Multidisciplinary Research and Return on Research Investment

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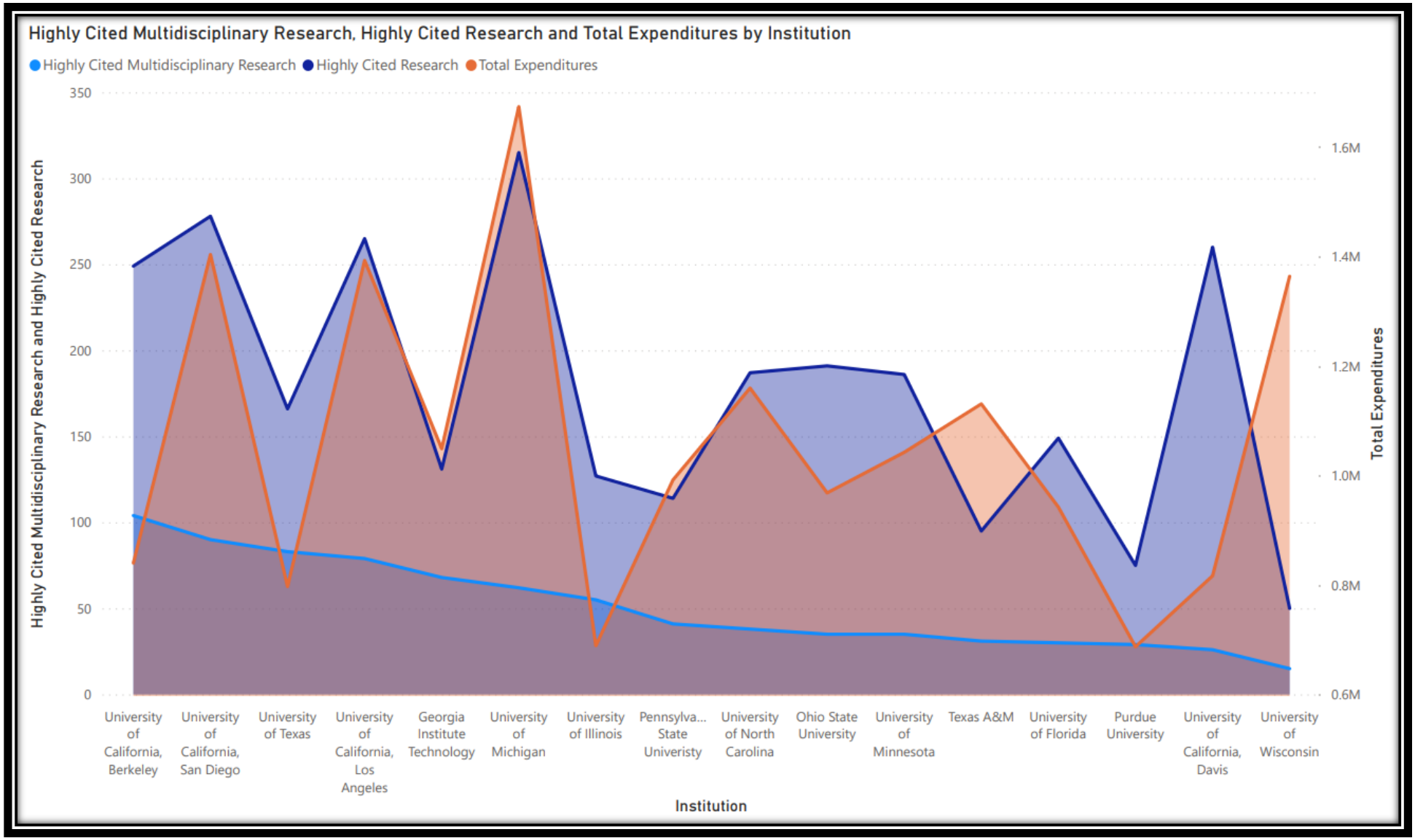
August 2022

Figure 1


Highly Cited Multidisciplinary Research, Highly Cited Research and Total Expenditures by Institution
Highly Cited Multidisciplinary Research
Highly Cited Research
Total Expenditures
Highly Cited Multidisciplinary Research and Highly Cited Research
Total Expenditures
350
300
250
200
150
100
50
0
1.6M
1.4M
1.2M
1.0M
0.8M
0.6M
University of California, Berkeley
University of California, San Diego
University of Texas
University of California, Los Angeles
Georgia Institute Technology
University of Michigan
University of Illinois
Pennsylva... State Univeristy
University of North Carolina
Ohio State University
University of Minnesota
Texas A&M
University of Florida
Purdue University
University of California, Davis
University of Wisconsin
Institution

Introduction

This research was conducted for the 2022 Student Data Science Competition at Texas A&M University. The competition requested participants to demonstrate the impact of Texas A&M University's research involving multiple disciplines through combining and analyzing bibliometric data concerning research publications (Texas A&M Institute of Data Science, 2022). Multidisciplinary research articles are characterized as two or more faculty members from different disciplines working together to publish a research article. It has been shown that, in general, multidisciplinary research articles are more highly cited than monodisciplinary research articles (Levitt & Thelwall, 2008).

The current article illustrates how multidisciplinary research affects the impact of research and, in turn, enhances utility of total expenditures at Texas A&M University and its peer institutions. To this end, this article seeks to illuminate a comparative analysis between Texas A&M University and its peer institutions. The comparative analysis illustrates how highly cited multidisciplinary research creates a return on research investment with regards to impactful research and total research and development (R&D) expenditures. The return on research investment can be defined as the amount of research citations divided by total R&D expenditures. The hypothesis is that highly cited multidisciplinary research can increase the total number of highly cited articles at a lower cost to institution in the year 2020. Thereby increasing return on research investment.

Materials

To consolidate all data, the datapoints were transferred to an Excel file. The first data points of "Higher Education R&D Expenditures" were extracted from a dataset on p. 119-120 from the *National Center for Science and Engineering Statistics'* document titled "Higher

Education Research and Development: Fiscal Year 2020" (National Center for Science and Engineering Statistics, 2021). This document ranked the total higher education R&D expenditures by institution. The data for total expenditures was extracted from this dataset for Texas A&M University and its peer institutions.

The second dataset was extracted from Web of Science database via the Texas A&M University Libraries. An advanced search on Web of Science was completed. The advanced search queried by Texas A&M and its peer institutions. Furthermore, the range of publications was restricted to year 2020 to keep the data consistent with the document, "Higher Education Research and Development: Fiscal Year 2020." Finally, to restrict the data to "impactful research," a quick filter within Web of Science, "Highly Cited Papers," was selected.

The last piece of data was a list of Texas A&M University and its peer institutions (i.e., University of Texas at Austin; University of California, Berkeley; University of Michigan; University of North Carolina at Chapel Hill; University of California, Los Angeles; University of California, San Diego; University of Wisconsin-Madison; University of Florida; Georgia Institute of Technology; University of Illinois at Urbana-Champaign; University of Minnesota, Twin Cities; Ohio State University; Pennsylvania State University; Purdue University; and University of California, Davis). This data was extracted from the Texas A&M University Vision 2020 (Texas A&M University, 2020).

According to Texas A&M University's Vision 2020, its peer institutions are characterized based on attributes that "distinguish great public universities" through considering "the most prominent ranking systems and their results as published by *US News & World Report* and the National Research Council. In addition, several other institutions with similar

colleges and programs were also identified to ensure accurate comparisons" (Texas A&M University, 2020).

The main source of data exploration was the data obtained from the Web of Science. At first, data solely from Texas A&M University was taken into consideration. The "Highly Cited Papers" filter was not applied for all the multidisciplinary research at Texas A&M University. The data did not show a return on research investment from the years 2011-2020 when it was compared to the *National Center for Science and Engineering Statistics'* dataset. The dataset listed total expenditures from years 2010-2020 for each institution. Despite the total R&D expenditures at Texas A&M University increasing and the multidisciplinary research at Texas A&M University increasing, the total number of "Highly Cited Papers" did not significantly increase from 2011-2020. Thus, according to the data, multidisciplinary research did not have a return on research investment with respect to impactful research. Therefore, the approach to compare Texas A&M University and its peer institutions was considered to create a more inclusive and illuminative process of multidisciplinary research and its impact on return on research investment.

Methods

First, extraction of data from Web of Science via the export feature was completed. The export feature allows data to be extracted per 1,000 rows. Multiple data extractions from Web of Science were necessary since all the data extracted was over 10,000 rows of data.

The *National Center for Science and Engineering Statistics'* document titled "Higher Education Research and Development: Fiscal Year 2020" was in the form of a PDF. Therefore, the data was converted to an Excel file for further manipulation. The corresponding rows were minimized to only Texas A&M University and its peer institutions. At first, Texas A&M

University's data was taken from years 2010-2020, but this data was not significant when it was correlated with "Highly Cited Papers" on Web of Science.

The data extracted from Web of Science and "Higher Education Research and Development: Fiscal Year 2020" was consolidated into an Excel sheet. A new sheet was created for the final analysis. This sheet had four variables (i.e., Institution, Highly Cited Research, Highly Cited Multidisciplinary Research, and Total Expenditures). This sheet was made into a table to help analyze the data using the Excel "ascending" and "sum" functions.

Finally, the data was transferred to Microsoft Power BI for the final analysis between the four variables. An "area chart" was created using the four variables. The area chart allowed for a comparison of multiple numerical variables by a category. Therefore, institutions were listed on the x-axis. Since "Highly Cited Multidisciplinary Research" was the main variable of analysis, it was the first variable listed on the chart. This method of analysis allowed a visual representation of the total of highly cited multidisciplinary research in descending order of institution. Thus, the metrics of "Highly Cited Research" and "Total Expenditures" was interpreted based off the impact of multidisciplinary research.

Results

As can be seen in Figure 1, this model showed the highly cited multidisciplinary research published by Texas A&M University and its peer institutions. There is a clear trend that shows multidisciplinary research leads to more impactful research across. The correlation between the multidisciplinary research and total research was R = .56. The correlation between total expenditures and multidisciplinary research was R = .12. Taking this into account, there was a correlation between multidisciplinary research and the other two numerical variables.

Discussion

To create an overarching view of the data, a visualization was created (Figure 1). The institutions are listed in descending order of multidisciplinary research article count. Institutions with a relatively low orange line compared to the purple line shows a large amount of return on research investment in terms of highly cited papers versus total R&D expenditures. Moreover, any institution with a higher orange line compared to the purple line shows a lower return on research investment in terms of highly cited papers versus total R&D expenditures. Essentially, if there is purple shading above an institution, then there is a good return on research investment on the amount of impactful research produced.

The above visualization depicts how University of California, Berkeley has the highest amount of highly cited multidisciplinary research articles. University of California, Berkeley had the twelfth highest total R&D expenditures, but it had the fifth highest amount of highly cited research articles. Moreover, it had the largest gap between "Total Expenditures" and "Highly Cited Research." Therefore, multidisciplinary research is shown to be a significant component of impactful research.

University of Wisconsin had the lowest amount of highly cited multidisciplinary research articles. It also had the lowest amount of highly cited research articles. Yet, it had the fourth largest total R&D expenditures. Again, this illustrates that a lack of multidisciplinary research creates a lower impact of research.

Relative to its peer institutions, Texas A&M University has room to increase the amount of multidisciplinary research publications to increase research impact. It ranked twelfth in the number of highly cited multidisciplinary research published. Moreover, it ranked fourteenth in the number of highly cited research published. Therefore, in order to increase its return on

research investment, Texas A&M University can increase its multidisciplinary research and create more impactful research.

University of Michigan had the highest amount of total R&D expenditures. Yet, University of Michigan was ranked sixth in highly cited multidisciplinary research. Moreover, it had the largest amount of highly cited publications. Therefore, multidisciplinary research was not the only component that factored into impactful research. Multidisciplinary research and total R&D expenditures both play a significant role in research dissemination.

Lastly, University of Texas and University of Illinois both had lower levels of R&D expenditures compared to the other institutions. Yet, both institutions showed a higher amount of highly cited research amongst its peers. University of Texas was ranked third in multidisciplinary research and University of Illinois was seventh. University of Texas was fourteenth in total R&D expenditure and University of Illinois was fifteenth. Again, this strongly advocates that multidisciplinary research can lower R&D expenditures while creating a greater amount of impactful research.

Conclusion

In conclusion, the data and visualization clearly show that multidisciplinary research is a large component of return on research investment for institutions that produce a large amount of impactful research. In the case of University of Michigan, it was shown that a large amount of total R&D expenditures can offset a lack of multidisciplinary research. However, for institutions that do not have as many resources, it should be considered to produce more multidisciplinary research to increase research dissemination.

Lastly, Texas A&M University has an opportunity to increase its multidisciplinary research which will create a greater return on research investment. In that vein, Texas A&M

University can create a greater level of research investment amongst its peers by incentivizing further collaborative research among its departments.

Limitations

This paper has its limitations as it was designed as an exploratory study for a student competition. First, it must be noted that this model only demonstrated the correlation between variables and does not imply causation. Another drawback was that the data was only taken from the year 2020. As stated earlier, when the years 2010-2020 were considered, there was not a significant impact of multidisciplinary research for Texas A&M University. Furthermore, the scope of this research is limited since only Texas A&M University and its peer institutions were considered in this study.

Acknowledgment

I would like to thank my supervisor, Dr. Bahman Shahri, from Texas A&M University Center for Teaching Excellence, for encouraging me to participate in the competition, his guidance on the research design, and mentorship throughout the writing process. I also would like to thank my fellow graduate assistant, Mr. Adharvan Sai Jakkula, from Texas A&M University Department of Computer Science and Engineering, for his contribution to the hypothesis and formulation of definitions. Finally, I am thankful to the judges of the 2022 Student Data Science Competition at Texas A&M University for selecting this paper into the finalist round for an in-person presentation.

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