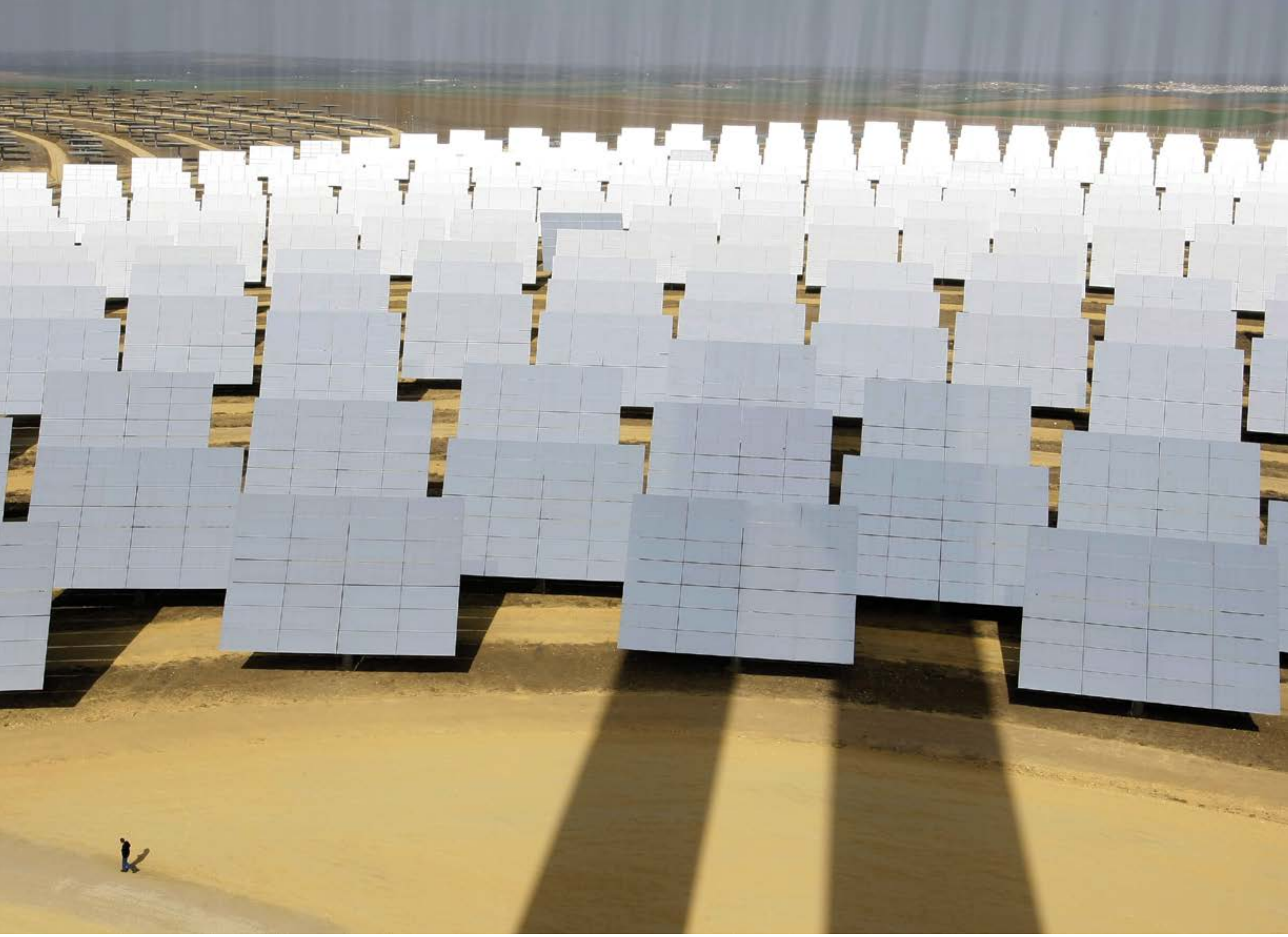

# Measuring Innovation, Knowledge Transfer and Economic Impact at Universities & Public Research Institutions

A Whitepaper

THOMSON REUTERS

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# Table of Contents

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# Executive Summary

This white paper outlines the nature of economic impact at universities and research organizations, suggests potential indicators of industry engagement and economic impact, demonstrates the pathway to economic impact via two cases studies and ranks leading U.S. universities and research organizations by their economic impact. This ranking is based on cutting-edge indicators from Thomson Reuters gold standard resources.

Findings include:

- Indicators to measure economic impact are not well developed for systematic institutional comparisons
- Data collected independently of institutions can measure performance regarding economic impact
- The time from initial investment in basic research to economic impact can take decades
- There are significant variances in data depending on the industrial sector involved
- Institutions may have impact on companies with which they are not directly collaborating
- MIT is the leading US university for economic impact, followed by Stanford and Harvard
- The Department of Health and Human Services (DHHS) is the leading non-university and comes in second overall; other governmental organizations have high volume in patent applications but little economic impact

# Introduction

Since World War II, research at universities and research organizations around the world has been better funded and more tightly managed than ever before in history. Indeed, research organizations and universities are now viewed not just as producers of knowledge and trainers of the next generation of leaders, but also as economic engines that convert public funding into knowledge, scholarship and products with an economic impact as a by-product of this engine's activity (Stephan, 2012). This explosion in the resources made available to universities for research and scholarship has been met with increasing interest in understanding how best to manage these resources and the activities they enable.

Gathering data on and facilitating analysis of universities' impact beyond traditional indicators of scholarly output is a difficult and mostly ad-hoc process. Universities are increasingly using their own data warehouses and analytic tools to understand how faculty, staff and students are generating new knowledge and how that new knowledge impacts the local, regional and national economy.

This paper describes the role universities and government research organizations play in the various pathways to economic impact and innovation, suggesting a variety of direct and indirect indicators. It also includes two case studies and an analysis of the economic impact of U.S. universities and government organizations based on datasets available today.

# Part I
# The Nature Of Economic Impact

### Defining the scope

Societal and economic impacts are intrinsically linked. For example, a policy to increase accessibility to university education for underprivileged youths can lead to societal impacts such as social mobility, empowerment and crime reduction, but may also have the economic impact of developing a skilled workforce and capacity for local industry.

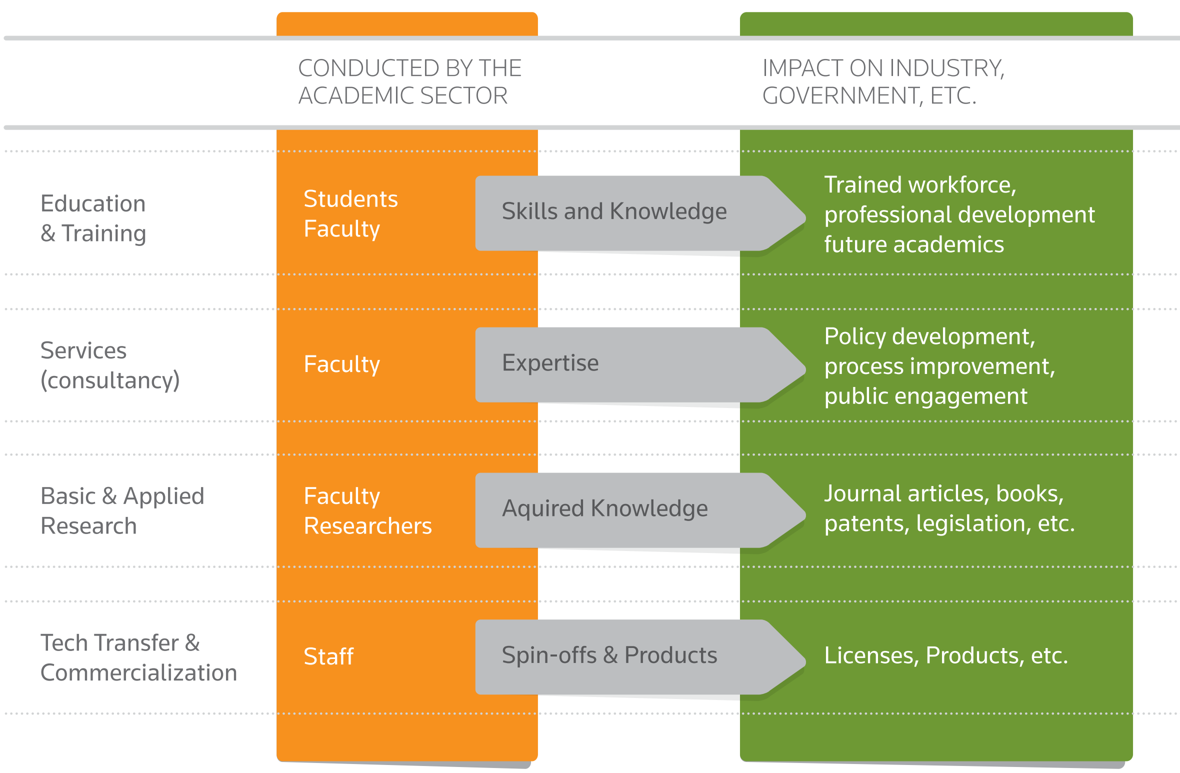
Although issues such as social inclusion, social mobility and societal impact are extremely important, this paper is focused on how one might quantify the innovation, knowledge transfer and the economic impacts of a university's multiple missions of research, education and services. The aim is to understand the nature of these activities so as to inform strategies for new data acquisition and indicator development.

### Different university missions result in different impacts

In the LERU paper "What are universities for?"(Boulton & Lucas, 2008), some of the multiple missions of universities are discussed and it is important to recognize that there is not a single model for a university or research organization. These differing missions will lead to different outcomes or impacts and the university's contribution to innovation and the economy is only part of the broader picture.

In general, there are four different mission areas through which universities can realize a direct economic benefit or impact. A schematic of this is depicted in Figure 1.

FIGURE 1: Schematic of the interaction between the academic and non-academic sectors




*Source: Thomson Reuters*

Other results may have an impact that is less direct to measure and therefore more challenging to credit. In addition, when developing indicators that demonstrate a university's economic impact, it is critical to measure the context and environment of the activity (e.g. research funding received via industry partners).

### The pathways of economic impact

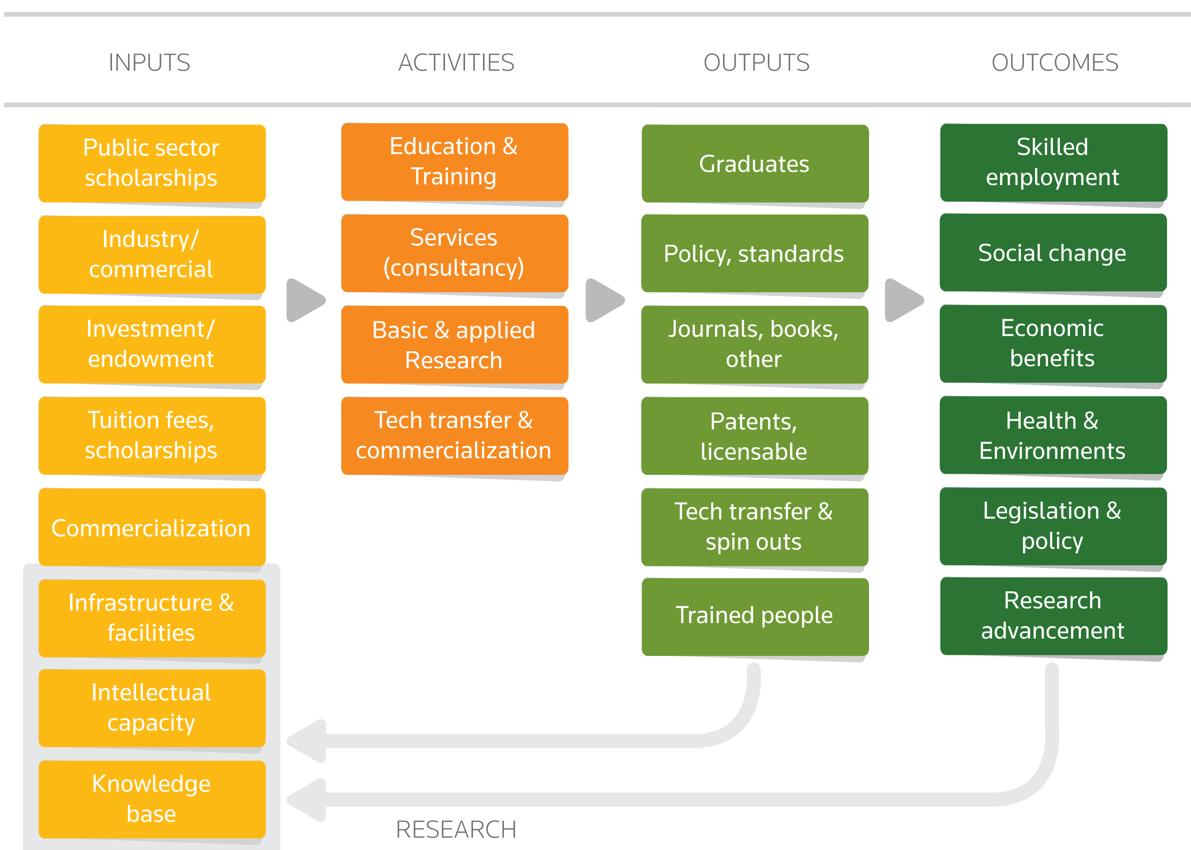
Figure 2 shows the flow from research inputs to research outputs and outcomes (or impact) and the associated key points.

One of the challenges to identifying and measuring impact is that time scales may be very long and there are many different pathways. For each individual outcome it may be possible to map all the activities and identify potential indicators for the different steps on the pathway. However, when looking at the macro scale of an institution or a country, a case-by-case mapping exercise becomes infeasible.

By looking at data in aggregate, indicators of the different steps towards economic impact can be considered proxies for performance. For example, even though a patent application may not necessarily result in a commercial product, measuring the total volume of patent applications produced by a university will indicate performance on the pathway to produce commercial products.

As with all evaluation methodologies, the use of multiple indicators portrays a more complete picture of the environment and performance.

FIGURE 2: The pathways of economic impact




*Source: Thomson Reuters*

# CASE STUDY 1:

## University innovation and economic impact case study–The path to a blockbuster drug

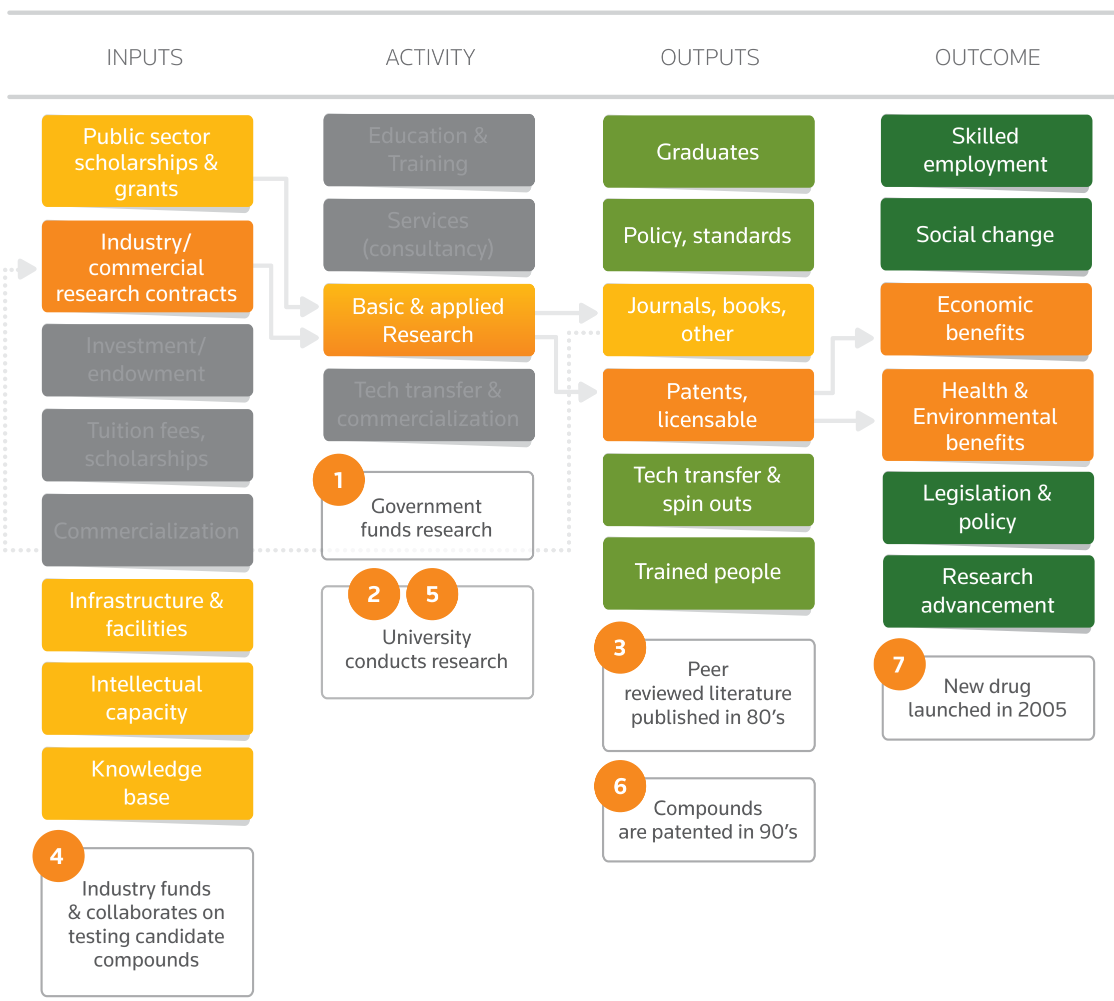
Figure 3 shows the key milestones in the development of a blockbuster drug that was originally researched by university faculty and eventually brought to market with huge success. This example underscores the length of time needed for the full impact of collaborative research to reach fruition.

During the first part of the 1980's, government funding (#1) supported in part university research (#2), which resulted in the discovery of new compounds that were shown to affect key components in the biological pathway of interest for epilepsy and other disorders.

The findings of these research projects, as reflected in peer-reviewed literature (#3), drew the interest of an industry partner, and in subsequent years the company worked with the faculty member to fund additional research (#4) to test a number of candidate compounds for efficacy in a mouse model of the disease (#5). One compound was found to be promising, and during the late 80's through the mid 90's the university and its industry partner were granted a series of patents (#6) that covered these compounds for use in modulating this biological pathway.

The compound then moved into clinical trials, was approved by the Food & Drug Administration (FDA) and released to market in 2005 (#7), reaching over $2 billion in annual sales. This success story of the impact of basic research was over 20 years in the making and provides an instructive case for consideration of the timelines relevant to measuring university impact.

FIGURE 3: The pathways of economic impact for a blockbuster drug




Source: Thomson Reuters

At different points on the pathway there are potential indicators of future success. For example, the acquisition of research funding from industry in step #4, papers co-authored with industry in step #5, and patents citing literature in step #6. Although the actual economic impact (and societal impact in terms of health benefits) can be measured in step #7, the long timescales required for regulatory approval of new drugs make this a less attractive indicator of the current performance in the academic sector. It is therefore advantageous to monitor data points along the pathway as predictors of economic impact.

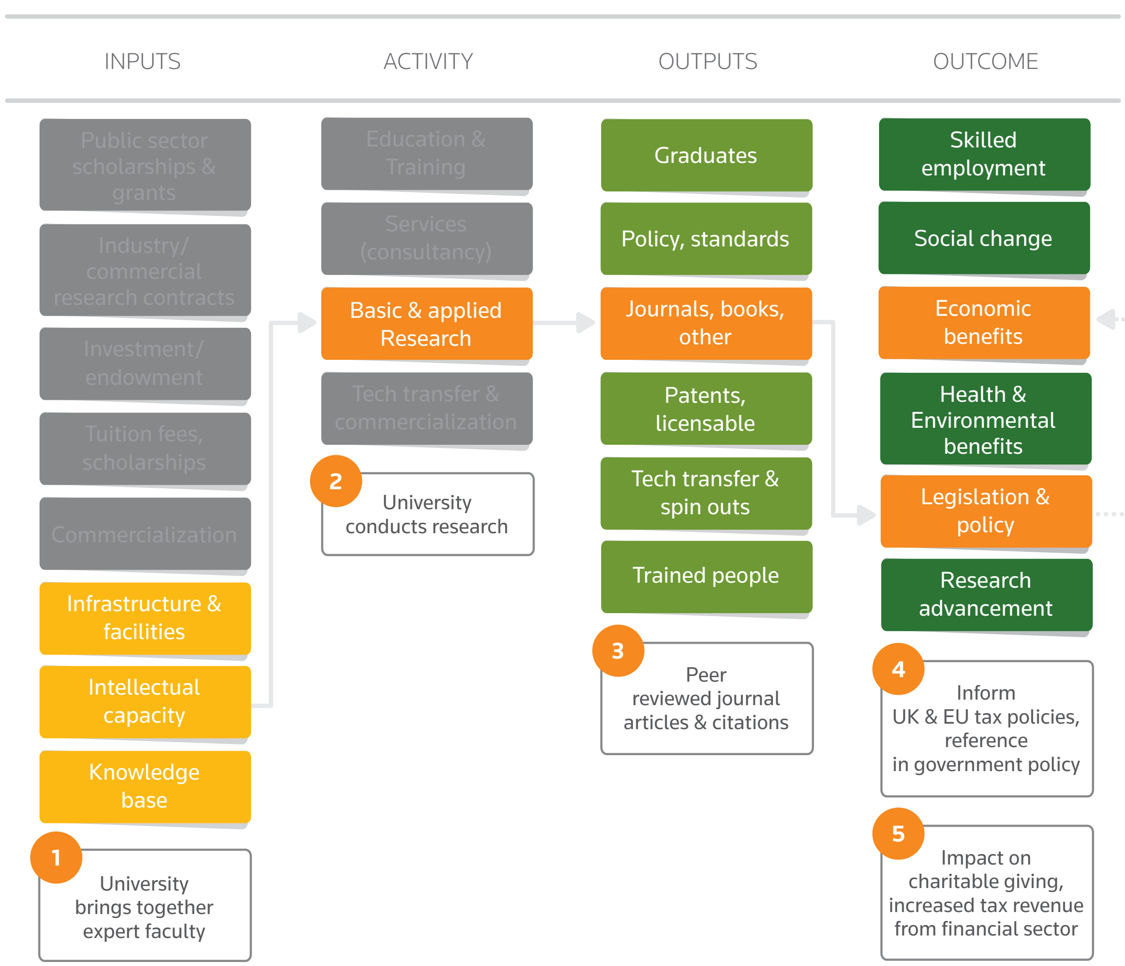
## CASE STUDY 2:

### Economics research impact on European Tax Policy

Figure 4 outlines how basic research impacts tax policy within the European Union (EU). Professors Kimberley Scharf and Benjamin Lockwood at the University of Warwick (#1) in the UK, influenced public policy debate leading to tax policy changes in the UK and EU. Scharf estimated the impact of proposed reforms to the UK Gift Aid program (#2 and #3), research that improved public understanding, led to the creation of an open discussion forum for affected parties, and shaped NGO/charity campaigns (#4 and #5).

Lockwood estimated the tax effects of removing UK VAT (goods and services tax) exemption from firms offering financial services in the EU (#2 and #3). The methods developed were adopted by EU analysts and underpinned EU estimates of the tax advantages enjoyed by the sector, leading to the 2011-12 imposition of a Financial Transactions Tax within 11 EU member states beginning in 2014 (#5).

FIGURE 4: The pathways to economic impact for research on European Tax Policy




*Source: Thomson Reuters*

## Potential indicators of economic impact

In this section we introduce some potential indicators of economic impact. These are by no means exhaustive and many of the activities and impacts described have been identified by other initiatives and efforts at defining metrics for assessing the economic impact of universities. An important underlying premise for most is that no single metric is sufficient. This is echoed by several other organizations as well.

For example, the Association of Public and Land-Grant Universities (APLU)'s Commission on Innovation, Competitiveness, and Economic Prosperity (CICEP) released in May 2014 their New Metrics Field Guide (New Metrics Field Guide, 2014), as a part of their Economic Engagement Framework. This guide emphasizes, as we do, that no single metric is sufficient. Their main areas of impact include: relationship with industry, developing the regional and national workforce and knowledge incubation and acceleration programs.

In another example from 2014, the Universities UK released its report entitled The Impact of Universities on the UK Economy (Kelly, McNicoll, & White, 2014) in which data from the Higher Education Statistics Agency (HESA) was analyzed to understand university income, employment profiles, expenditures and multiplier effects on the economy. This study considered the UK Higher Education Industry as a whole, facilitating economic modeling and allowing the authors to directly measure university impact on the economy.

There are many challenges with the development of similar indicators that include a global perspective, such as: the lack of a unified economic statistics data set, the lack of data collection protocols and definitions and a lack of centralized data warehousing. However, as discussed in Part II of this report, some of the indicators are available independently of the universities and research organizations and can be analyzed today.

### 1 | EDUCATION AND TRAINING

Universities play an important role in developing a highly skilled workforce through the formal education of students, professional training and the development of faculty and researchers. This workforce then goes on to be employed in the public and private sectors resulting in innovative and economic activities. Potential indicators of the economic impact of education include:

- Graduate employment rates
- Average graduate salaries (after x number of years)
- Value, enrollment and number of professional training/development programs
- Number and proportion of courses accredited/recognized by professional bodies
- Number of and enrollment in entrepreneurship courses/programs
- Value and number of scholarships awarded by industry or investment made by the commercial sector in education or professional development
- Alumni in positions of leadership or esteem, for example, executives in large companies, membership of professional bodies, successful artists, etc.*

### 2 | BASIC AND APPLIED RESEARCH

Basic and applied research carried out at universities is by its nature novel and can achieve social, cultural and economic benefits. There may be many different pathways to impact, and during the course of the research lifecycle there can be interim steps where impact is achieved and subsequently built upon. Measures of inputs and outputs of research that are relevant when considering a university's innovation or economic impact include:

- Value of research contracts from industry
- Number of research contracts from industry
- Number of papers that contain acknowledgement of funding from industry*
- Number and proportion of papers co-authored with industry*
- Number of articles that have been cited by papers authored by industry and the volume of citations*
- Patent applications made by the university*
- Proportion of patent applications that were granted*
- Number of patents that have been cited by other patents and the volume of citations*
- Number of articles that have been cited by patents and the volume of citations*

** Used in the analysis in Part II*

## 3 | TECHNOLOGY TRANSFER, COMMERCIALIZATION

Commercialization of scholarly research through the licensing of intellectual property and the transfer of skills, knowledge and technology are typically not measured systematically. The following are suggested measures of the context and impact of university activities for technology transfer and commercialization:

- Number of university staff in technology transfer offices
- Number of disclosures
- Number of intellectual property licences
- Value of intellectual property income
- Number of active patents
- Venture capital investment in spin-off companies
- Number of spin-off companies
- Value of sale of shares of spin-offs
- Proportion of spin off companies still in operation after 5 years
- Revenue of spin off companies after 5 years

## 4 | CONSULTANCY SERVICES AND NON-PROFIT SECONDARY IMPACT IN PRACTICE

Many universities provide a variety of consulting and services that make faculty expertise available to industry and government. These services frequently lead to economic benefits in terms of improved decision making, improved efficiency and process.

- Number of consultancy contracts or engagements
- Value of consultancy revenue
- Number of faculty on advisory boards of companies, NGOs and government organizations
- Co-authorship, citation or news mention in acts of parliaments
- Co-authorship, citation or news mention in changes to statutes
- Co-authorship, citation or news mention in regulations, standards and legislation
- Co-authorship, citation or news mention in policy recommendations
- Authorship of new datasets or resources that facilitate improvements to business processes


**REUTERS/**JAMAL SAIDI

# Part II
# Sample Analysis Using Currently Available Indicators

In part I of this paper we introduced some of the potential indicators that can be used to measure the economic impact that universities have. In Part II, we take a closer look and perform a sample evaluation using indicators derived from Thomson Reuters services that can be applied to any organization without the need for additional data collection from that organization.

## Scope and methodology:

The data comes from three different sources:

- Data on scholarly publications and citations are sourced from Thomson Reuters InCites™, which is the gold standard for bibliometric evaluation (http://researchanalytics.thomsonreuters.com/incites/)
- Patent data is sourced from Thomson Reuters Derwent World Patents Index (DWPI), which is the world's largest and most authoritative database of patents. The Patent Citation Index is also used which is a complementary database of patent citations (http://ip.thomsonreuters.com/product/derwent-world-patents-index)
- Thomson Reuters Officers & Directors information is sourced from the Thomson Reuters Finance & Risk division (http://thomsonreuters.com/en/products-services/financial/company-data/officers-directors.html)

For the purposes of simplicity and comparability, this analysis is limited to organizations based in the United States and only to the top 25 public organizations as measured by the number of basic patents filed with the United States Patent and Trademark Office (USPTO).

A unique invention is defined as the first publication of a patent document for a new technology, drug, business process, etc. In DWPI, these are called "basic" patents. DWPI provides a record of patents published by 50 patent issuing authorities worldwide to enable a comprehensive picture of the innovation landscape. Subsequent filings for the same invention are recorded as patent "equivalents" in DWPI and collated into "patent families". For this analysis, equivalent patents were not included in the patent count; however, equivalent patents are used as part of additional analysis such as to determine the global diversity of a patent filing or if the patent has been granted or not.

For both the patent and article analysis, the time period has been limited to 2008-2012. This retrospective approach allows sufficient time for citations to accumulate and for patent examinations to have been conducted by the USPTO, is also sufficiently current to represent recent performance. A five year period was chosen for statistical relevance and stability.

For the article analysis, the specific sources are the Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) and the Arts & Humanities Citation (A&HC) Index. The document types are limited to articles and reviews only.

Care is taken to unify name variants throughout the process. For example, items affiliated with the Harvard Business School will be unified to Harvard University.

It is not always possible to disambiguate the different components of university systems. For example, all patents by the University of California are filed through a central administration office and it is not possible to disambiguate which of the various campuses conducted the research. This is not a deficiency in the data analysis or indexing, but it is an artefact of how the university administers its intellectual property. For purposes of this analysis, university systems are mostly used instead of the individual campuses.

Table 1 details a description of each indicator and the activity it performs.

TABLE 1: Indicator descriptions & sources

| INDICATOR | ACTIVITY | SOURCE | DESCRIPTION |
|---|---|---|---|
| Number of patents | Output | DWPI | The number of basic patents filed by the organization is an indication of research output with potential for commercial value. |
| Granted patents per application | Outcome | DWPI | The proportion of patent applications that are granted shows the success rate in the patent filing process and indicates the significance of the inventions. |
| Patent global diversity | Outcome | DWPI | The proportion of patents that have been filed in a second major country is a measure of the globally diversity of the patent portfolio. Filing a patent is an expensive and laborious process and filing in multiple countries is an indication that the invention is non-trivial and has commercial value. |
| Patent citations per patent | Outcome | DWPI | This indicator measures the average number of times a patent family has been cited by other patents. As part of the patent inspection process, the patent examiner will cite relevant prior art. The number of times a patent has been cited is an indication that it has had impact on future R&D. |
| % patents cited one or more times | Outcome | DWPI | This indicator is the proportion of papers that have been cited by other patents one or more times. It is a complementary indicator to the “Patent citations per patent” indicator. |
| Patent citations per article | Outcome | DWPI / InCites | Similar to “Patent citations per patent,” this indicator measures the average number of times an article has been cited by patents. This unique indicator is an indication that basic research conducted in an academic setting (as measured by articles) has had influence and impact upon commercial R&D (as measured by patents). |
| % Articles co-authored with industry | Output / Outcome | InCites | The volume articles that contain one or more co-authors from a commercial entity. This indicator shows the volume of research activity that is conducted in collaboration with industry and is an indicator of potential future economic impact. |
| Citations affiliated with industry per article | Outcome | InCites | Article-to-article citations are an established indicator of influence and research impact. By limiting the citing items only to those items that are affiliated with industry, it becomes an indicator of the influence and impact that basic research conducted in an academic setting has had on commercial research. |
| % Articles containing acknowledgement of funding from industry | Input | InCites | An indication of commercial sector investment. Although the articles themselves are a research output, the funding acknowledgment is an indication of research funding and is therefore an input measure. |
| Officers & Directors (F&R) Alma Mater | Output | Finance & Risk | Officers & Directors are senior executives in global companies. This indicator counts the number of executives per organization. This is a long-term indication of a university’s ability to create industry leaders and train an elite workforce. |

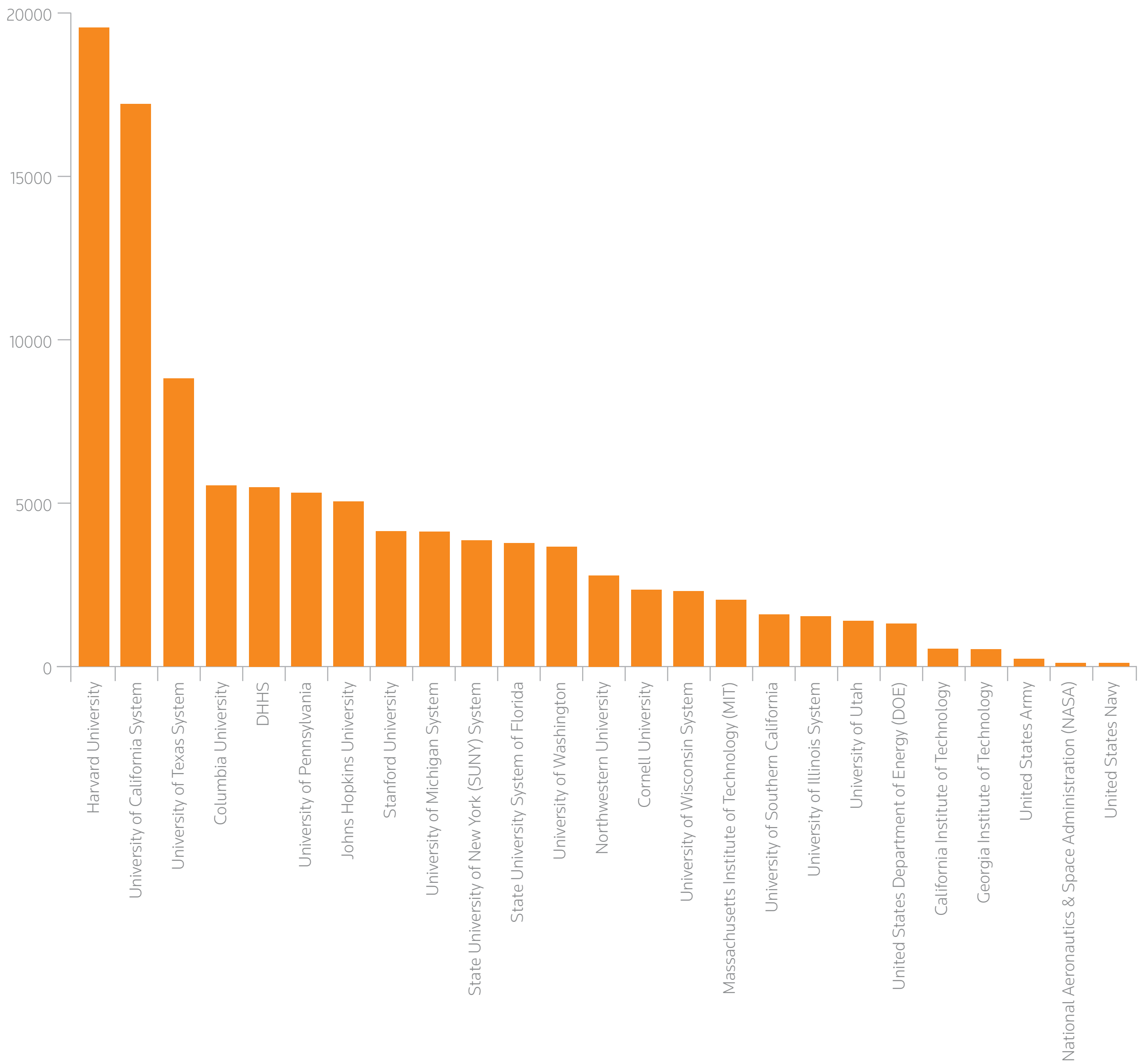
## Results

The indicator descriptions and sources can be used to indicate performance in the various aspects of innovation, knowledge transfer and economic impact. Many of the activities are impossible to measure directly but these indicators can act as a proxy for performance.

Each indicator in isolation may not be a robust indication of performance, but taken together they can identify those institutions that are having the most impact.

## Results

CHART 1: Number of research articles that acknowledge receiving funds from industry

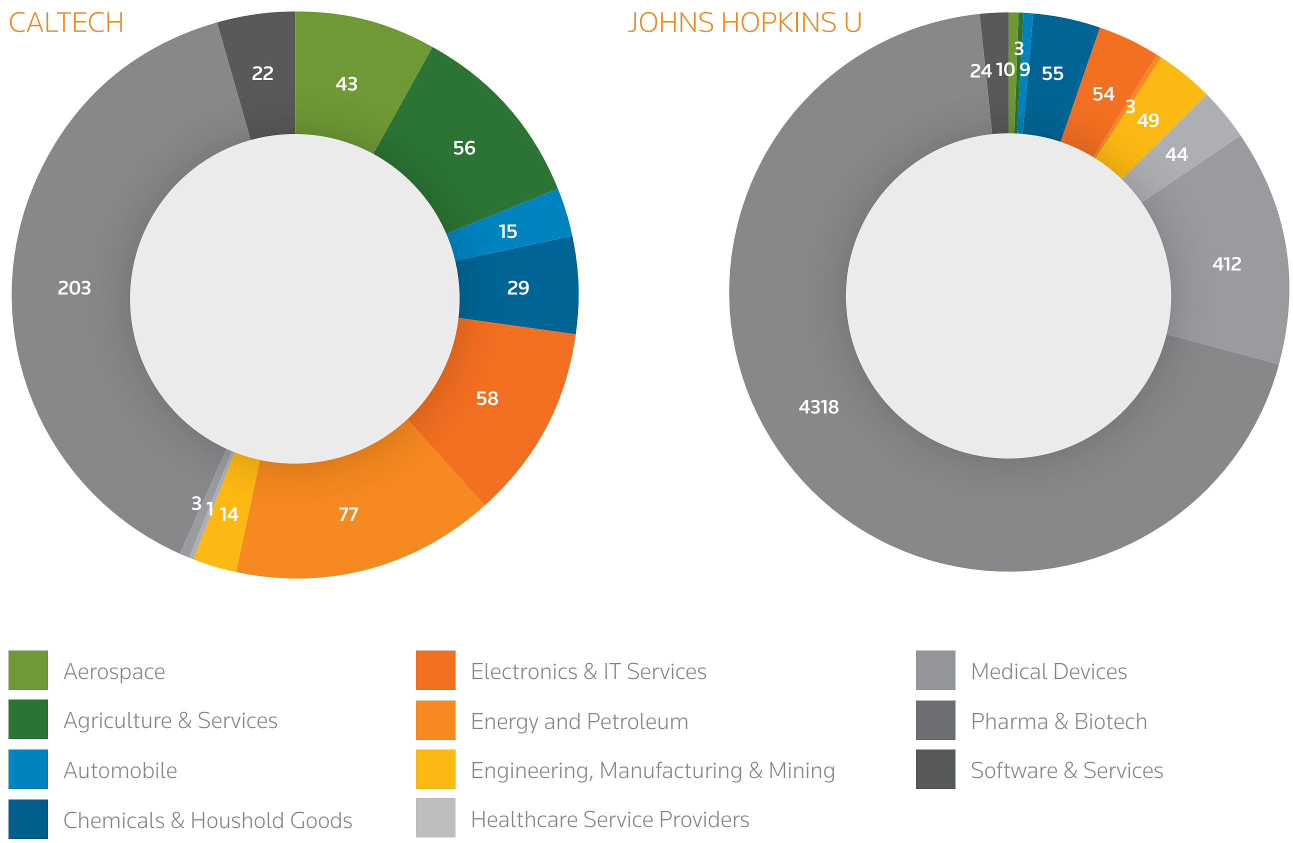



*Source: Thomson Reuters Web of Science*

Chart 1 shows the number of scholarly articles affiliated with each university that contain acknowledgment of funding support from a commercial entity. Although a scholarly article is an output of research rather than an input, the funding acknowledgement is an indicator that a commercial organization has provided financial support for the research.

Looking at the data, there appears to be bias toward organizations with a focus on health and medicine. This is consistent with other bibliometric indicators where there tends to be a higher volume of academic papers published in health related disciplines than other disciplines. This is explored further in this paper.

CHART 2: Number of research articles that acknowledge receiving funds from industry, by industry sector




*Source: Thomson Reuters Web of Science*

Chart B shows the difference in the origin of corporate research funding by industry sector as measured by the count of funding acknowledgements.

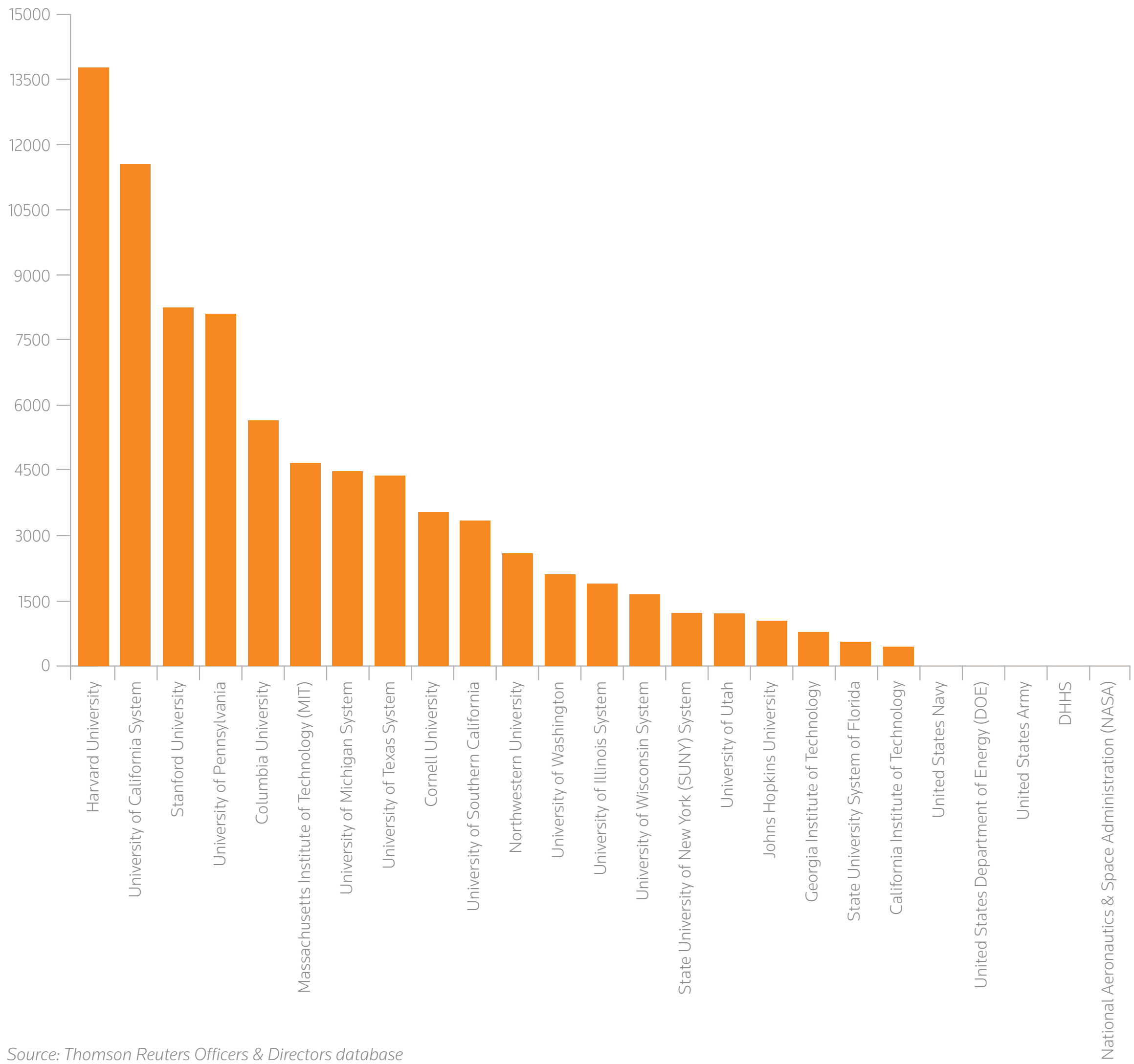
In the case of Caltech, even though it doesn't have a medical school, it conducts research in the life sciences area which is relevant to the pharmaceutical and biotech industries.

However, a university that has a focus on medical sciences, such as Johns Hopkins University, shows how the pharmaceutical, biotech, medical devices and healthcare sectors account for approximately 95% of all funding acknowledgments.

REUTERS/MORTEZA NIKOUBAZI

## Output Indicators

CHART 3: Officers & Directors (O&D)

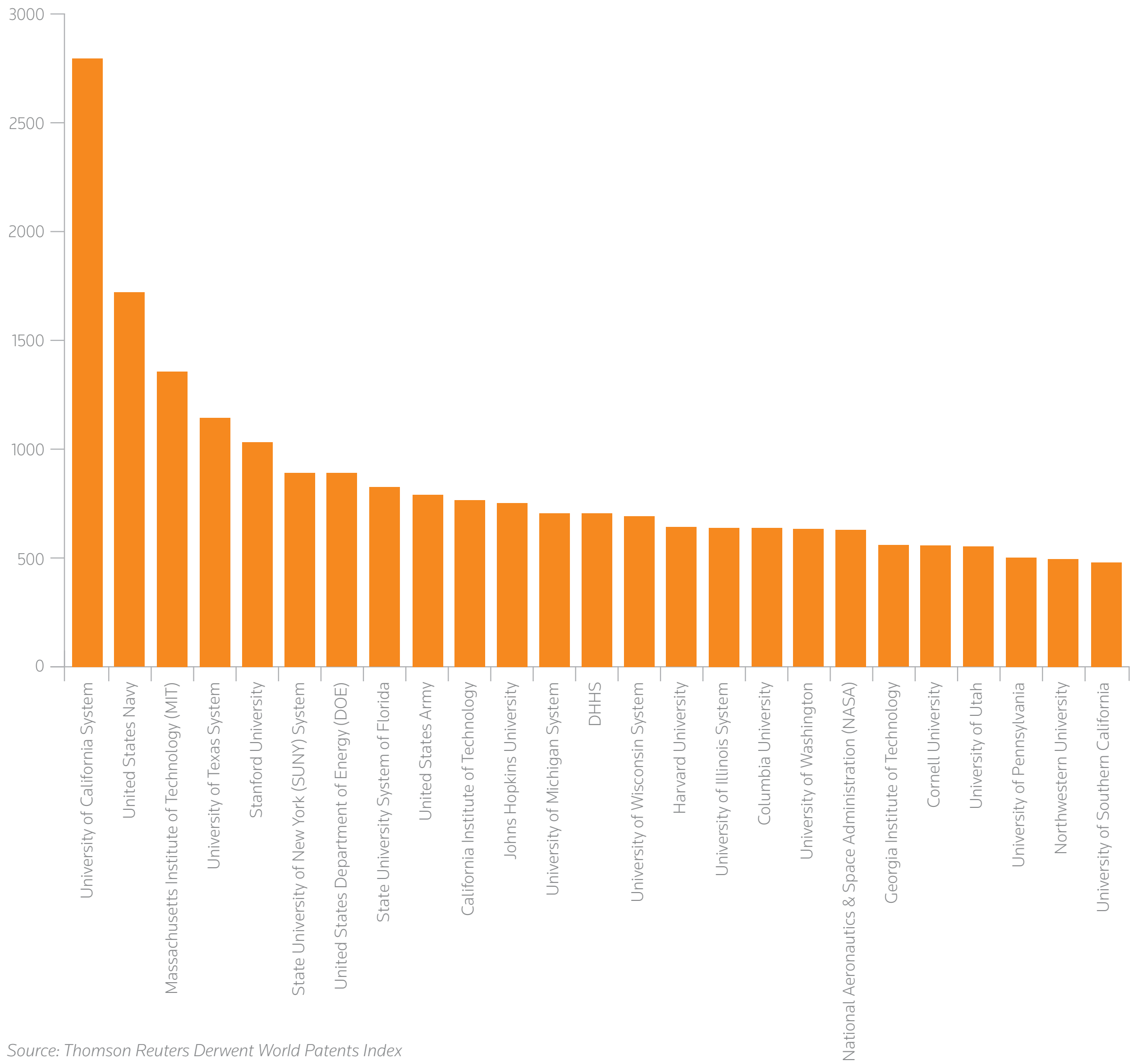



*Source: Thomson Reuters Officers & Directors database*

Chart 3 shows the number of Officers & Directors (members of the executive boards of global listed companies) that graduated from each university. Non-university research organizations are included in the analysis, but as they do not have any graduates are given a value of 0.

This indicator is a proxy for the impact that the universities' education programs have in terms of the ability to train people for a leadership role in a corporate environment.

CHART 4: Volume of patents



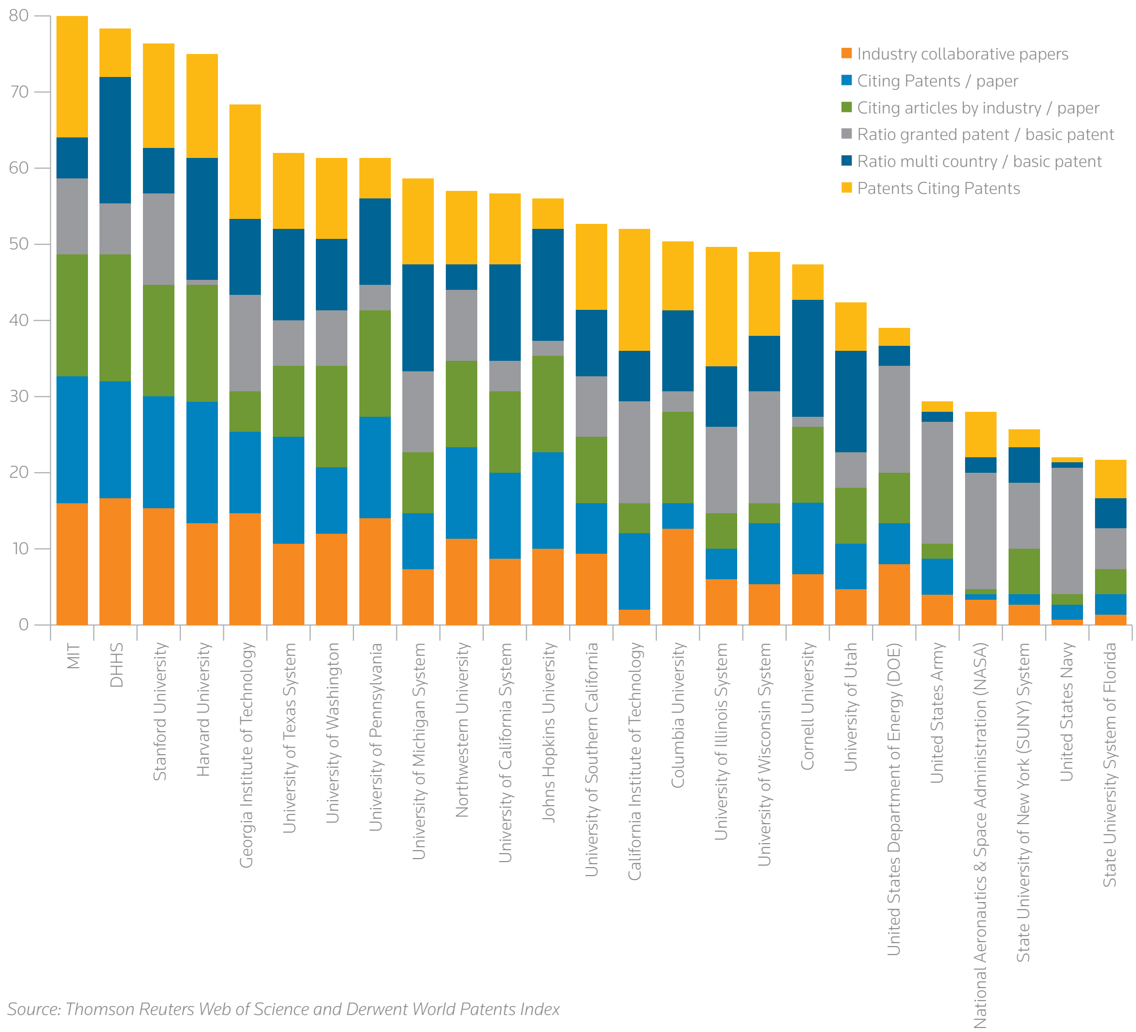

*Source: Thomson Reuters Derwent World Patents Index*

Chart 4 shows the volume of basic patents for each organization listed in DWPI between 2008 and 2012. The volume of patents is an indication of the amount of research that has commercial value. However, patent activity may be influenced by other factors, such as that the organization may have mandates to encourage faculty to apply for patents.

The very high volume of patents by governmental organizations, particularly the US Navy, is surprising. The volume of patents is proportionally higher than its volume of journal articles. The reasons for this high volume of patent activity is not clear but may be related to the organization's desire to control and protect its intellectual property rather than a desire to commercialize it.

## Outcome Indicators

CHART 5: Summary of the performance by outcome (impact) indicators for the top 25 US organizations




*Source: Thomson Reuters Web of Science and Derwent World Patents Index*

Chart 5 shows the combination of all outcome (impact) indicators.

Two of the indicators used ("% of patent families cited" and "average patent cites / patent family") are different aspects of the same outcome and therefore have been combined into a single indicator (Patents Citing Patents). As such, there are six distinct indicators each with equal weighting.

To combine the indicators, each organization is assigned a score based on the inverse of the ranking position of the organization for that indicator. Scores have been adjusted to range from 1 to 16.67 so that the theoretical maximum combined score (if the organization were ranked #1 in every indicator) is 100 and the theoretical minimum combined score (if they were ranked last in every indicator) is 6.

MIT takes the lead, performing well in all indicators except the ratio of multi-country to basic patents.

The Department of Health and Human Services (DHHS), which includes the National Institutes of Health (NIH), the Food & Drug Administration (FDA) and the Centers for Disease Control and Prevention (CDC), comes in second. This is in strong contrast to the other governmental organizations on the list—the US Army, US Navy and NASA—all of which perform poorly with the exception of the indicator of the ratio of granted to basic patents. It may be the case that these organizations are actively patenting their inventions for purposes of protection of the intellectual property with no intention to commercialize or promote their research.

Table 2 shows the same data based on ranking position for each of the seven indicators (including the two separate indicators of Patents Citing Patents). The underlying data can be seen in the appendix.

TABLE 2: Rank for each indicator of outcome (impact) for the top 25 US organizations

| ORGANIZATION | INDUSTRY COLLAB-ORATION | CITING PATENTS / PAPER | CITING ARTICLES BY INDUSTRY / PAPER | RATIO GRANTED PATENTS | RATIO MULTI COUNTRY | % OF PATENTS CITED | AVERAGE PATENT CITES / PATENT |
|---|---|---|---|---|---|---|---|
| Massachusetts Institute of Technology (MIT) | 2 | 1 | 2 | 11 | 18 | 1 | 3 |
| Stanford University | 3 | 4 | 4 | 8 | 17 | 5 | 6 |
| Harvard University | 6 | 2 | 3 | 25 | 2 | 6 | 5 |
| Department of Health and Human Services | 1 | 3 | 1 | 16 | 1 | 18 | 15 |
| Georgia Institute of Technology | 4 | 10 | 18 | 7 | 11 | 3 | 4 |
| University of Texas System | 10 | 5 | 12 | 17 | 8 | 8 | 14 |
| University of Washington | 8 | 13 | 6 | 15 | 12 | 7 | 13 |
| University of Michigan System | 15 | 15 | 14 | 10 | 5 | 10 | 8 |
| California Institute of Technology | 23 | 11 | 20 | 6 | 16 | 2 | 2 |
| University of Pennsylvania | 5 | 6 | 5 | 21 | 9 | 20 | 16 |
| Northwestern University | 9 | 8 | 9 | 12 | 21 | 12 | 11 |
| University of California System | 13 | 9 | 10 | 20 | 7 | 15 | 9 |
| University of Illinois System | 17 | 20 | 19 | 9 | 14 | 4 | 1 |
| University of Southern California | 12 | 16 | 13 | 14 | 13 | 11 | 7 |
| Johns Hopkins University | 11 | 7 | 7 | 23 | 4 | 21 | 19 |
| University of Wisconsin System | 18 | 14 | 22 | 4 | 15 | 9 | 10 |
| Columbia University | 7 | 21 | 8 | 22 | 10 | 13 | 12 |
| Cornell University | 16 | 12 | 11 | 24 | 3 | 17 | 21 |
| University of Utah | 19 | 17 | 15 | 19 | 6 | 16 | 17 |
| United States Department of Energy (DOE) | 14 | 18 | 16 | 5 | 22 | 23 | 22 |
| National Aeronautics & Space Administration (NASA) | 21 | 25 | 25 | 3 | 23 | 14 | 20 |
| United States Army | 20 | 19 | 23 | 2 | 24 | 24 | 24 |
| State University of New York (SUNY) System | 22 | 24 | 17 | 13 | 19 | 22 | 23 |
| State University System of Florida | 24 | 22 | 21 | 18 | 20 | 19 | 18 |
| United States Navy | 25 | 23 | 24 | 1 | 25 | 25 | 25 |

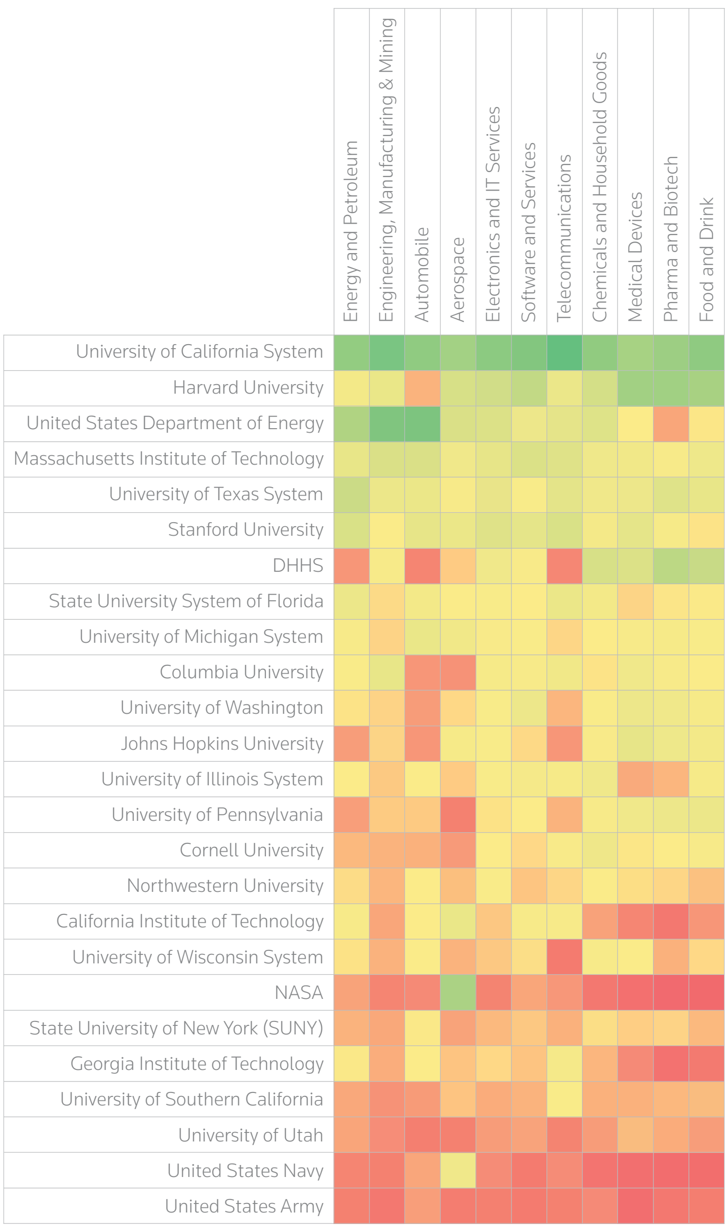
*Source: Thomson Reuters Web of Science and Derwent World Patents Index*

## Industry sector analysis

As discussed earlier in this paper, there can be different levels of activity based on the discipline of the research. In particular, activity relating to the pharmaceutical industry would appear to be one of the strongest areas of collaboration with academia. These differing levels of activity may mask areas of strength or weakness for individual organizations. Therefore, it is of great interest to look at different industry segments in isolation to see what impact each organization has had on the sector.

Chart 6 shows the variance across industry sectors for one indicator (total citing articles by industry). This shows the impact that each industry has had on that sector. NASA is a particularly interesting case in that its impact is very clearly focused on the Aerospace industry. The DHHS is also interesting in that its focus is on industries relating to the health sciences, but there is also impact in Electronics & IT Services and Software & Services.

CHART 6: Relative number of citing articles by commercial entities across industry sectors

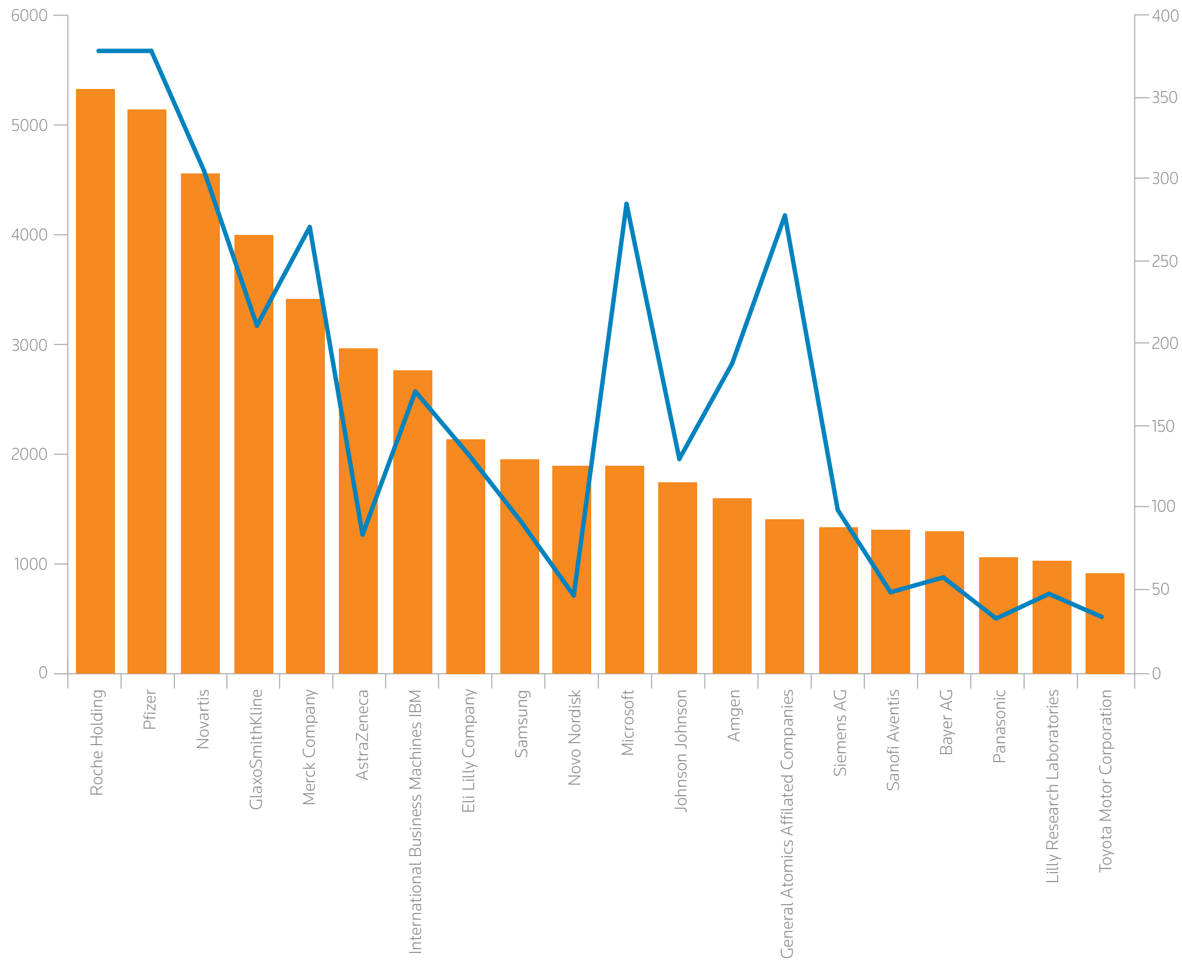



LEGEND

Each box on the matrix represents the volume of citing articles, compared to the average of the 25 institutions analyzed for that sector. Green represents the count of citing articles being higher than average, yellow is equal to average and red is below average. The highest value is around six times the average rate and the lowest value is less than 1% of the average rate.

*Source: Thomson Reuters Web of Science*

CHART 7: Comparison of citing companies and co-authorship for the University of California




*Source: Thomson Reuters Web of Science and Officers & Directors database*

Chart 7 shows a comparison of the direct relationship a research organization has with a company as measured by co-authored papers (blue line and right-hand axis), and the indirect relationship as measured by the citing articles (orange bars and left-hand axis) for the collected articles from the University of California.

# Closing Considerations

As we can see from the real-world examples in this paper, each group of indicators has different timelines and volume considerations that are impacted by the context of the research area and the institutional context. In the development of robust indicators for the measurement of university impact, attention must be paid to the timing of each indicator. To the extent possible, retrospective trends of indicators and impact should be applied in the development of current indicators. In addition, a university's impact on a number of indicators can be combined to reflect the overall impact within the Lifecycle of Innovation.

Part II of this paper demonstrates that it is feasible to generate a picture of a university's impact based on economic impact. We encourage universities and organizations to leverage these data when seeking evidence of their broader impact.

Finally, most important to the development of indicators of economic impact and innovation is a clear and transparent treatment of what the data represent and how well the indicators reflect the university's impact. Indicators are just that, indicators, and they must be interpreted appropriately and with recognition of their limitations.

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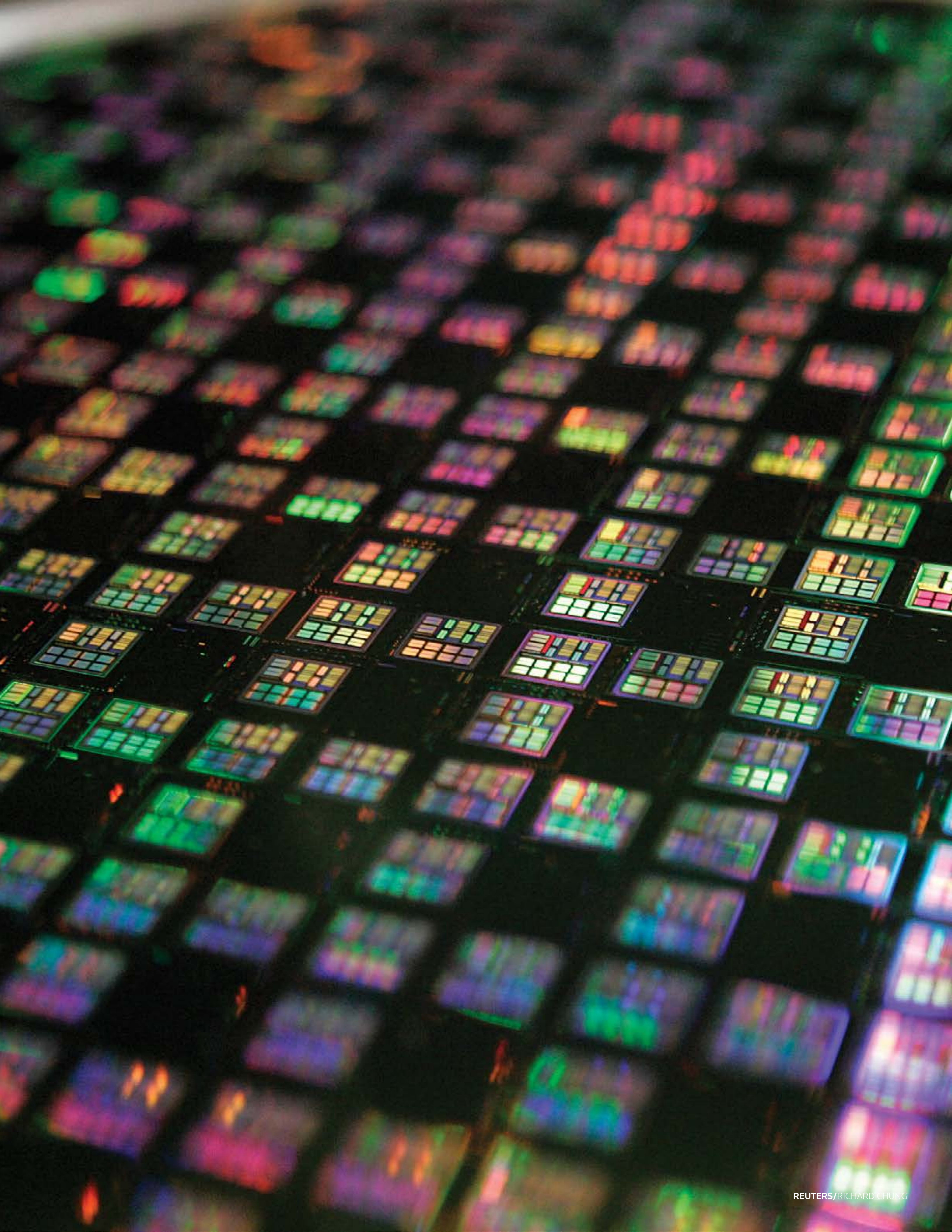

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# About the Authors

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Dr. Joshua Schnell is Director, Government & Academia within the Intellectual Property & Science division of Thomson Reuters. He has expertise in science planning and assessment, the evaluation of research and development (R&D) programs, and in science and technology (S&T) policy, as well as helps to set the strategic direction of Thomson Reuters solutions. Previously, he oversaw a team of analysts conducting program evaluations of research and training programs and developing tools for data-driven science management. Before joining Thomson Reuters, Dr. Schnell directed the analytics group at a science management start-up in the Washington DC area, worked in research administration at Northwestern University, and was a S&T Policy Graduate Fellow at the US National Academies of Science. He holds a PhD from Northwestern University.

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## APPENDIX | DATA TABLES

| Organization Name | Number of patents | Granted patents per application | Patent global diversity | Patent citations per patent | % patents cited one or more times | Patent citations per article | % Articles co-authored with industry | Citations affiliated with industry per article | % Articles containing acknowl-edgement of funding from industry | Officers & Directors (F&R) Alma Mater |
|---|---|---|---|---|---|---|---|---|---|---|
| University of California System | 2,796 | 49.3% | 29.1% | 2.34 | 53.6% | 0.069 | 2.70% | 0.465 | 10.1% | 11,551 |
| United States Navy | 1,720 | 90.2% | 5.5% | 1.21 | 45.3% | 0.039 | 1.28% | 0.162 | 1.3% | 0 |
| Massachusetts Institute of Technology | 1,357 | 58.1% | 21.4% | 2.86 | 63.2% | 0.161 | 4.20% | 0.752 | 8.1% | 4,675 |
| University of Texas System | 1,144 | 51.3% | 28.3% | 1.93 | 57.3% | 0.087 | 2.90% | 0.441 | 12.9% | 4,381 |
| Stanford University | 1,032 | 66.5% | 23.2% | 2.56 | 59.6% | 0.096 | 3.83% | 0.595 | 12.6% | 8,254 |
| United States Department of Energy | 890 | 75.7% | 14.6% | 1.52 | 46.9% | 0.057 | 2.59% | 0.301 | 2.4% | 0 |
| State University of New York System | 891 | 55.7% | 21.4% | 1.51 | 46.9% | 0.037 | 1.94% | 0.288 | 12.0% | 1,224 |
| State University System of Florida | 825 | 50.7% | 21.3% | 1.64 | 49.5% | 0.045 | 1.73% | 0.230 | 6.9% | 559 |
| United States Army | 791 | 88.0% | 5.7% | 1.28 | 46.0% | 0.053 | 2.00% | 0.194 | 2.4% | 0 |
| California Institute of Technology | 766 | 71.1% | 24.3% | 2.96 | 62.1% | 0.066 | 1.86% | 0.269 | 3.6% | 441 |
| Johns Hopkins University | 752 | 35.0% | 31.4% | 1.64 | 48.4% | 0.070 | 2.86% | 0.520 | 13.8% | 1,045 |
| University of Michigan System | 705 | 58.6% | 30.5% | 2.50 | 56.2% | 0.059 | 2.56% | 0.406 | 10.7% | 4,484 |
| Department of Health and Human Services | 705 | 52.1% | 50.5% | 1.88 | 51.9% | 0.103 | 5.76% | 0.775 | 9.6% | 0 |
| University of Wisconsin System | 692 | 76.7% | 25.3% | 2.34 | 56.9% | 0.060 | 2.27% | 0.229 | 7.0% | 1,653 |
| Harvard University | 642 | 34.1% | 38.8% | 2.75 | 59.3% | 0.111 | 3.26% | 0.724 | 22.6% | 13,780 |
| University of Illinois System | 639 | 62.0% | 26.1% | 3.29 | 61.0% | 0.051 | 2.30% | 0.270 | 4.5% | 1,890 |
| Columbia University | 637 | 42.7% | 27.3% | 2.27 | 54.2% | 0.050 | 2.96% | 0.506 | 18.4% | 5,658 |
| University of Washington | 633 | 52.9% | 26.9% | 2.24 | 58.1% | 0.062 | 2.94% | 0.521 | 10.7% | 2,113 |
| National Aeronautics & Space Administration | 630 | 87.0% | 7.3% | 1.62 | 54.0% | 0.009 | 1.96% | 0.097 | 0.7% | 0 |
| Georgia Institute of Technology | 559 | 66.7% | 27.0% | 2.85 | 61.4% | 0.069 | 3.59% | 0.272 | 4.0% | 779 |
| Cornell University | 558 | 34.9% | 38.7% | 1.61 | 52.2% | 0.066 | 2.37% | 0.462 | 8.9% | 3,541 |
| University of Utah | 552 | 49.5% | 30.4% | 1.78 | 52.9% | 0.057 | 2.24% | 0.389 | 9.6% | 1,205 |
| University of Pennsylvania | 502 | 47.6% | 28.1% | 1.80 | 49.2% | 0.071 | 3.43% | 0.580 | 16.1% | 8,109 |
| Northwestern University | 495 | 57.4% | 18.6% | 2.33 | 54.3% | 0.070 | 2.92% | 0.478 | 12.7% | 2,596 |
| University of Southern California | 480 | 54.6% | 26.5% | 2.55 | 55.8% | 0.058 | 2.78% | 0.417 | 9.2% | 3,343 |

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