 ranking as the university didn't participate in the AUTM survey at the time. Columbia recorded stellar performances across indicators, and stood out in licensing income. The University of Florida is third, up from fifth in 2006, close behind Columbia University. At 97.81, the University of Florida is just 0.12 points below Columbia. Many are aware of the tremendous source of income that Gatorade has provided the University of Florida, but the university's overall success is due to much more than one product.

Brigham Young University (BYU) is fourth, up from seventh in 2006, with an overall score of 96.63. BYU performed admirably across all metrics, standing out in its ability to spawn start-up companies and its efficiency relative to research spending. Stanford University's high placement, coming in at fifth, isn't a surprise to anyone who pays attention to initial public offerings (IPOs) or tech stock market capitalizations. While Stanford's rank edged down from fourth in 2006, the university didn't fall as much as other universities rose. University of Pennsylvania ranked sixth, with an index score of 95.39, up from 12th in 2006.

University of Washington (UW) ranks seventh, a notable increase from 24th in 2006. The Massachusetts Institute of Technology (MIT), ranks eighth, down from first in the 2006 index. However, we should not assume MIT's commercialization prowess has diminished, as they are the top performer without a medical school. The California Institute of Technology (Caltech) ranks ninth, with an index score of 94.11. Patents were a particular strength – Caltech outperformed all its peers with more than 660 patents issued to the university between 2012 and 2015. Carnegie Mellon University rounds out the top 10 with an index score of 93.72. New York University is ranked at 11th. Purdue is 12th, a leap from its 39th position in 2006 and the highest-ranking university in the Midwest. The University of Texas System is 13th, followed by the University of Minnesota at 14th. The University of California, Los Angeles (UCLA) is 15th, up 30 places from its 45th position in 2006. The University of Michigan is 16th, Cornell University is 17th and the University of Illinois is 18th.

The University of South Florida is 19th, a jump from 74th in 2006. The university has stepped up its game in research and commercialization. The University of California, San Diego is 20th. Arizona State University (ASU) is 21st, an impressive improvement from 43rd in 2006. The University of Central Florida (UCF), based in Orlando, is 22nd. A sea change, of sorts, occurred at UCF after it was granted a medical school in 2006. Northwestern University is among the elite performers at 23rd, an advancement from 70th in 2006. The University of Pittsburgh is 24th, followed by North Carolina State at 25th.

Research universities are one of the strongest assets America can use to compete in the age of innovation. Research funding should be a top priority for enhancing American economic growth.

Universities that succeed at technology transfer and commercialization include both public and private universities. They are spread across the country; 13 of the top 25 universities are based in red states, all are in major metropolitan areas, and all range in size. These universities can be leveraged to boost and spread middle class job creation in their home states. While innovation is not confined to blue states, blue states have been more successful in leveraging university research for economic benefit.

University research funding can support the creation of both middle- and high-skill industry jobs through innovation, commercialization, and technology transfer. As products and services are created and licensed, there are a myriad of multiplier impacts felt across the economy.

Universities are a source of competitive advantage; they create a skilled workforce and through R&D and tech-transfer help create new technologies and new industries.

Universities that lead the Milken Institute's University Technology Transfer and Commercialization Index actively promote tech-transfer, allowing other universities to learn from their strategies. The below articulates the Milken Institute's recommendations based on our recent findings:

- **Maintain basic scientific research funding.** Basic research provides long-term economic benefits by allowing universities to take on research that has a low probability of quick commercial success, but potential to deliver a high reward and to create whole new industries.

- **Incentivize technology transfer through a new federal commercialization fund.** The federal government should increase research funding under a special commercialization pool. Universities demonstrating greater commercialization success in the market should receive higher funding in this program.

- **Increase technology transfer capacity through federal matching grants.** The federal government should commence a matching grant program with states to fund an increase in staff and resources in TTOs. Higher rates of academic entrepreneurship are essential to reviving declining start-up rates and productivity across the economy. New firms have higher productivity as they are at the cutting edge of technology.

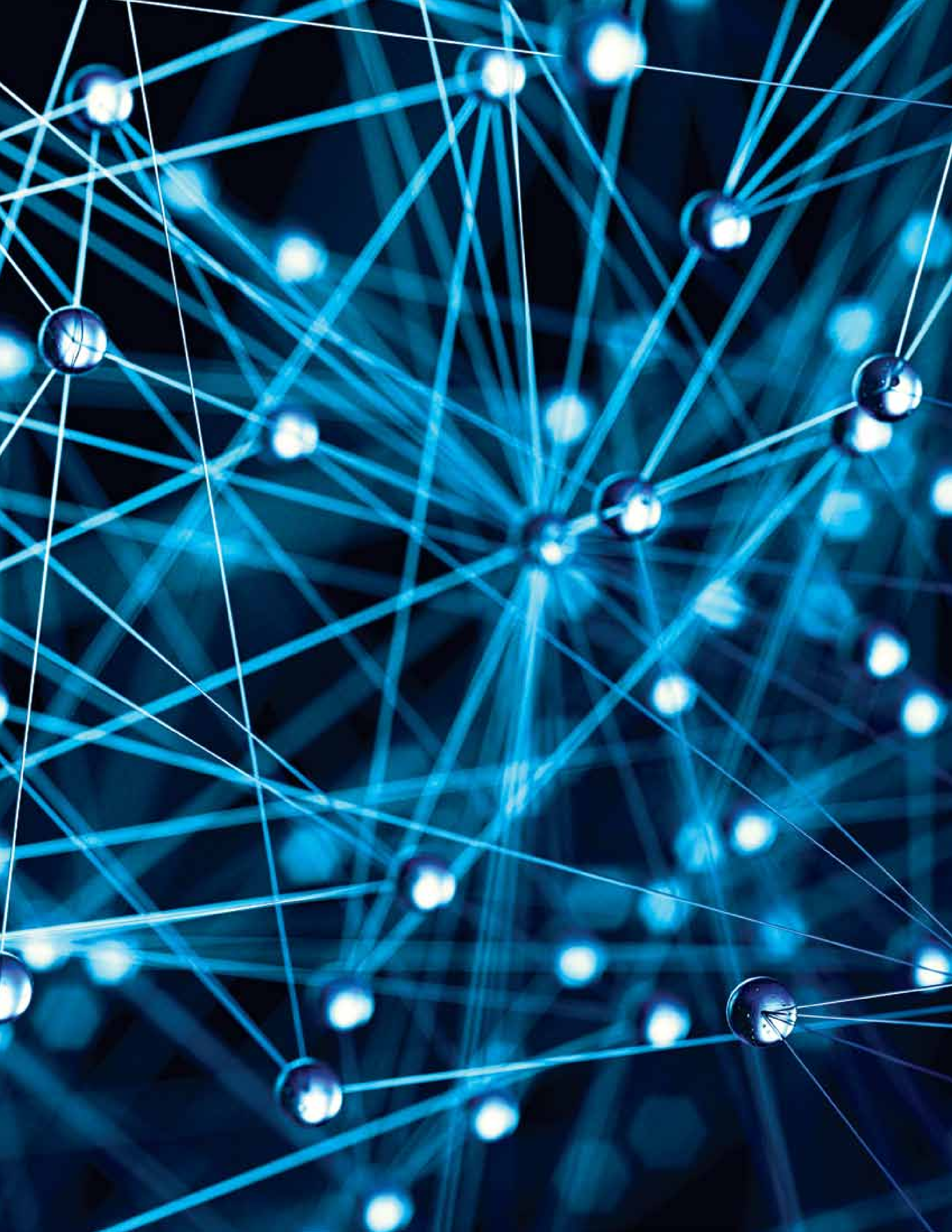
- **Increase technology transfer efficiency by adopting best practices.** At the state level, policies should be implemented that incentivize the adoption of best practices in commercialization at public universities, including TTOs. Efficiency gaps between universities outside of the top 25 in our Technology Transfer and Commercialization Index should be narrowed.

TABLE ES 1

TOP 25 UNIVERSITY TECHNOLOGY TRANSFER AND COMMERCIALIZATION INDEX

RANK	INSTITUTION	INDEXED SCORE
1	University of Utah	100
2	Columbia University	97.83
3	University of Florida	97.66
4	Brigham Young University	97.58
5	Stanford University	95.6
6	University of Pennsylvania	95.39
7	University of Washington	95.11
8	Massachusetts Institute of Technology	94.33
9	California Institute of Technology	94.11
10	Carnegie Mellon University	93.54
11	New York University	93.41
12	Purdue University	93.02
13	University of Texas System	92.88
14	University of Minnesota	92.75
15	University of California, Los Angeles*	92.13
16	University of Michigan	91.58
17	Cornell University	89.49
18	University of Illinois Chicago Urbana	89.37
19	University of South Florida	88.93
20	University of California, San Diego*	88.55
21	Arizona State University	88.49
22	University of Central Florida	88.21
23	Northwestern University	87.95
24	University of Pittsburgh	87.75
25	North Carolina State University	87.73

*Sources: Milken Institute, AUTM STATT Data Set, University of California Office of the President. * indicate data was not in the AUTM data set.*



1

INTRODUCTION

It is increasingly recognized that innovative activities – and their commercial applications – are driving long-term economic growth around the globe. This is most apparent in developed nations and their economies, and emerging countries recognize that they must promote and nurture innovation to grow.[2] While industry energizes innovation through research and development (R&D) initiatives, the impetus that fuels knowledge-based growth once again lies in the American research university.[3] As new, bi-directional information exchanges open up between academic and industry researchers – as opposed to past linear models – more commercially attuned knowledge exchange is shared, leading to a rise in entrepreneurial success and economic impact.

In the 21st century, public and private research universities are the seed capital for creating knowledge that fosters scientific- and technology-based economic development. Yet there are key underpinnings required to promote success in knowledge-based economic development: creating the highly trained human capital that industry requires, and capitalizing on research by converting it for private-sector consumption. These two foundational components, along with its efficiency depict the production of universities that are delivering on their mission.[4]

The dissemination of university-developed intellectual property (IP) occurs through a variety of complex channels. In this study we focus on the primary channels of research conversion to IP as measured by patenting and licensing activity, which, in turn, leads to either academic start-ups or externally-formed entrepreneurial entities, along with the income that accrues to a university from licensing its IP. These measures are available from the Association of University Technology Managers (AUTM), which has collected this information through member surveys for nearly three decades.[5] Engagement with universities and other private and government research organizations has steadily increased over the years, and in its latest survey, virtually all major research entities participated. The study includes an update to the Milken Institute University Technology Transfer and Commercialization Index (Index) from our 2006 report "Mind to Market."[6]

There are many other metrics for evaluating the success of university IP dissemination to the marketplace. Collaborative research engagement between academic researchers across geographies, including international borders, can lead to wider dispersion of knowledge and commercial impact, although the majority of these knowledge spillovers are highly localized.[7] Collaborative research with private sector firms is another pathway for knowledge absorption to occur outside a Technology Transfer Office (TTO). Other significant growth channels include: academics who conduct contract research/consulting, and those who are available for ad-hoc council or networking on an informal basis with applied practitioners.[8] Joint publication with industry-based researchers, staff exchange, and even graduate student supervision are other modes of knowledge exchange.[9] These informal, tacit transfers of knowledge are facilitated through repeated interaction and may generate substantial commercial value.[10]

A comprehensive survey of the various communications channels for the transmission of innovations between universities, federal laboratories, firm research, and development facilities highlights how industries valued these relationships.[11] The survey found that biopharmaceutical senior management ascribed higher value to patents and license agreements with universities than executives from other industries; however, those surveyed found research publications, conferences, consulting, and other ad-hoc contact to be more important.

There are many later stage, post-market metrics of technology transfer and commercialization performance such as job creation, employee wages, sales, and market capitalization of academic-derived enterprises and firms which license IP. If data were more readily available, a comprehensive and longer-term series of impact metrics could be developed. However, even these measures do not capture another often missed form of remuneration: the millions of dollars that former students donate back to their universities such as Google co-founders Sergey Brin and Larry Page at Stanford or Michael Dell to the University of Texas, Austin. Michael Dell was motivated to give back after the University provided him a dormitory room to start his computer retailing firm. Increasingly, many universities are setting students up for success by providing centers for entrepreneurship. This permits deeper engagement and sources of future income.

The implementation of the Bayh-Dole Act of 1980, which gave universities and federal laboratories ownership of their IP and the right to license it, has led to a series of actions by universities to incentivize academic researchers to become entrepreneurs. The prospect of non-traditional income stemming from licensing, spin-offs, and joint industry research acted as a major inducement for universities to support these efforts during a time of tight public funding. Dynamics supporting commercialization success include the creation of TTOs, government enticements and partnerships, new industry funding mechanisms, private equity outreach efforts, and enhanced recognition of university-generated patents and products in the marketplace.

At the same time, there is concern that the extent of academic entrepreneurship may not be fully recorded.[12] Sometimes this is referred to as technology transfer that "goes out the backdoor." Many times universities have willingly looked the other way to reward or retain star scientists, but other times have sought legal remedies. For example, in 2002, Yale University sued Nobel Prize winner in Chemistry, John Fenn, for commercializing a patent he developed while still a researcher at Yale. The judge overseeing the case found against Fenn and awarded Yale University $1 million in damages.[13]

2 TECHNOLOGY TRANSFER, COMMERCIALIZATION PROCESS, AND REGIONAL ECONOMIES

2.1. TECHNOLOGY TRANSFER AND COMMERCIALIZATION PROCESS

University technology transfer and commercialization has a long history in the United States with much of the initial documented impact dating back to the 1930s and 1940s when Karl Compton was President of MIT. Compton advocated for professional entrepreneurship and offered support to his professors to participate. Further, Compton actively campaigned for the creation of American Research and Development, the first non-family venture capital firm, which funded many early MIT spin-offs.[14] Also in the 1930s, Stanford electrical engineer Fred Terman encouraged his students to work for local companies or start their own businesses rather than move to established firms back East. These students include now household names William Hewlett and David Packard, who decided to start their own firm in a garage between the fruit orchards.[15]

However, the modern era of university commercialization commenced when collaborative research on recombinant DNA conducted in the 1970s by Stanley Cohen at Stanford and Herbert Boyer at University of California, San Francisco, led to the birth of the biotechnology industry. Human insulin – the first new drug based on Cohen and Boyer's discovery – was approved for human use in 1982 after Genentech invested in follow on R&D.[16]

Most major U.S. research universities established TTOs to actively seek, register, and patent IP and manage the commercialization of their discoveries. Professional TTO staff regularly engage with university researchers to assess whether there is potential commercial merit to early-stage research. TTO staff assists in filing invention disclosures, applies for patents with the U.S. Patent and Trademark Office, develops strategies for commercializing the IP, and arranges networking opportunities with the business and private equity communities.[17]

This process is very labor intensive and must be conducted with great professionalism and sensitivity. TTO staff must balance the needs of the university, researchers, licensing firms and financiers with government entities and the public that support – and ultimately benefit from – the products and services created, along with the economic vitality and job creation derived from the commercialization process.[18] The social and cultural capital in a university builds trust and permits greater successful IP transfer.

2.2. CONTRIBUTIONS TO REGIONAL ECONOMIES

Regional economies benefit the most from the knowledge spillovers from universities. Technology-based clusters develop based upon their unique ecosystems. The Milken Institute described and documented this process in its 2015 study, California's Innovation-Based Economy: Policies to Maintain and Enhance It.

Innovation-based clusters are spatial concentrations of often competing, sometimes collaborating firms and their related supplier network, including a variety of supporting institutions. Innovative clusters form and expand largely because new knowledge tends to be generated, conveyed, and collected more efficiently in close proximity.

This supplier network includes research universities and government labs that commercialize research in the form of spinout firms and through licensing to established firms within the cluster.[19]

The local research and development environment and culture are essential to assembling new industry clusters from transformative technologies or sustaining the vitality of existing industry clusters. It is possible to seed a new cluster by attracting firms that have achieved commercialization success in another geography, but those regions with indigenous R&D have clear advantages in developing clusters that hang together over the long haul. Local innovation scope is contingent upon the extent of a region's innovation competencies, along with the unique cluster attributes that augment innovation and the extent of the dynamic interactions among them. Positive feedback loops are generated by greater investments in R&D as they improve research capacities and entice additional funding by both the private and public sectors.

The regional context is critical to understanding the success and impact of university knowledge flows. In some cases university discoveries – especially in the biomedical area – play a foundational role in developing a local cluster. In other cases, a large industry presence provides the absorptive capacity (the ability of local firms to be aware of and to recognize the value of new, externally derived information, as well as to integrate and apply it to commercial endeavors) to draw out the IP from universities and find a home.

A wide body of literature exists documenting the localized capture of university-developed IP. This ranges from paper citations,[20] citation of patents by local firms vis-à-vis those residing outside the geographic area,[21] firm growth based upon proximity to a university,[22] and the concept of a knowledge filter. A knowledge filter functions as a barrier to the successful conversion of IP to new products and services. Nearby new or incumbent firms minimize the severity of knowledge filters as they can better envision how it is applied.[23] It is the capture of non-codified, tacit information that can best be accomplished through proximity and frequent engagement.

2.3. HISTORY OF TECHNOLOGY TRANSFER

The patenting and subsequent commercial exploitation of research findings at universities and federal research laboratories has not traditionally been a core focus of faculty and staff at these institutions. Some barriers are cultural and others institutional, for example, there is often a desire to focus on developing solutions to interesting problems, irrespective of their direct market value. Others include institutional incentive structures that reward the quantity and quality of publications instead of patents. Additionally, many researchers seek to make work available for the public good. These barriers impede the success of TTOs.[24] Indeed, the conflicting and expanding priorities for universities – generating new knowledge, educating students, preparing graduates for the workforce, and commercializing research – compete for faculty attention. While the added revenue, and economic impact of effective technology transfer is attractive to universities, striking the right balance between traditional institutional priorities and capitalizing on new revenue streams is crucial.

Some important legal barriers to technology transfer were removed in the early 1980s. The Bayh-Dole Act, which came into law in 1981, enabled universities rather than federal funding agencies to claim the intellectual property generated by research funded by the U.S. government.[25] Retaining title created a larger incentive for universities and innovators to pursue patents and licensing. The bill explicitly encouraged collaboration with the private sector, and aimed to reduce the administrative costs of pursuing commercialization by moving control out of government bureaucracy to universities. Other changes, for example the creation of the Court of Appeals for Federal Circuit, which helped enforce university patent rights, also contributed to a more attractive technology transfer environment at the time.[26] In the decade after the passing of the Act in 1980, the number of university TTOs in the U.S. increased from 25 to 200.[27] The number of TTO-tracked patents issued has almost quadrupled between 1995 and 2015.[28]

2.4. SUMMARY OF SCALE OF ACTIVITY

More than 1,000 firms were launched in fiscal year 2015 through TTOs at research universities, with more than 70 percent of start-ups located in the same state as the affiliated university.[29] Other indicators of the health of the technology transfer process include the more than 6,600 patents issued and continuing growth of licensing income – with the number of these partnerships between academia and industry facilitated by TTOs up more than 17 percent to 6,300.[30] Not all entrepreneurial activity related to universities passes through TTOs, however their metrics are an indicator of the types of contribution that university research can make to economic growth, and the university's vital role in the respective, regional innovation economy.

Figure 1: Total patents issued from technology transfer offices

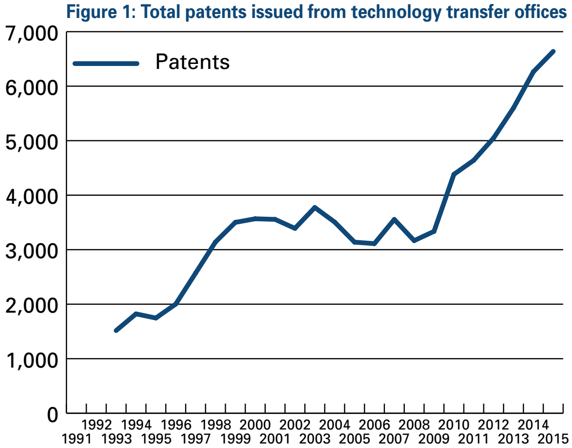


Figure 2: Total licenses issued

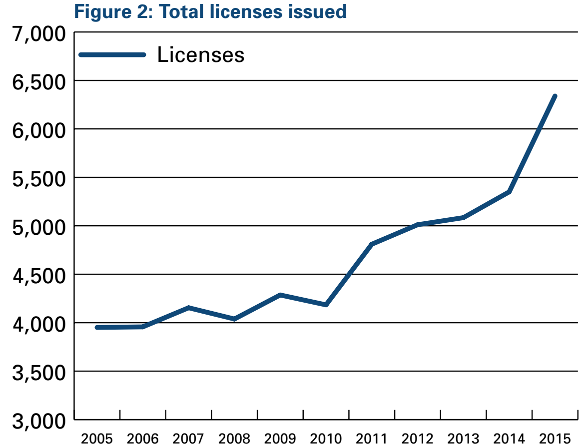


Figure 3: Total licensing income

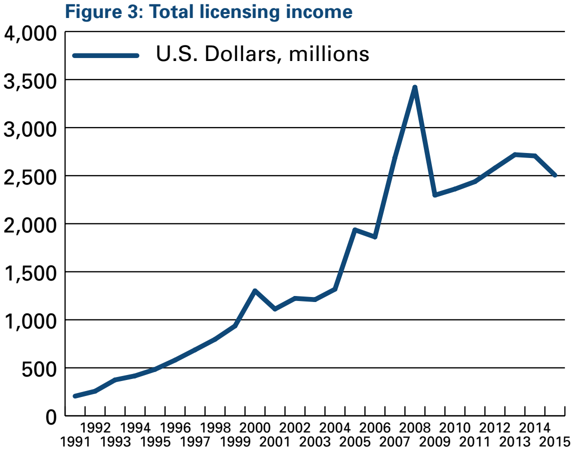
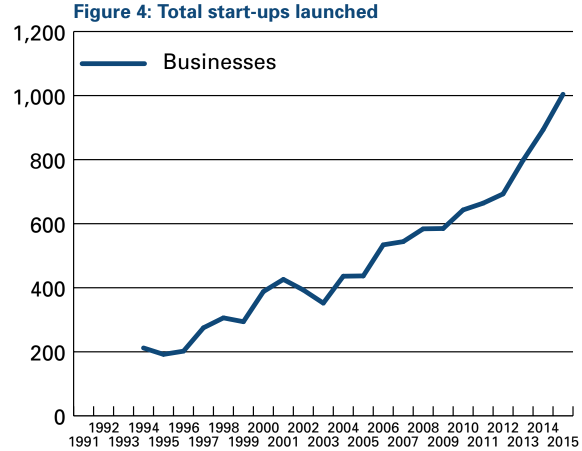


Figure 4: Total start-ups launched



3 UNIVERSITY TECHNOLOGY TRANSFER AND COMMERCIALIZATION INDEX

Development of an aggregate ranking across research universities with multiple disciplines is fraught with challenges; nevertheless, the University Technology Transfer and Commercial Index (Index) is a metrics-based benchmark that is helpful in assessing the relative position among peers and in recognizing best practices.

The Index is based on data collected by the Association of University Technology Managers (AUTM) via the AUTM's Annual Licensing Activity Survey, with one exception, the University of California System.[31]

The Index is measured using four-year averages (2012-15) for four key indicators of technology transfer success: patents issued, licenses issued, licensing income, and start-ups formed. These are normalized based on a four-year average of research dollars received by each university to yield four additional variables, for a total of eight.

Each university has distinctive – sometimes subtle – differences in structure, culture, and institutional factors (including whether it is a public or private institution) that necessitate alternative strategies on IP commercialization. For example, a university with scientific expertise in the life sciences will develop a commercialization approach different from a university with an advantage in engineering.

When ranking and scoring the Index, a primary consideration is to determine the appropriate balance between absolute and relative measures of commercialization. We would expect that a large research university that attracts substantial public funding to achieve larger commercialization outcomes relative to a smaller university. Scale is important in assessing the impact of research universities. However, absolute outcome measures don't address the productivity or efficiency of commercialization activity. For this reason, we include the outcome metrics normalized by research expenditures.

The weights in Table 2 are applied to these eight variables to generate a score, and research institutions are ranked from highest to lowest score. The final score is generated by indexing all raw scores to the highest performer, yielding a top score of 100 for the first place institution. The result is an index that identifies universities with consistent performances across the metrics.

Table 2: University Technology Transfer and Commercialization Index Variable Weights

	FOUR-YEAR AVERAGE, PERCENT	FOUR-YEAR AVERAGE PER RESEARCH DOLLAR, PERCENT	TOTAL WEIGHT, PERCENT
Patents issued	7.5	7.5	15
Licenses issued	7.5	7.5	15
Licensing income	17.5	17.5	35
Start-ups formed	17.5	17.5	35
Total	50	50	100

This index is designed to evaluate the relative position of university research quality, its market applicability, and TTO performance in the U.S. The purpose is to provide an easy to understand measure of the commercialization output of the U.S.'s higher education institutions. The potential impact on economic development from commercialization of university research is large, and is important to maintaining innovation in the U.S. The AUTM data is self-reported by university TTO and as universities do not seek to commercialize technology in the same way as the private sector does, there can be delays in reporting and clustering of data over the reported years.

There are caveats in using the AUTM data set, but it provides the most comprehensive measures in the public domain. For example, count of patents issued can be inconsistent due to multiple filings and holders being counted for collaborative research projects as well. A license might be issued for an innovation that has just become viable or an innovation that was rediscovered from a nascent patent.[32] This can be due to changing industry needs, or to the inefficiency of the TTO, that sometimes lack the resources to be a successful matchmaker between a seller and buyer.

The licensing income data that AUTM collects may be affected by inconsistency of revenue. If a license holder suspends use of a license, or an agreement is based on a one-time payment, the revenue generated in one year may not reflect the overall impact of the innovation. This is why we benchmark performance over a four-year window. Similarly, in some cases a few blockbuster licenses generate a significant amount of income.

Since 1967, the royalties accrued by the Gatorade Trust have exceeded $1 billion dollars, with University of Florida reaping $281 million from their stake in the product.[33] Ohio University generated $80-$100 million since 2005 when it licensed SOMAVERT to Pfizer.[34] These outliers may make it difficult to evaluate a diminution in income from new innovations.

Start-up data tracking may have issues with underreporting or inconsistency as students and faculty bypass the technology transfer system, avoiding ties to the institution itself. In areas that have strong entrepreneurial infrastructure in place, start-ups may not require the expertise of a TTO. The reverse is also true; an absence of a rich entrepreneur milieu will increase utilization of TTOs.

Table 3: University Technology Transfer and Commercialization Index: Top 25 Institutions

RANK	INSTITUTION	PATENTS SCORE	LICENSES ISSUED SCORE	LICENSES INCOME SCORE	START-UP SCORE	INDEXED SCORE
1	University of Utah	88.27	89.38	94.04	93.90	100
2	Columbia University	85.86	84.54	97.08	88.50	97.83
3	University of Florida	88.60	95.37	91.60	87.84	97.66
4	Brigham Young University	85.59	85.83	86.76	94.95	97.58
5	Stanford University	96.28	85.43	94.57	81.94	95.6
6	University of Pennsylvania	83.30	86.52	91.62	87.66	95.39
7	University of Washington	79.56	100.00	93.73	79.30	95.11
8	Massachusetts Institute of Technology	96.76	77.92	92.91	82.00	94.33
9	California Institute of Technology	100.00	76.07	91.53	81.14	94.11
10	Carnegie Mellon University	75.57	92.29	88.50	87.05	93.54
11	New York University	84.48	78.27	98.60	77.76	93.41
12	Purdue University	85.58	86.56	85.45	86.87	93.02
13	University of Texas System	87.02	82.90	89.75	81.91	92.88
14	University of Minnesota	76.71	91.99	90.75	80.80	92.75
15	University of California, Los Angeles*	93.32	77.37	68.43	100.00	92.13
16	University of Michigan	86.03	84.96	89.98	75.03	91.58
17	Cornell University	84.49	91.52	86.42	74.32	89.49
18	University of Illinois Chicago Urbana	84.66	78.16	89.83	75.87	89.37
19	University of South Florida	89.25	83.45	81.23	79.65	88.93
20	University of California, San Diego*	89.14	83.65	65.76	93.53	88.55
21	Arizona State University	79.29	79.87	82.32	82.67	88.49
22	University of Central Florida	91.93	69.34	79.69	83.75	88.21
23	Northwestern University	84.88	69.32	88.85	77.44	87.95
24	University of Pittsburgh	78.31	91.48	87.84	71.37	87.75
25	North Carolina State University	74.56	86.10	86.54	76.29	87.73

*Sources: Milken Institute, AUTM STATT Data Set, University of California Office of the President. * indicate data was not in the AUTM data set.*

A DEEP DIVE INTO UNIVERSITIES AND THEIR RANKINGS ON THE INDEX

The **University of Utah** (Utah) is first in our University Technology Transfer and Commercialization Index (an index score of 100), up from 14th in our original ranking released in 2006. Many were surprised at Utah's strong showing in 2006, but the institution has quietly evolved into one of the most prestigious research universities in the nation with a strong emphasis on commercializing its research.[35] Utah attracted $417.2 million in research spending in 2015, placing it among the top tier institutions in the nation. Utah consistently ranked high across all indicators; patents, licenses, licensing income, and start-ups in both absolute size and normalized by research expenditures, although it did not rank first in any single category. Utah was propelled to the number one position due to licensing income and start-ups which received the highest weights in the overall index.

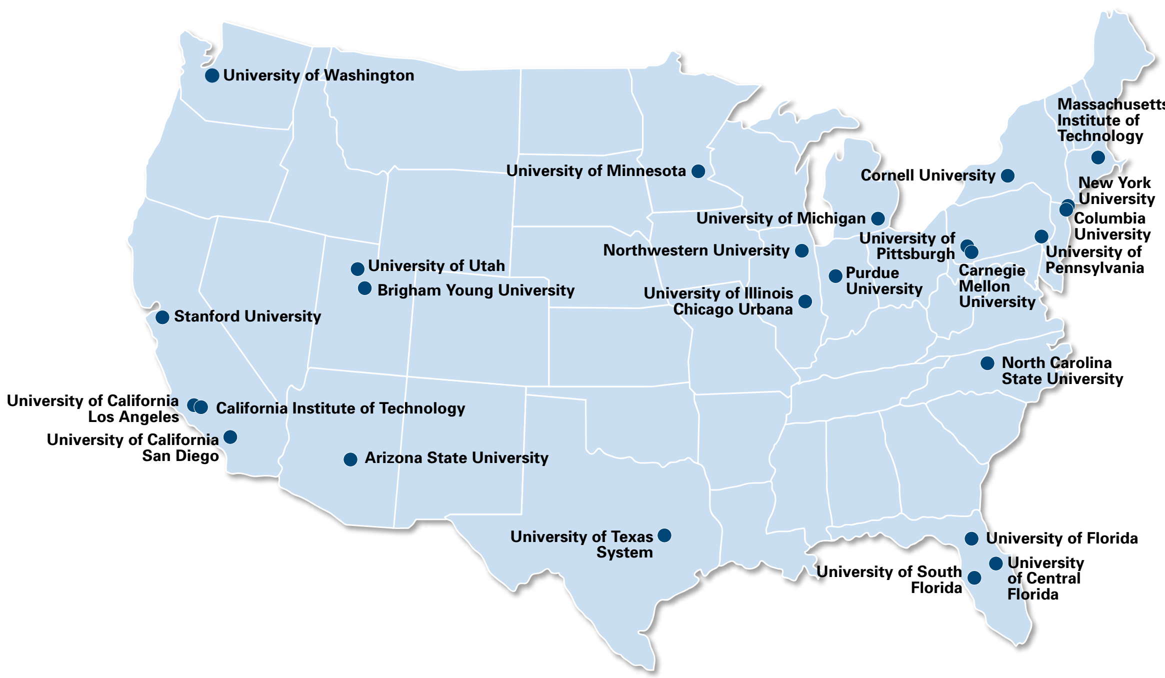
From 2012 to 2015, Utah generated $211.8 million in licensing income or $135.8 thousand per million in research expenditure. Over the same period Utah recorded 69 start-ups, a remarkable accomplishment as the university is based in Salt Lake City, a smaller metropolitan area. Utah has a strong entrepreneurial culture and an incentive system that makes it attractive for research faculty and students alike. Its Technology and Venture Commercialization (TVC) office is among the best in the nation in evaluating and minimizing risk, as well as aiding in the commercialization process. The Commercialization Engine Committee is a notable, unique asset and is comprised of a network of external experts from a variety of fields who offer counsel and make the process highly efficient.[36]

When appointed vice president for research at the University of Utah in 2016, Dr. Andrew Weyrich made a statement that encapsulated the uniqueness of the culture at the institution:

> The commercialization of our research discoveries at the University of Utah has had a tremendous impact on people's lives and on the common good. These positive effects are a principal reason why the university has so strongly supported translational research. As the new vice president for research, I look forward to continuing this support and working with the TVC to catalyze and transform our discoveries into practical use.

The University of Utah has many different sources of research and commercialization but its focus on biomedical is a key foundation. At its Center for Medical Innovation (Center), doctors and students drawn to innovation have a central resource.[37] The Center functions as an information and gathering focal point for faculty, students, and industry in the health sciences. Another resource is the Entrepreneurial Faculty Scholars program which coalesces innovative faculty who are dedicated to encouraging and enriching translational experiences for both faculty and student entrepreneurs. The university also has the Lassonde Entrepreneur Institute that serves as a launching pad for student entrepreneur programs ranging from business plan competitions, innovation courses, internships to commercialization opportunities. Finally, it also has a Center for Engineering Innovation.

Figure 5 Top 25 University Technology Transfer and Commercialization Map



Columbia University is second on the University Technology Transfer and Commercialization Index. Columbia was not in our 2006 ranking as the university didn't participate in the AUTM survey at the time. Columbia recorded stellar performances across the indicators, but stood out in licensing income. Here, Columbia is well known in the commercialization of medical research, especially from income on its cancer drug, Erbitux. However, Columbia's success isn't based on one blockbuster drug.[38] Over the four years in our analysis, Columbia ranked second in licensing income at $678.0 million, just behind NYU. Columbia performed solidly across patents (392), licenses (330), and start-ups (74) over the period. Importantly, Columbia didn't just score high on licensing income in total, but also due to income relative to research expenditures at $223.3 thousand per million in research – a measure of efficiency.

Columbia Technology Ventures (CTV) is the conduit through which the university's IP is commercialized. In the past, it has commercialized such technologies as the iPod Touch, Blu-ray Disc, Direct TV, and Adobe Illustrator's paintbrush. Orin Herskovitz, head of CTV, summarized the university's approach when he stated: "Our mission is to transfer the most technologies possible from the lab to the market, things that benefit society." Further, he went on to say, "We also want to support researchers and their research programs, and promote a culture of entrepreneurship here at Columbia." These efforts resulted in hundreds of jobs in the greater New York City area. Columbia takes great pride in pushing many promising technologies and drug discoveries across the "valley of death," a commonly used phrase to describe the phase between research and successful commercialization.[39] The CTV has two separate offices – one adjacent to Columbia's medical campus, and one at Morningside – which reflects the university's commitment to commercialization success.

The **University of Florida (UF)** is third, up from fifth in 2006. At 97.81, the University of Florida is just 0.12 points below Columbia. Many are aware of the tremendous source of income that Gatorade provided the university, but Florida's overall success is due to much more than one product. Over the past four years reported in the AUTM survey, Florida generated 395 patents, 547 licenses, $127.9 million in income, and 62 start-ups. Furthermore, it efficiently turned research into licensing income. In 2015, the university experienced a record-breaking year for commercialization with licenses executed up 43 percent from the previous year with one of the top technology transfer staffs in the nation. David Norton, vice president of research, outlined the university's approach when he stated, "Our top-ranked tech transfer operation is driving economic development and cycling royalty dollars back into research." He went on to add, "More importantly, it's moving the research out of the lab and into the world."[40]

In describing Florida's recent technology transfer performance, David Day, its highly regarded head of technology licensing stated, "This is an astonishing set of numbers that far surpasses our previous high-water mark." He went on to state, "It is a credit to the outstanding people at the University of Florida: the brilliant scientists and the best tech transfer team in the world."[41] Day recognizes the collaborative combination that is required for commercialization success. Florida has been efficacious in the biomedical space in recent years. For example, in July 2016, AGTC became the first start-up at the University of Florida to secure a billion dollar agreement when it announced a collaboration with biotech giant Biogen to further develop gene-based therapies for rare eye diseases. Another promising start-up is Banyan Biomarkers, which is working on a blood test that provides a straightforward diagnosis for concussions.

Brigham Young University (BYU) is fourth, up from seventh in 2006, with an overall score of 96.63. BYU performed admirably in all the metrics, but stood out in its ability to spawn start-up companies and its efficiency in doing so relative to research spending. BYU's fourth place is a noteworthy achievement when we consider that it only had $32.2 million in research expenditures in 2015. For example, Johns Hopkins University had the highest research expenditure total of $1.55 billion in 2015. BYU has a highly entrepreneurial culture and some of the strongest incentives available for faculty. Revenues received by licensing are split at 45 percent for the inventor(s) as personal income and the university at 55 percent for research support.[42] That is a strong, motivating incentive for faculty researchers.

The entrepreneurial culture at BYU is focusing on student endeavors as well. The Rollins Center for Entrepreneurship and Technology attempts to provide a supportive, nurturing environment for students for starting and growing technology ventures. The Rollins Center's vision and mission statements emphasize this importance to the university: "Vision – Become the global leader in successful campus-inspired entrepreneurial ventures; and Mission – Inspire and prepare students to be world-class leaders in entrepreneurship and technology, foster interaction with successful role models, and facilitate supporting faculty research."[43] Technology transfer is focused in three areas with different department heads in life sciences, software, and engineering.

Stanford University's high placement, coming in at fifth, isn't a surprise to anyone who pays attention to IPOs or tech stock market capitalizations. While its rank edged down from fourth in 2006, Stanford didn't fall as much as other universities rose. Stanford's commercialization performance hasn't waned in any regard. The university's business school helped establish an entrepreneurial culture throughout the institution, and when combined with its medical school, it has formidable capabilities in the commercialization space. You simply cannot consider the innovations that come from Silicon Valley without acknowledging the essential role that Stanford played in the Valley's formation and expansion. Stanford scored highest on patents and licensing income. However, keep in mind that Stanford had $946.4 million in research expenditure in 2015, which demonstrates that for in order for it to be ranked fifth, it needed to be highly proficient in terms of converting inputs (research dollars) into outputs (patents, licenses, licensing income, and start-ups).

Stanford's Office of Technology Licensing (OTL) was established in 1970, long before there was even a whisper about the future Bayh-Dole Act. Its first license agreement was valued at $5,000. Cumulatively since 1970, OTL handled licenses that generated $1.77 billion in royalties. Of that total, $319 million went to departments, $318 million to inventors and $308 million to the schools.[44] The OTL explains that its philosophy is "…to maintain good relationships with our inventors and licensees, the keys to our success; to plant as many seeds (licenses) as possible so that we can enable the transfer of research to companies; to be flexible, be reasonable, and be business-like within a university environment." Most are aware of Stanford's key biotechnology innovations, but few know that in 1971 Stanford researchers developed FM Sound Synthesis which led to Yamaha's electric piano and, ultimately, sound chips in electronic devices.

University of Pennsylvania (Penn) ranks sixth, with an index score of 95.39, up from 12th in 2006. Consistent performance across all our indicators contributed to its high placement. The Penn Center for Innovation consolidated Penn's TTO and other programs relating to commercialization and start-ups in 2014. Penn attracts significant research funding, more than $888 million in 2015, and $3.6 billion between 2012 and 2015. Licensing income generated $42 million in 2015.

The Pennovation Center serves as an incubator and hub for innovative activity with Penn, and forms a key part of the 23-acre Pennovation Works research and business park adjacent to the university. It includes co-working space available to both university-related ventures and private-sector firms, and flexible laboratory and production space. Penn also partners with industry, for example jointly pursuing cancer therapies with pharmaceutical firm Novartis in the Novartis-Penn Center for Advanced Cellular Therapeutics located on campus. President Amy Gutmann places an emphasis on innovation based on interdisciplinary collaboration, following the strong foundation laid by her predecessor Judith Rodin.

University of Washington (UW) ranks seventh, an appreciable increase from 24th in 2006, with an index score of 95.11. UW had the highest score on our licenses issued sub-index, the only institution to file more than 1,000 between 2012-2015. License income was another strength, generating $42.8 million in 2015. Restructured as CoMotion in 2015, UW broadened its TTO mission to better integrate the university into the innovation ecosystem. CoMotion labs, innovation grants, and mentorship all aim to foster innovation transfer in a wide range of fields, with wet and dry labs along with office space available for 30-50 start-ups in their incubator.

A leading recipient of federal research grants, UW spent $1.4 billion on research in 2015. The UW School of Medicine attracted half of the research dollars in 2016, and 27 percent of the start-ups in the CoMotion labs were in the biotech and healthcare field. Information technology and software firms made up 26 percent, with Apple acquiring Turi for $200 million in 2016. UW has partnered with major local firms on CoMotion initiatives, including Microsoft on the Global Innovation Exchange and Amazon on the Amazon Catalyst program, which award grants of up to $100,000 to UW innovators who address large, real-world problems.

The **Massachusetts Institute of Technology** (MIT), ranks eighth on the Index, down from first in the 2006. However, we cannot assume MIT's commercialization prowess has diminished, as they are the top performer without a medical school. Over the past decade, commercialization in the life sciences was a key source of focus and impact in licensing offices. MIT's performance sets a standard to which other universities should aspire, with its principal focus in engineering and other STEM-generated IP. MIT scored highest in patent and licensing income performance. In our four-year scoring period, MIT generated 1,127 patents and $309.4 million in licensing income. MIT's Technology Licensing Office (TLO) reported that 279 patents were issued in 2016.[45] President Rafael Reif continues a long tradition of supporting MIT entrepreneurship.

MIT takes great pride in that its IP is fully searchable on its website for potential licensees and this transparency clearly aids licensing. In the early 2000s, a researcher began to chemically alter human insulin for diabetes at MIT's Nanostructured Material Research Laboratory. The modified insulin reduces the injections required per day to one. In 2003, the drug known as SmartInsulin was licensed through MIT's TLO and its scientist inventor co-founded the company SmartCells to further develop the drug. In 2010, Merck & Co. bought SmartCells for a substantial up-front sum and potential milestone payments of $500 million more if successful – an unprecedented pre-clinical stage deal.[46] Having a long history of technology commercialization, MIT tends to attract researchers with a particular predisposition towards entrepreneurship. Further, it has aggressive incentives in place to remind researchers of the potential financial remuneration. MIT's strategy is to maximize the number of technologies developed rather than to concentrate on picking a few winners.

The **California Institute of Technology** (Caltech) ranks ninth, with an index score of 94.11. Patents were a particular strength – Caltech outperformed its peers with more than 660 patents issued to the University between 2012 and 2015. Licenses generated $104 million in income over the same period. The Office of Technology Transfer and Corporate Partnerships (OTTCP) works to protect and commercialize innovations with researchers at Caltech and the Jet Propulsion Laboratory (JPL), a national laboratory managed for NASA by Caltech. Start-up firms are typically in the life or physical sciences, including cancer treatments and medical technology despite the absence of a medical school. It has one of the most professional technology transfer staffs in the nation headed by Fred Farina.

Caltech is one of three major research institutions that participates in the Innovation-Node Los Angeles, funded in part by the National Science Foundation, to speed up commercialization and support entrepreneurship among engineering researchers. It includes the FLoW program at the Resnick Sustainability Institute at Caltech, which focuses on fostering entrepreneurship and discovery in the cleantech field and runs training, business plan competitions, and grant programs for young entrepreneurs.

Carnegie Mellon University ranks 10th with an index score of 93.72. Located in Pittsburgh, and home to world-class computer science and robotics research, the University has several programs that facilitate technology transfer and commercialization, including the Center for Technology Transfer and Enterprise Creation (CTTEC). Project Olympus, an initiative of Carnegie Mellon's computer science department, supports very early stage entrepreneurs with advice, micro-grants, and introductions to help them network and establish new companies. CyLab, focused on cyber security, pursues partnerships with both the public and private sectors to develop and transfer research products into use. Undergraduates are encouraged to engage through targeted coursework, and student entrepreneurs can compete for $60,000 in investment through the McGinnis Venture Competition.

Although it does not have a medical school, Carnegie Mellon attracted $244 million in research expenditures in 2015. Overall, 312 licenses were issued between 2012 and 2015, and $38 million in licensing income was generated over the same period. After the university settled the patent infringement suit related to the use of data storage technology discovered by Carnegie Mellon University Professor Jose Moura, and his former graduate student Aleksander Kavcic, against Marvell Semiconductor Inc. and Marvell Technology Group Ltd., Kavcic, and his wife created the Mary Jo Howard Dively Fund for Technology Transfer and Enterprise Creation. The $3 million fund will further expand CTTEC's capacity and is named after Carnegie Mellon's General Counsel in recognition of her support.

Just outside the top ten is **New York University** (NYU) at 11th, slipping one spot from 2006; however Columbia did not participate in 2006 so NYU can claim its position unaltered. As previously mentioned, NYU had the highest licensing income over the four-year comparison period. NYU had less strength in forming start-up companies, which kept it out of top ten. **Purdue** is 12th, a leap from its 39th position in 2006 and the highest-ranking university in the Midwest. Purdue is renowned for its engineering school and former Indiana governor, and current Purdue president, Mitch Daniels, has emphasized the importance of commercialization for Purdue and the state's economy.

The **University of Texas System** is 13th. Texas reports its statistics to AUTM as a system, but UT Houston Medical School and UT Austin account for the bulk of the licensing activity. Next, at 14th, is the **University of Minnesota** with its high-caliber medical devices and diagnostic research, slipping from seventh in 2006. The **University of California, Los Angeles** (UCLA) is 15th, a jump of 30 places from its 45th position in 2006. Chancellor Gene Block re-engineered UCLA's culture since joining the institution in 2007 to focus research acumen on commercialization. UCLA is first among all universities in its performance in start-ups.

The **University of Michigan** is 16th, down seven places from 2006. However, here, unlike its football team, Michigan easily outpaces Ohio State, which is 55th. A great engineering school and an equally impressive performance in commercialization outcomes since it is in Ann Arbor, a smaller metropolitan area. **Cornell University** is 17th, down one place from 2006. Cornell's strength lies in the number of licenses relative to its research spending.

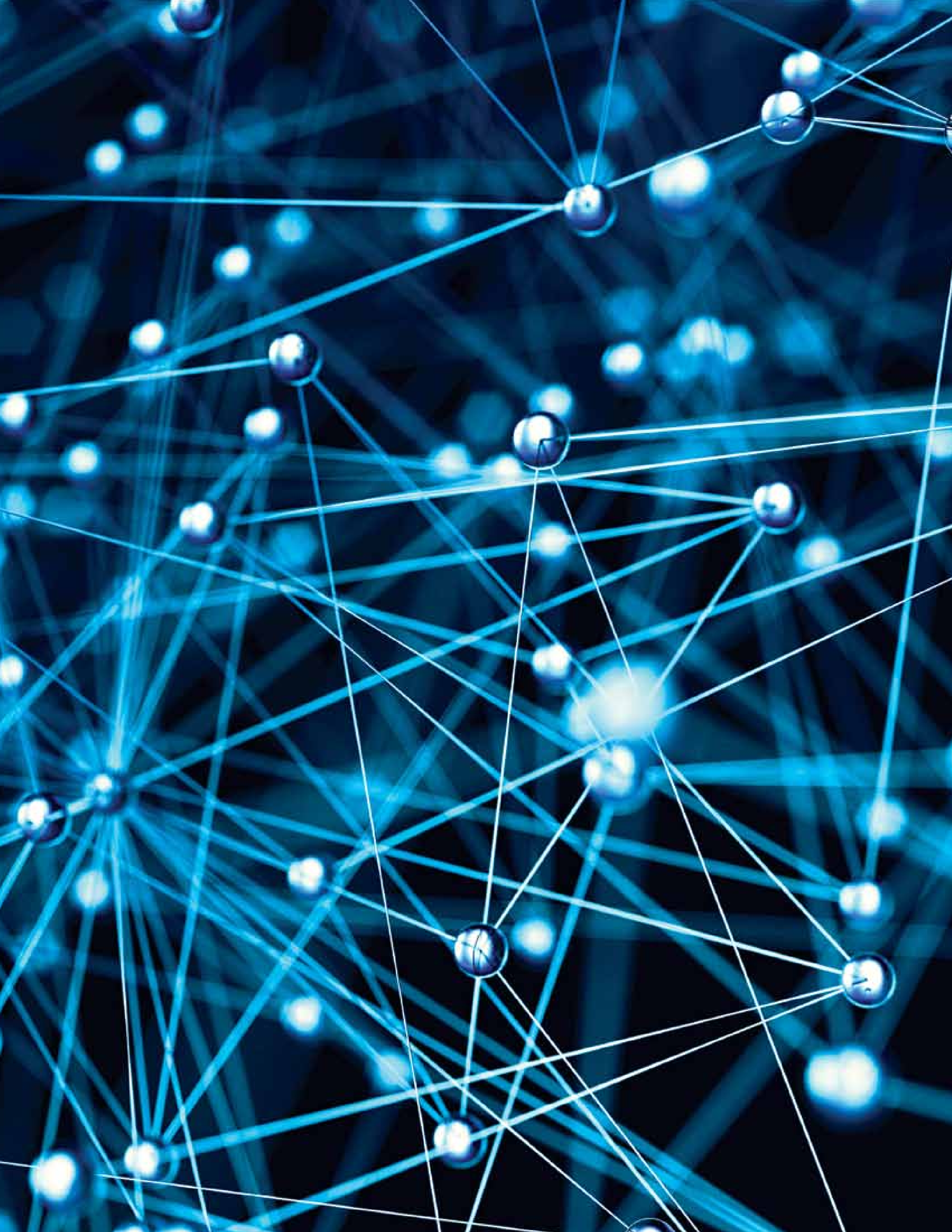
The **University of Illinois**, including both Urbana/Champaign and Chicago, is 18th. The **University of South Florida** is 19th, a jump from 74th in 2006. South Florida stepped up its game in research and commercialization. At number 20 is the **University of California, San Diego**. Its strength is in biotech commercialization and the university played a central role in the region developing one of the premier biotech clusters in the world. Further, this is up from 28th in 2006.

Arizona State University (ASU) is 21st, an impressive improvement from 43rd in 2006. Under President Michael Crow's leadership, the entire research enterprise was reconfigured with an emphasis on commercialization. AzTE was formed in 2003 to manage ASU's Exclusive Intellectual Property Management Company. Its goal is "…the rapid and wide dissemination of ASU discoveries and inventions to the marketplace." ASU monitors it commercialization performance (outputs) relative to the size of its research operations (inputs).[47]

The **University of Central Florida** (UCF), based in Orlando, is 22nd. UCF did not report technology transfer information to AUTM in 2006. A sea change occurred at the institution after it was granted a medical school in 2006, based, in part, on research conducted by the Milken Institute demonstrating the potential economic impact.[48] The university emphasizes that "The UCF Health Sciences Campus at Lake Nona now includes the medical school's new 170,000-square-foot medical education facility, featuring the latest in lab and classroom technology, as well as its new 198,000-square-foot Burnett Biomedical Sciences building," indicating its commercialization focus.[49]

Northwestern University is among the elite performers at 23rd, an advancement from 70th in 2006. The Innovation and New Ventures Office (INVO) was formed to leverage the strong scientific and medical research platform at the university. Additionally, Morton Schapiro was named president in 2008 and his background as an economist and his specialty in higher education demonstrates that he is keen on measuring academic commercialization productivity similar to its teaching productivity.

The **University of Pittsburgh** is 24th, up from 35th in 2006. It has a top medical school and collaborates more with Carnegie Mellon. Rounding out the top 25 is **North Carolina State University**. It is the only Research Triangle school in the top 25 and achieved notoriety with start-ups such as SAS.



4 UNIVERSITY TECHNOLOGY TRANSFER AND JOB CREATION

Innovations – and the universities that enable and equip researchers – have created new industries and opportunities, and played a major role in the evolution of the U.S. economy. Changes in the make-up of the economy can be observed through categories used to track economic indicators. The U.S. Economic Classification Policy Committee in 1997, in coordination with Statistics Canada and Instituto Nacional de Estadistica Geografia, implemented the North American Industrial Classification System (NAICS) to address changes in the way North America's economy functioned. The replacement of Standard Industrial Codes (SIC) for the NAICS allowed for a more inclusive and expandable system to define changes and additions to the industrial make-up of the continent. Changes in these codes and the Standard Occupational Classification (SOC) codes are an objective measure of the relevance of new industries, occupations, and the evolution of the economy.

For example, the SOCs have changed recently to distinguish between computer programmers, software developers (applications & system software), and web developers.[50] In 1997 the information industry category had a total of four subsectors but by 2002 the number had increased to nine. Similarly, a NAICS for scientific R&D services did not exist in 1997 but did in 2002.[51] By 2007 the information industry sector included its specific first six-digit sector NAICS 541711 (R&D bio-technology).[52, 53] In 2017, NAICS 5417 was updated to separate biotechnology (NAICS 54174) and nanotechnology (NAICS 541713).[54] The introduction of new NAICS means that a nascent sector has grown to the point of individual recognition. Since 1997, the 660 six-digit NAICS have grown to 1,057, pointing to the ongoing development and regeneration of the U.S. economy as innovation adds new industries and jobs to replace the old.[55, 56]

4.1. CLUSTERS AND THE INNOVATION ECONOMY

An examination of innovation ecosystems highlights the pivotal role played by universities. The latest wave of innovations have two defining characteristics: first, the concentration of innovation activity in urban areas with a large share of national research activity; and second, the need for a highly educated and skilled labor supply. These two characteristics are fed by the human capital creation throughout the higher education system in the U.S. Investment in university R&D operations provides a platform where innovation can occur, thanks to an incentive system that encourages risk taking.

From students to faculty, R&D opportunities allow for the creation of the next frontier. The platform that universities create allows interaction between expert knowledge and ambition, and has shown efficacy in being a force for job creation.[57] The foundational research that eventually resulted in the creation of the Internet was conducted at the University of California, Los Angeles. The pace of technological advancement has given rise to new ways to create and deliver both products and services – from doctor visits conducted through video to the way we shop. The creative disruption that technology has brought puts pressure on businesses and industries to innovate as incremental improvements alone are unlikely to survive in a competitive market. Maintaining the health of the whole innovation ecosystem is crucial to avoiding obsolescence.

The archetypal example of economic clustering and the influence that universities have on economic growth is the San Francisco Bay Area. Stanford, U.C. Berkley, and U.C. San Francisco each played a material role through expert knowledge, networking, and providing creative space. The Bay Area became the largest high-tech cluster in the world, in large part due to Stanford's pivotal role as incubator from which the IT revolution found its legs and the significant advances in IT and medicine at the U.C. San Francisco medical school. The interplay between university research and the private sector is a force in the U.S. economy that cannot be overstated. Numerous examples where universities and research institutions allowed researchers to explore novel ideas, make groundbreaking discoveries, and then translate these into entrepreneurial endeavors played an enabling role in establishing clusters. As metropolitan areas continue to grow based upon innovation, funding universities and creating human capital becomes ever more important. University research and technology transfer to the private sector can provide the competitive advantage that a company needs to create jobs and wage growth.

The clustering of industries reinforces and amplifies discrepancies between metropolitan economies. Private industry made up the majority of R&D investment in the U.S., concentrated in high-tech clusters.[58] In order to expand the benefits of job creation from the newest wave of technological progress, the university platform for innovation needs to be maintained and allowed to grow. Providing funding for universities where private investment is not concentrated creates opportunity for job creation were both human capital is created and R&D occurs.[59] This type of investment will help to generate a platform for innovation, job growth, and a pathway up the socioeconomic ladder. The effects of the accumulation of knowledge and its dissemination compound over time. This provides increased returns through innovation, networking, and knowledge transfers created by universities.[60, 61]

University research activity also helps train the workforce needed by private-sector innovators. Providing scientists experience in conducting high quality laboratory work and investigating new ideas under the guidance of experts in the field yields economic benefits. The transfer of knowledge and skills out of universities through their graduates aids the dissemination of new discoveries in the economy, independent of the research and commercialization channel. While universities and colleges are already providing an essential service – training the workforce required by the private sector – research universities also train the very researchers that help businesses innovate and create new products, processes, and business opportunities.

4.2. CASE STUDY: LIFE SCIENCE INDUSTRIES

Job creation has long been a focus of economic policy; however, there have been rising concerns over whether wage growth accompanies this job creation. Middle class sustaining jobs in the U.S. are increasingly found in the knowledge economy, which relies on a highly educated workforce. However, investment in R&D has economic spillover effects that provide support through other sectors for a higher standard of living more broadly. Comparing high-tech metro clusters to states where there are no identifiable clusters demonstrates universities will play an increasingly significant role in R&D. In states without life sciences clusters, these spillover effects can benefit from the presence of a university. This section focuses on industries that benefit from the knowledge economy but do not require a four-year college degree to achieve higher wages.

Higher education institutions operate hospitals and medical schools that require capital investment and the labor of support sectors. By breaking down the life science industry into sub-sectors, we can look at where the demand for highly skilled workers shifts to manufacturing a product. We focus on pharmaceuticals and medicine manufacturers (NAICS 3254). We also look at medical device manufacturers (NAICS 3391). These two sectors are heavily dependent on research by a highly skilled and educated workforce, but also lead to a manufactured product. Jobs in these two sectors generally command above average wages in their state and allow for broader opportunity. Among the top ten highest employed occupations in the pharmaceutical and medicine manufacturing, five are related to the R&D side of the industry.[62] The other five are tied to manufacturing or general operations.[63] None of the latter five require a college degree but they do require some additional technical training.[64] The top ten medical device manufacturing occupations include only one that requires a college degree. This sector generally requires some type of additional training and a high school diploma.[65]

Table 4: Ratio of Top to Bottom Locations Economic Indicators

SECTORS		WAGES PER WORKER		RGDP PER WORKER	
		averages	ratios	averages	ratios
3254: Pharmaceuticals and Pharmaceuticals Manufacturers	Metros	$125,912	1.4	$781,306	3.57
	States	$89,740		$218,719	
3391: Medical Device Manufacturing	Metros	$95,269	1.7	$160,692	1.36
	states	$50,420		$117,769	

Sources: Moody's Analytics, County Business Patterns, Milken Institute.

Taking the top states by output in these two life science-related sectors and identifying their metropolitan clusters, we compare them to states with no such clustering of output (see Table 8 in the Appendix for the list of states and metropolitan clusters). The aim is to provide an example of how universities can contribute to economic spillovers to highlight the employment and wage benefit from R&D activity. The concentration of employment in the metros versus the states is 9.51 (NAICS 3254) and 2.89 (NAICS 3392) times higher, and raw employment is 16.73 and 4.14, respectively, times higher between these two groups. The support services required to utilize an innovation can be provided through the private sector in conjunction with universities. There is a positive relationship between the presence of medical schools, university hospitals, and research funding on life science employment in a metro (see Table 7 in the Appendix). These two geographic groups have a clear division based on economic output, but the wage per worker between these groups is not as divergent in comparison. The wage gap is 1.4 times greater for pharmaceutical and medicine manufacturers between the top and bottom geographies. For medical device manufacturing, wages are 1.7 times higher in the metropolitan clusters compared to the non-cluster states. The states have lower average wages than the metros, but the wages for the life-science industries are higher than the state average wage per worker. The higher wages can help spur consumer spending and contribute to growth, while also creating further value down the supply chain as the products designed through R&D are manufactured and sold. R&D activity is influenced by the universities activities, but provide substantial benefits outside of the high-tech clusters.

Table 5: Sector Geographies vs. Total State Wages per Worker

	PHARMACEUTICALS AND PHARMA-CEUTICALS MANUFACTURERS			MEDICAL DEVICE MANUFACTURING		
Metropolitan clusters sector by state total	Metro Sector State Total	$144,200 $60,504	2.38	Metro Sector State Total	$94,382 $60,504	1.79
State sector by state total	State sector State Tot	$88,451 $49,297	1.56	State sector State Total	$55,602 $49,297	1.14

Sources: Moody's Analytics, County Business Patterns, Milken Institute.

The sectors' wage per worker for the metros and the states, with a few exceptions, are higher than average.[66] In places without a cluster like Vermont, the presence of a medical school and hospital produce higher wage jobs. In Burlington, VT the average wage per worker in the pharmaceutical and medicine manufacturing is 2.4 times higher than the state wage per worker. An example of a cluster driving bifurcated wages is found in comparing Omaha-Council Bluff, NE-IA and Durham, NC. Omaha employs 387 people in scientific research and development services throughout the metro, and 488 in pharmaceutical and medicine manufacturing.[67] The concentration of life science economic output in Omaha results from just the manufacturing side of pharmaceuticals, as can be seen from the relatively low average wage per worker of $34,761. At the other end of the spectrum is Durham with 7,154 jobs in the life sciences and average wages per worker of $141,059, where 16,322 are employed in scientific R&D. The total university research funding in the Durham metro is almost 14 times higher than Omaha, which helps to draw in private R&D.

In having universities co-located with industry in a metropolitan area, benefits accrue in a non-linear manner, which can help create jobs and higher wages. This demonstrates the quality of jobs created through linkage to R&D activity. The co-location of manufacturing industries has shown positive impacts on employment.[68] We have strong statistical evidence of the importance of university R&D in building industry agglomerations.[69] University R&D activity creates talent and spurs innovation, thus becoming a vital part of a cluster. As industries mature, diffusion of production enables places with less activity to benefit.

5 CONCLUSIONS AND POLICY RECOMMENDATIONS

Research universities are one of the strongest assets America can use to compete in the age of innovation. Federal and other sources of public funding for university research should be viewed as an investment with a high rate of return. Research funding should be a top priority for enhancing American economic growth.

Universities that succeed at technology transfer and commercialization include both public and private universities. They are spread across the country, 13 of the top 25 universities are based in red states, all are in major metro areas, and all range in size. These universities can be leveraged to boost and spread middle class job creation in their home states. While innovation is not confined to blue states, blue states have been more successful in leveraging university research for economic benefit.

University research funding can support the creation of both middle- and high-skill industry jobs through innovation, commercialization and technology transfer. As products and services are created and licensed, there are a myriad of multiplier impacts felt across the economy.

Universities are a source of competitive advantage; they create a skilled workforce and through R&D and tech-transfer help create new technologies and new industries.

Universities that lead the Milken Institute's University Technology Transfer and Commercialization Index actively promote tech-transfer, allowing other universities to learn from their strategies. The list below articulates the Milken Institute's recommendations based on our recent findings:

- **Maintain basic scientific research funding.** Basic research provides long-term economic benefits by allowing universities to take on research that has a low probability of quick commercial success, but potential to deliver a high reward to create whole new industries.
- **Incentivize technology transfer through a new federal commercialization fund.** To foster technology transfer of these discoveries, the federal government should increase research funding under a special commercialization pool, which includes monitoring innovation pipeline metrics. Universities demonstrating greater commercialization success in the market should receive higher funding in this program.
- **Increase technology transfer capacity through federal matching grants.** The federal government should commence a matching grant program with states to fund an increase in staff and resources at TTOs. This would result in more research dollars making their way to the market and having economic impact. Higher rates of academic entrepreneurship are essential to reviving the declining start-up rates and productivity across the entire economy. New firms have higher productivity as they are at the cutting edge of technology.
- **Increase technology transfer efficiency by adopting best practices.** At the state level, policies should be implemented that incentivize the adoption of best practices in commercialization at public universities including TTOs. If efficiency gaps between universities outside of the top 25 in our Technology Transfer and Commercialization Index can be narrowed, there will be substantially more funds available for investing in additional research and academic programs, not to mention higher private sector job creation.

6 FULL RESULTS

Milken Institute Technology Transfer and Commercialization Index: Universities & Research Institutions*

Rank	Institution	Patent Issued Score	Licensing Issued Score	Licensing Income Score	Start-up Score	Index Score
1	University of Utah	88.27	89.38	94.04	93.90	100.00
2	Columbia University	85.86	84.54	97.08	88.50	97.93
3	University of Florida	88.60	95.37	91.60	87.84	97.81
4	Brigham Young University	85.59	85.83	86.76	94.95	96.63
5	Stanford University	96.28	85.43	94.57	81.94	96.33
6	University of Pennsylvania	83.30	86.52	91.62	87.66	95.45
7	University of Washington/Wash. Res. Fdn.	79.56	100.00	93.73	79.30	94.66
8	Massachusetts Institute of Technology (MIT)	96.76	77.92	92.91	82.00	94.58
9	California Institute of Technology	100.00	76.07	91.53	81.14	93.96
10	Carnegie Mellon University	75.57	92.29	88.50	87.05	93.72
11	New York University	84.48	78.27	98.60	77.76	93.20
12	Purdue Research Fdn.	85.58	86.56	85.45	86.87	93.19
13	University of Texas System	87.02	82.90	89.75	81.91	92.58
14	University of Minnesota	76.71	91.99	90.75	80.80	92.34
15	University of California, Los Angeles	93.32	77.37	68.43	100.00	91.48
16	University of Michigan	86.03	84.96	89.98	75.03	90.23
17	Cornell University	84.49	91.52	86.42	74.32	89.44
18	University of Illinois Chicago Urbana	84.66	78.16	89.83	75.87	89.17
19	University of South Florida	89.25	83.45	81.23	79.65	88.95
20	University of California, San Diego	89.14	83.65	65.76	93.53	88.36
21	Arizona State University	79.29	79.87	82.32	82.67	88.31
22	University of Central Florida	91.93	69.34	79.69	83.75	88.06
23	Northwestern University	84.88	69.32	88.85	77.44	87.99
24	Cleveland Clinic	85.51	76.51	90.86	71.88	87.92
25	University of Pittsburgh	78.31	91.48	87.84	71.37	87.84
26	North Carolina State University	74.56	86.10	86.54	76.29	87.73
27	Harvard University	83.74	75.74	88.14	75.14	87.71
28	University of New Mexico/Sci. & Tech. Corp.	82.59	68.46	82.53	83.19	87.27
29	University of Southern California	85.02	71.09	85.28	76.81	86.71
30	Stevens Institute of Technology	70.71	54.23	79.90	95.08	86.54
31	The General Hospital dba Massachusetts General Hospital	83.05	86.43	93.33	61.06	85.97
32	Georgia Institute of Technology	84.22	77.48	80.86	76.83	85.95
33	Johns Hopkins University	79.27	84.61	87.41	69.27	85.93
34	Duke University	75.62	90.98	90.75	64.55	85.84
35	University of Nebraska	69.73	77.83	87.02	76.39	85.82
36	Mayo Foundation for Medical Education and Research	80.98	83.36	91.50	63.96	85.54
37	Whitehead Institute for Biomedical Research	81.27	76.03	89.03	69.23	85.46

Rank	Institution	Patent Issued Score	Licensing Issued Score	Licensing Income Score	Start-up Score	Index Score
38	University of Colorado	73.48	70.54	88.28	73.67	84.70
39	University of Missouri all campuses	78.32	72.12	87.65	71.35	84.62
40	UW-Madison/WARF	90.44	72.94	92.26	60.90	84.51
41	University of California, Davis	78.72	90.23	64.82	85.56	84.36
42	Vanderbilt University	75.54	85.24	87.79	65.91	84.30
43	University of North Carolina Charlotte	76.78	68.64	74.97	84.65	84.04
44	University of North Carolina Chapel Hill	69.46	77.26	83.62	75.23	83.96
45	University of Houston	75.82	54.19	92.05	73.84	83.92
46	Drexel University	85.53	70.47	77.45	77.22	83.88
47	Oregon State University	65.90	95.25	87.24	65.11	83.84
48	University of Virginia Patent Fdn.	73.74	81.29	84.10	69.71	83.40
49	Indiana University Res. & Technology Corp.(IURTC)	68.69	66.45	85.36	76.62	83.27
50	The Research Foundation for The State University of New York	78.29	69.29	87.24	69.31	83.23
51	University of Georgia	77.36	95.58	86.95	57.67	82.83
52	Tufts University	78.08	60.19	87.30	70.21	82.08
53	University of California, Berkley	79.85	74.21	61.99	87.81	81.73
54	University of California, San Francisco	75.40	78.56	67.52	82.19	81.68
55	Ohio State University	73.05	73.96	80.91	71.68	81.64
56	University System of Maryland	79.08	66.99	80.33	71.82	81.32
57	Clemson University	75.35	60.41	81.77	74.12	81.06
58	University of Arizona	66.98	77.47	80.76	70.51	80.72
59	University of Iowa Research Fdn.	69.17	66.52	83.25	71.62	80.67
60	Colorado State University	68.49	73.49	82.55	69.09	80.47
61	University of Akron	82.06	56.59	77.56	75.50	80.46
62	Princeton University	77.77	61.10	98.74	53.71	80.26
63	University of Oregon	59.38	92.02	89.79	57.12	80.20
64	University of California, Irvine	77.17	70.49	63.70	84.71	80.17
65	University of Massachusetts	78.66	68.06	91.96	56.65	80.08
66	University of Toledo	76.53	69.97	82.57	65.72	79.93
67	Memorial Sloan Kettering Cancer Center	66.31	82.62	98.85	48.30	79.89
68	Beth Israel Deaconess Medical Ctr.	69.00	70.84	85.21	65.77	79.87
69	Baylor College of Medicine	51.54	79.70	87.45	67.01	79.79
70	Yeshiva University	71.98	78.21	86.06	60.00	79.68
71	Rutgers The State University of NJ	79.95	80.25	87.59	54.07	79.64
72	Emory University	69.20	76.78	88.53	59.07	79.58
73	Washington State University	67.62	78.07	79.14	68.48	79.54
74	University of Connecticut	76.81	64.16	81.52	68.07	79.52
75	Mount Sinai School of Medicine of NYU	62.47	77.00	94.27	55.41	79.32
76	Southern Illinois University	69.70	56.17	82.74	72.72	79.30
77	Rice University	90.53	64.13	83.08	59.88	79.23
78	Texas A&M University System	69.25	69.24	87.20	62.57	79.19
79	Washington State University Research Fdn.	61.21	81.53	79.12	68.22	78.96
80	University of Kentucky Research Fdn.	76.20	55.66	84.07	67.61	78.83

Rank	Institution	Patent Issued Score	Licensing Issued Score	Licensing Income Score	Start-up Score	Index Score
81	Penn State University	72.11	64.01	81.16	68.20	78.65
82	The Salk Institute for Biological Studies	66.94	77.52	87.65	58.00	78.60
83	University of California, Santa Barbra	88.37	69.16	62.33	77.29	78.44
84	Brigham & Women's Hospital Inc.	68.57	75.07	86.94	57.55	78.02
85	University of Tennessee	73.92	63.60	81.24	65.69	77.96
86	Children's Hospital Boston	75.51	77.31	88.16	51.99	77.87
87	University of Arkansas for Medical Sciences	55.74	59.21	83.58	72.75	77.85
88	Florida State University	79.60	60.81	80.00	65.23	77.78
89	Cold Spring Harbor Laboratory	50.15	72.97	86.80	65.47	77.64
90	Utah State University	70.33	69.53	80.68	64.17	77.55
91	Louisiana Tech University	72.53	60.32	77.91	69.79	77.49
92	Louisiana State University System	66.17	69.62	87.27	59.16	77.49
93	Virginia Tech Intellectual Properties Inc.	63.92	67.81	82.16	65.87	77.43
94	Oregon Health & Science University	69.82	87.42	81.87	55.09	77.38
95	H Lee Moffitt Cancer Ctr & Res Institute	64.20	61.72	86.36	63.31	77.11
96	Tulane University	57.17	55.58	87.19	67.88	77.02
97	Iowa State University	71.58	87.41	86.88	48.37	77.02
98	University of Chicago/UCTech	64.86	65.98	86.73	59.40	76.57
99	Temple University	63.05	61.71	86.10	62.30	76.44
100	Dana-Farber Cancer Institute	70.85	79.51	85.78	51.14	76.25
101	University of Rochester	77.08	66.69	92.01	47.28	76.08
102	Portland State University	61.61	89.84	79.22	56.46	75.96
103	University of Kansas	73.89	72.52	88.93	48.28	75.72
104	Medical University of South Carolina	62.78	55.40	80.50	68.66	75.66
105	Cedars-Sinai Medical Ctr.	72.66	62.98	91.43	50.18	75.64
106	Rockefeller University	72.13	81.32	92.89	40.71	75.49
107	Virginia Commonwealth University	62.36	59.48	83.04	63.57	75.29
108	University of Vermont	67.66	58.85	80.08	63.73	74.99
109	University of Miami	53.61	62.30	83.77	64.22	74.85
110	Providence Health & Services Oregon	71.63	39.38	82.98	67.08	74.84
111	Indiana University (ARTI)	45.75	59.03	83.91	68.06	74.55
112	University of Cincinnati	68.32	69.50	77.64	59.35	74.24
113	Ohio University	72.02	34.95	91.60	57.98	74.00
114	North Dakota State University	64.92	91.75	84.22	42.98	73.59
115	Michigan Technological University	56.88	69.90	77.45	61.82	73.32
116	Hospital for Special Surgery	59.67	71.34	87.56	49.05	72.99
117	Georgetown University	70.30	53.29	89.09	50.67	72.98
118	University of Delaware	63.22	59.13	77.33	62.01	72.62
119	University of Arkansas Fayetteville	69.00	83.32	81.71	44.62	72.56
120	University of California, Riverside	65.91	82.13	62.37	65.72	72.53
121	Oklahoma State University	59.97	58.44	84.28	56.46	72.51
122	University of South Carolina	76.43	48.97	75.98	61.59	72.44
123	City of Hope National Medical Ctr. & Beckman Research Institute	65.46	56.82	100.00	38.73	72.38

Rank	Institution	Patent Issued Score	Licensing Issued Score	Licensing Income Score	Start-up Score	Index Score
124	University of Notre Dame	68.78	61.97	76.93	57.29	72.04
125	National Jewish Health	66.97	71.01	75.98	53.94	71.59
126	San Diego State University	51.94	68.84	80.54	56.54	71.51
127	Texas Tech University System	34.91	57.89	75.84	72.62	71.28
128	WiSys Technology Foundation	66.65	62.11	76.42	55.85	70.98
129	Thomas Jefferson University	61.09	62.16	82.15	52.42	70.96
130	University of Wisconsin at Milwaukee	59.88	64.99	72.76	60.56	70.75
131	New Jersey Institute of Technology	78.74	54.47	75.21	54.29	70.66
132	University of Oklahoma All Campuses	65.07	57.24	83.14	50.76	70.55
133	Kansas State University Research Fdn.	59.31	65.48	84.40	47.41	70.17
134	Dartmouth College	77.42	54.55	86.94	40.83	69.80
135	University of Alabama	66.51	54.85	70.14	61.16	69.41
136	Boston University/Boston Medical Ctr.	64.58	46.39	85.08	50.38	69.30
137	University of Alabama in Huntsville	51.32	37.43	82.37	62.18	69.14
138	East Carolina University	62.39	58.25	76.18	54.07	68.90
139	Rensselaer Polytechnic Institute	59.85	49.73	80.52	52.51	68.16
140	Georgia Regents University	64.45	61.98	75.29	49.91	67.93
141	Auburn University	71.85	65.83	80.98	38.42	67.56
142	Michigan State University	73.43	74.47	84.80	29.61	67.32
143	Montana State University	55.94	78.35	78.69	41.37	67.26
144	Duquesne University	75.37	41.25	58.75	67.90	66.88
145	Eastern Virginia Medical School	45.82	57.84	72.99	59.02	66.81
146	University of Mississippi	53.00	51.44	79.48	52.14	66.79
147	Brandeis University	62.49	49.17	84.75	43.31	66.61
148	University of North Carolina at Greensboro	44.76	66.54	72.93	53.81	66.05
149	Sanford-Burnham Medical Research Institute	73.64	54.89	85.64	33.59	66.01
150	Fred Hutchinson Cancer Res. Ctr.	46.02	60.48	89.87	38.70	65.97
151	Brown University	64.75	58.08	83.32	37.11	65.54
152	University of California, Santa Cruz	62.63	55.49	51.33	71.06	65.52
153	University of New Hampshire	48.93	92.68	78.56	33.44	65.39
154	Rochester Institute of Technology	63.59	49.14	78.55	45.72	65.35
155	The UAB Research Fdn.	61.11	69.19	84.33	31.03	64.83
156	Medical College of Wisconsin Research Fndtn	54.88	51.19	78.82	43.35	63.48
157	Mississippi State University	54.49	51.69	74.85	46.71	63.27
158	University of Idaho	56.01	60.43	80.98	35.73	63.09
159	Johns Hopkins University Applied Physics Laboratory	60.24	58.31	75.93	39.77	63.05
160	The Jackson Laboratory	58.18	97.31	85.31	14.03	62.85
161	University of South Alabama	44.38	56.36	85.59	37.16	62.83
162	University of Northern Iowa	42.91	50.23	74.53	51.37	62.79
163	University of Alaska Anchorage	53.42	52.22	66.88	52.51	62.35
164	Old Dominion University	64.07	51.09	66.38	48.63	62.24
165	Wistar Institute	53.41	70.89	94.98	15.21	61.90
166	West Virginia University	51.37	56.92	73.06	43.36	61.66

Rank	Institution	Patent Issued Score	Licensing Issued Score	Licensing Income Score	Start-up Score	Index Score
167	University of Memphis	60.04	49.93	70.64	43.31	61.00
168	Boise State University	63.42	92.22	70.93	23.14	60.88
169	Tufts Medical Center	57.12	35.75	82.62	38.22	60.83
170	Children's Hospital Los Angeles	0.00	56.99	80.19	52.45	59.48
171	University of California, Merced	53.68	57.61	44.15	62.69	58.52
172	New Mexico State University	43.64	46.10	58.06	56.87	58.09
173	University of Nevada at Reno	67.03	34.24	73.45	36.27	57.98
174	Wayne State University	68.68	43.43	78.13	26.66	57.88
175	University of North Texas Health Science Ctr.	51.14	52.05	73.21	35.40	57.87
176	Children's Hospital of Philadelphia	51.12	53.22	77.27	29.88	57.50
177	University of Hawaii	49.36	42.63	74.53	36.07	56.81
178	Creighton University	58.67	43.90	71.43	33.86	56.52
179	South Dakota State University	42.51	70.57	84.71	15.33	56.23
180	Northern Arizona University	51.48	28.12	71.70	38.05	54.47
181	Nationwide Children's Hospital	48.01	51.03	78.55	22.59	54.37
182	Wichita State University	33.52	48.93	61.15	45.83	53.89
183	St. Jude Children's Research Hospital	52.96	66.04	88.64	0.00	52.88
184	Lehigh University	67.06	32.19	77.71	18.71	52.62
185	University of Louisville	71.03	59.23	82.65	0.00	52.44
186	New York Blood Ctr.	60.40	47.82	87.57	0.00	50.72
187	Lawrence Livermore National Laboratory	0.00	40.24	82.94	32.98	50.43
188	Children's Hospital Cincinnati	55.16	64.51	81.68	0.00	50.35
189	Woods Hole Oceanographic Institute	38.14	29.78	77.31	25.72	50.04
190	University of Rhode Island	60.64	60.52	76.19	0.00	48.51
191	University of North Dakota	54.95	33.54	75.24	14.45	48.32
192	Case Western Reserve University	76.39	73.43	0.00	63.01	48.17
193	Fox Chase Cancer Center	31.15	73.74	80.63	0.00	47.56
194	Augusta University	56.41	55.52	77.01	0.00	47.33
195	Northern Illinois University	73.63	44.33	74.25	0.00	47.26
196	Boyce Thompson Institute for Plant Research	39.04	67.28	77.85	0.00	46.73
197	University of South Dakota	33.41	22.84	68.40	29.54	46.22
198	Children's Hospital Oakland Research Institute	62.88	46.28	75.13	0.00	46.16
199	Marquette University	60.45	30.15	81.72	0.00	45.65
200	University of Dayton	57.44	44.02	73.99	0.00	44.48
201	Washington University of St. Louis	70.15	77.85	0.00	52.60	43.94
202	Rush University Medical Center	37.36	31.50	86.04	0.00	43.76
203	Loyola University of Chicago	43.88	13.25	88.05	0.00	42.61
204	George Mason University	67.74	19.05	71.83	0.00	41.28
205	Blood Center of Wisconsin	0.00	58.32	81.02	0.00	40.14
206	Wright State University	53.34	30.62	68.91	0.00	39.72
207	The Catholic University of America	50.48	0.00	80.22	0.00	38.57
208	The University of Southern Mississippi	23.68	35.33	74.73	0.00	37.87
209	Colorado School of Mines	63.28	63.76	0.00	40.86	36.09

Rank	Institution	Patent Issued Score	Licensing Issued Score	Licensing Income Score	Start-up Score	Index Score
210	Wake Forest University	0.00	67.93	0.00	65.66	35.89
211	Lawrence Berkeley National Laboratory	33.07	25.70	29.20	39.36	35.50
212	The Forsyth Institute	43.62	0.00	70.49	0.00	33.77
213	Miami University	34.29	0.00	67.43	0.00	31.10
214	University of West Florida	0.00	39.25	62.56	0.00	30.06
215	Florida International University	19.80	0.00	69.70	0.00	29.61
216	University of Maine	64.26	46.63	0.00	26.71	28.11
217	University of North Florida	0.00	0.00	67.27	0.00	25.47
218	Research Corporation Technologies	18.86	25.38	47.55	0.00	25.18
219	Illinois State University	37.11	26.62	0.00	0.00	10.34
220	National Radio Astronomy Observatory	47.09	0.00	0.00	0.00	7.64
221	University of Louisiana at Lafayette	0.00	41.73	0.00	0.00	6.77
222	Children's National Health System	31.73	0.00	0.00	0.00	5.15
223	Ball State University	29.85	0.00	0.00	0.00	4.84
224	University of Denver	24.78	0.00	0.00	0.00	4.02
225	California State University Institute	0.00	0.00	0.00	0.00	0.00
225	Embry-Riddle Aeronautical University	0.00	0.00	0.00	0.00	0.00
225	Hackensack University Medical Center	0.00	0.00	0.00	0.00	0.00
225	Idaho State University	0.00	0.00	0.00	0.00	0.00
225	Kent State University	0.00	0.00	0.00	0.00	0.00
225	Salish Kootenai College	0.00	0.00	0.00	0.00	0.00

* *Please note that this complete list of results includes both universities and research institutions, and therefore does not align completely with the Top 25 Universities results discussed earlier in this report.*

7 APPENDIX

7.1. METHODOLOGY OF INDEX CONSTRUCTION

Step 1: Data Collection

- Using the AUTM data for the four most recent years we have averaged five variables by institution so that each one has a data point. (1) Patents Issued, (2) Licenses Issued, (3) Licensing Income, (4) Start-ups Formed, and (5) Total Research Funding. Total research funding is not one of the index indicators but is used in the calculations.

Step 2: Transforming Variables-part 1

- Patents Issued, Licenses Issued, Licensing Income, Start-ups are standardized by Total Research Funding. This results in a total of eight variables both averaged and standardized.

Step 3: Transforming Variables-part 2

- We take each one of these variables and take their natural logarithm.
- From here we score each institution out of 100 based on the highest scoring institution for each variable.

Step 4: Index Calculation-Stage 1

- Taking the averaged variable and its standardized counterpart we weight both of them equally 50%-50% and multiply them together. This results in four different score variables.

Step 5: Index Calculation-Stage 2

- We weight these four score variables: Patents Issued (15%), Licenses Issued (15%), Licensing Income (35%), and Start-ups Formed (35%) and multiply these weighted variables together. Multiplying these variables together yields a raw index score.

Step 6: Index Calculation Final Calculations

- From this score we again index out of 100 based on the highest scoring institution for each variable and rank them.

Table 6: Milken Institute

Indicators		Weights for Stage 1	Weights for Stage 2
Patents Issued	Count	50%	15%
	Count per Research Dollar	50%	
Licenses Issued	Count	50%	15%
	Count per Research Dollar	50%	
Licensing Income	Count	50%	35%
	Count per Research Dollar	50%	
Start-ups	Count	50%	35%
	Count per Research Dollar	50%	

Additionally ensuring that institutions were not counted twice on account of their data being labeled differently for the same institution was a key factor in data quality. There are several university system offices that account for multiple TTOs. We broke out the University of California system but University of Texas, Texas A&M, North Texas, Missouri, Maryland, and Oklahoma systems where not broken out because of lack or quality of data issues. Due to data availability and measurement concerns, factors like consultancy, job creation, and capacity have been left out of this index.

7.2. SUPPORTING TABLES FOR CASE STUDY IN SECTION 4.2

Table 7

One tail two-sample T-tests of equal variance with correlations		
Correlations (T-statistics)	**NAICS 3254 Employment**	**NAICS 3391 Employment**
Hospitals	0.42 (5.39)***	0.39 (7.17) ***
Medical School	0.59 (5.39) ***	0.46 (7.17) ***
LN (Total Research Funding)	0.55 (5.33) ***	0.53 (7.09) ***

*H0 : μ1=μ2, H1: μ1>μ2, *=10% **=5% ***=1% confidence level, NAICS sectors are sample one and university hospitals, medical schools and the natural logarithm of total research funding are sample 2.*

Table 8: Life Science Metro Clusters vs. States

Metropolitan clusters of the top tier states by sectors 3254 & 3391 output		Bottom tier states by sectors 3254 & 3391 output	
Boston, MA	San Francisco, CA	New Mexico	Arkansas
New York City, NY	Houston, TX	Vermont	Wyoming
Philadelphia, PA	Chicago, IL	Idaho	Nevada
Durham, NC	Baltimore, MD	Montana	Hawaii
Bridgeport-Stamford-Norwalk, CT	Indianapolis-Carmel-Anderson, IN	Oregon	Arizona
Omaha-Council Bluffs , NE			

Sources: Moody's Analytics, Milken Institute.

ENDNOTES

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