Title

Local Citation Analysis of National Science Foundation and National Institutes of Health Grant
Applications: Meeting the Needs of Researchers

Authors

Amalia Monroe-Gulick, Lea Currie and Travis Weller

Abstract

Supporting and meeting the research needs of faculty members is a priority at the University of Kansas

because of the necessity for external grant-funding. For this study, the authors analyzed the citations

from successful NIH and NSF grant applications submitted between 2005 and 2013. The purpose was to

identify the types of resources used by researchers and determine if KU Libraries are currently providing

access. In addition to access, the authors analyzed the age, format, whether journals were provided in a

journal package or aggregator, subject area, and open access status. Overall, the authors found KU

Libraries' collection provides substantial support for researchers who submitted successful NSF and NIH

grant applications.

Introduction

Academic libraries support the research mission of their institutions throughout the entire research

lifecycle. However, the literature on collection management most often focuses on how well the

collection meets the needs of faculty as they publish the results of their research. In this project, the

authors set out to understand how responsive the library collection is to faculty members' needs at

another critical stage of their research career – as they submit applications for federal research funding.

In this study, the authors analyzed the reference pages of successful NIH and NSF applications by

researchers at the University of Kansas.

A member of the Association of American Universities since 1909, The University of Kansas (KU)

has 13 schools, including the only schools of pharmacy and medicine in the state of Kansas. KU has 11

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other research centers that oversee research in life span issues, the humanities, transportation, the environment, biosciences, biodiversity, polar ices sheets, and more. The university also has nine core service laboratories and affiliated centers specializing in such fields as biomedical research, molecular structures, technology commercialization, and oil recovery.

In the most recently published annual report on sponsored research at KU[1], the University ranked 39th among national public research universities in federally funded research. The School of Pharmacy ranked second nationally in the amount of National Institutes of Health (NIH) research funding it received. KU brought in more than 3200 new and ongoing grants and more than $275,000,000 for sponsored project activity. 898 of these grants were funded by the NIH and 315 grants were funded by the National Science Foundation (NSF).

For the purpose of this study, the authors chose to analyze the citations from successful grant applications for NIH and NSF grants from 2005-2013. By identifying the resources cited in funded grant proposals submitted by KU affiliates, the authors sought to demonstrate the KU Libraries' aid in supporting the grant writing process at KU. It was also hoped that by identifying the types of resources used in grant applications, KU librarians could develop a better understanding of the resources in subject areas that are most used by researchers to help inform collection management decisions.

With three quarters of the library budget going to pay for bundled journal packages and full-text databases, the authors were also interested in determining if subscribing to these journals is a fiscally sound decision. It has become increasingly difficult to make a case to continue subscriptions to large journal packages, particularly from the large commercial publishers like Elsevier, Wiley-Blackwell, and Springer. While researchers pressure the Libraries to provide access to journal content, there is also

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[1] http://research.ku.edu/sites/research.ku.edu/files/docs/2012_Annual_Report_RGS.pdf. This report includes both the KU-Lawrence and the KU-Medical Center campus.

philosophical pressure at KU to stop supporting these companies and to support more open access efforts. By gathering and analyzing citation data from successful grant applications, the authors aimed to answer the following research questions:

1. Does the KU Libraries provide access to the cited items in successful NSF and NIH grant applications?

2. What are the most heavily used items in these grant applications?

3. What is the average age of the cited items in these grant applications?

4. What is the most prevalent format provided? (monograph, journal, conference proceeding, documents, etc.)

5. Is access to journal articles provided through a journal package or aggregator database?

6. What subject areas are the most used in these grant applications?

7. Who are the most important and popular publishers to grant writers?

8. Do researchers cite articles from open access journals?

Literature Review

Few academic libraries have undertaken citation analysis projects to test the value of library collections in support of grant writing by faculty on college campuses. The more common practice has been to conduct citation analysis to find strengths and weaknesses in library collections and to provide substantive evidence to support funding electronic resources and journal packages. Carol Tenopir has conducted several citation analysis studies to demonstrate return on investment (ROI) and the value of library collections in supporting the grant writing process.[1] [2] In 2010, she expanded a case study conducted with the University of Illinois at Urbana-Champaign which developed a methodology for calculating the library's ROI to the university through grants received.[3] Using the same methodology, she expanded the study to eight institutions in eight countries, collecting both quantitative and

qualitative data on grant proposals by using a combination of faculty surveys, interviews with university administrators, and data on grant proposals and the library budget. The results proved the value of the library to the institution by demonstrating improvement of grant proposal and report writing and in helping to attract grant income. Tenopir continued to measure ROI and the value of academic libraries by reporting on a series of surveys to gather information on purpose, outcomes, and value of scholarly article readings and access to collections through the library. Results prove that for every dollar invested the library, many more dollars are returned in grant income and successful grant proposals.

Pan, Wiersma, and Fong also sought to provide evidence of ROI and the value of library collections by analyzing the extent to which use of online library resources contribute to faculty teaching and research outcomes.[4] This study used a combination of citation analysis and faculty interviews to verify the number of resources provided by the libraries and calculate an estimated cost of resources not provided by the libraries. Through faculty interviews, the authors reported on the number of readings faculty used to prepare for the classes they taught and the number of resources they assigned as class readings. The authors calculated the cost-benefit analysis and ROI to show the increase in value on dollars spent to provide evidence that the libraries' collections directly support the research and teaching outcomes of faculty.

The purpose of many citation analysis studies is strictly to provide evidence that the academic library collections are useful to researchers. Smith used citation analysis to evaluate the usefulness of the University of Georgia Libraries' collections by seeking the answer to one simple question: Do we own the things our students use?[5] By sampling citations from theses and dissertations produced in 1991 and 2001, the author was able to provide evidence that students put the library collections to good use and that usefulness did not change over the 10 year period. At the University of California at Santa Barbara, citation analysis was utilized to determine if the Sciences-Engineering Library was meeting the needs of faculty at the California NanaSystems Institute.[6] This study was used to develop a core list of

journals to support the research of the Institute. Fuchs, Thomsen, Bias, and Davis combined two

evaluation methods to prove the usefulness of the collections at the University of Texas at Austin

Libraries.[7] By using citation analysis along with behavioral data gleaned from a survey of dissertation

authors, the study aimed to collect data on citations of items provided by the libraries as well as data on

the dissertation authors' experiences, needs, and wishes.

Much of the literature on citation analysis digs deeper into the types of resources used by

researchers, the age of the resources used, the use of print versus the use of electronic resources, the

use of monographs versus journals, and the identification of the most popular publishers and journal

packages. These studies are often used to identify the subject areas used by researchers and to gather

evidence of the interdisciplinary research taking place on college campuses. Williams and Fletcher used

a sample of masters' theses to identify the research materials used by graduate engineering students.[8]

They gathered evidence of formats cited by the students, the age of the cited items, the most frequently

cited journals, and the extent of non-engineering materials cited in the theses. This data was

subsequently used for evaluating and selecting materials and identifying citation pattern variations that

exist among engineering disciplines. Choinski examined the journal literature cited by pharmacy faculty

at the University of Mississippi to determine the most frequently used titles, their subject areas, the age

of the citations relative to the source articles, and the major publishers of those journals.[9] The purpose

of a study conducted by Kuruppu and Moore was to examine the literature used by graduate students to

identify citation pattern variations that exist among subject areas.[10] This study provided a good

understanding of the influence of different formats and ages of literature on the research projects of

graduate students.

Four major goals drove a case study that analyzed the literature used by the neuroscientists at

the University of Maryland.[11] The authors sought to 1) identify the literature used by programs in

neuroscience and cognitive science, 2) identify the journals in which the neuroscientists most frequently

published and those they cited, 3) determine the number of years between the publication dates of papers authored by the researchers and the dates of each item in their bibliographies to assess their needs for newer or older items, and 4) identify the co-authorship patterns of the researchers. Sherriff gathered evidence from history researchers to examine the hypothesis that research in the humanities and social sciences involves greater use of monographs than journal articles, and involves greater use of older materials.[12] The author also took the study one step further by determining the use of foreign language material in history research and the availability of the cited sources in the libraries. Kayongo and Helm sought to determine the extent to which collections at Notre Dame met the needs of graduate students by identifying what types of materials the graduate students were citing in their dissertations, whether or not the library owned the cited materials, and how different disciplines compared in their citations patterns.[13]

In an effort to examine whether the University of Kansas Libraries provide the appropriate materials faculty need for their research, Currie and Monroe-Gulick conducted an extensive citation analysis to determine the formats used by the different disciplines, the age of the cited materials, whether the cited journal articles were provided by aggregator databases or journal packages, the most-cited publishers, and variation of citation patterns among the different disciplines.[14] Salisbury and Smith used Web of Science to identify the periodical literature in which their researchers published and those they cite in their publications.[15] The overall objective of their study was to provide evidence-based data of periodical use to assist with collection decisions and to identify collection strengths. Kimball, Stephens, Hubbard, and Pickett sought to determine how well the Texas A&M University Libraries met the needs of their faculty researchers in Atmospheric Sciences.[16] They identified the formats cited by the researchers, the ages of the cited publications, and whether or not they were owned by the library. Kaczor also conducted a study of researchers in Atmospheric Sciences by focusing her study on doctoral

students to find out what types of information resources they were citing, which journals were the most important to this program, and the ages of the journals cited.[17]

A few citation analysis studies use a more unique approach to gather data to support their hypotheses. Feyereisen and Spoiden compared citation counts to other indicators of use of periodicals by analyzing bibliographies from master's and doctoral theses in a university library of psychology and education sciences.[18] Using the Journal Citation Reports (JCR), the authors determined if JCR data was valid indicators of local use. Wilson and Tenopir determined the extent to which researchers publish in or cite from journals tracked in the Web of Science database.[19] They also identified the average number of coauthors per faculty and what were the author's positions in multi-authored publications. Wilson and Tenopir were also unique in determining if citing or reading practices were different from those faculties with more coauthors. Do academics who read more publish more or have more cited references per paper? What is the quality of the source and cited journals as determined by their impact factors? To what extent is the library collections meeting the needs of researchers based on where they publish and what they cite? Along with answering these questions, the authors also identified what resources were provided by the library collection in print or electronic format. Vallmitjana and Sabate used bibliographic references in doctoral dissertations in chemistry to identify the proportion of journals cited, if there was a relationship between the top journals' rank and their impact factor, along with the age of the citations and the cost per citation.[20] This information helped with renewal and cancellation decisions as well as determining obsolescence of journals to manage space in the library. Although, Carol Tenopir has written on ROI in libraries who support the grant writing process, this study is the first to gather and analyze citations from NIH and NSF grants at a major research university.

Methodology

The authors obtained the bibliography portion of successfully-funded NIH and NSF grant applications submitted by researchers at the KU-Lawrence campus between 2005 and May of 2013 from the Office of Research at KU after permission was granted by the applicants via email. The authors obtained 24 bibliographies from NIH applications, and 50 from NSF applications. Nineteen academic departments and research institutes were represented, as determined by the status of the primary investigator (see Chart 1).

Chart 1: Number of Successful NSF/NIH Grant Applications (**by academic department or research institute)**
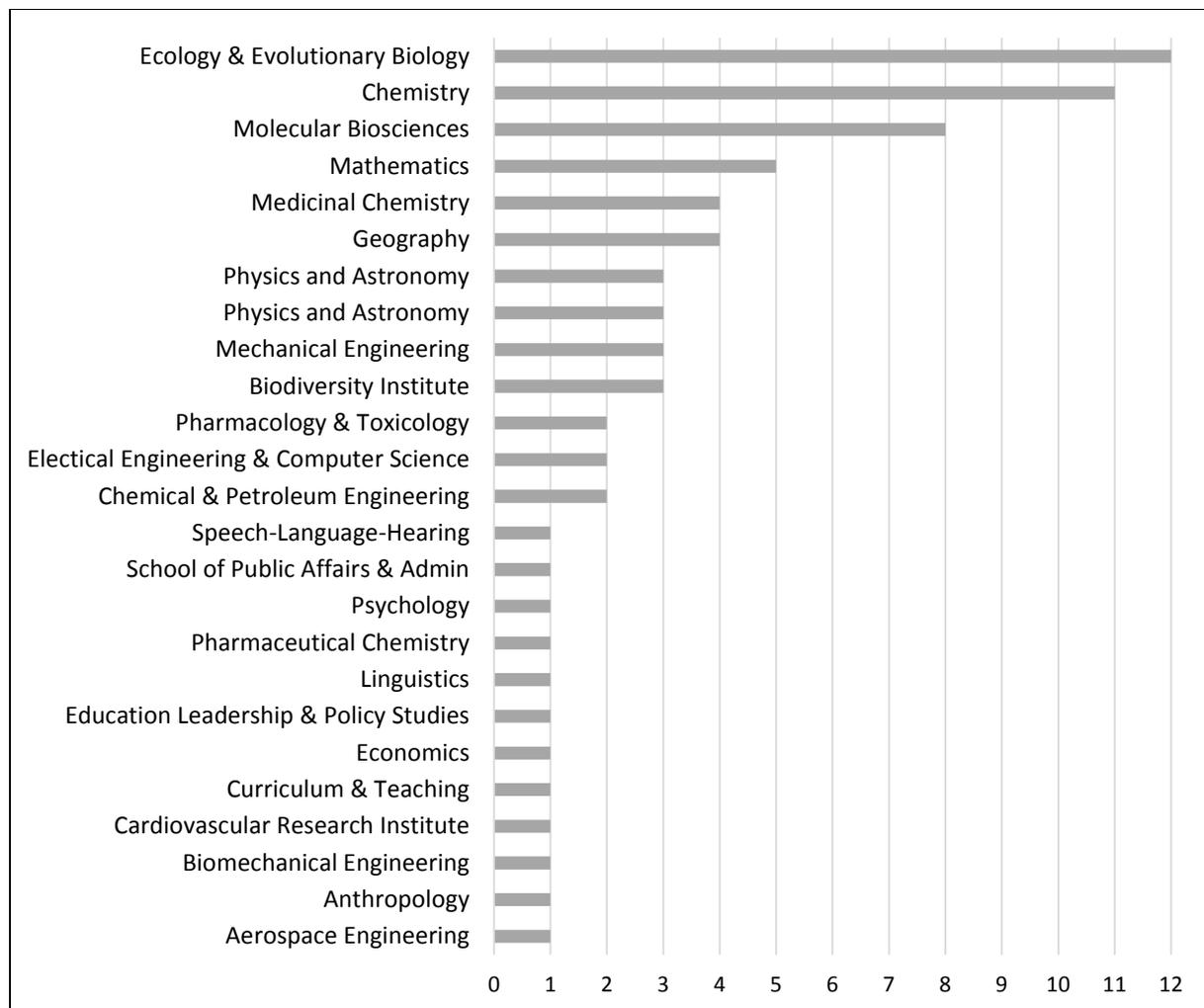
The sciences, as expected, comprised the majority of the successful grant applications. There were, however, 11% (8) applications from the social sciences. The total number of citations from the bibliographies gathered from both the NSF and NIH applications was 5917, with a sample size of 1079 (see Table 1 for agency summary). The sample was drawn from a randomization of each grant applicant's total citation list using an Excel spreadsheet. The authors determined the scope of this study should be narrowed down to the analysis of journal articles and book citations since book and article citations comprised 88% of the total sample (954 citations). The other citations included reports, white papers and government documents that were, at times, difficult for the authors to determine accessibility.

Table 1: Sample Size by Agency

	Population	Sample Size
Overall	5917	1079
NSF	3601	564
NIH	2316	515

Once the random sample was identified, well trained student assistants recorded the following information for each citation:

1. Publisher
2. Publication date
3. Type of resource (journal article, book, report, etc.)

After the journal articles and books were identified, the following data was recorded for those two types of citations:

1. Call number

2. KU availability

3. Print access

4. Electronic access

For the journal articles, the following information was also gathered:

1. Access through a journal package

2. Access from an aggregator database

3. Number of aggregators providing access to an article

4. Indexing in Journal Citation Reports, when available

5. Open access status of journal articles

7. Impact factor, when available

Specific data points were collected to obtain enough information about the cited items to understand what types of resources successful grant applicants were citing in their grant applications. One of the goals of this research project was to better inform collection management decisions. Therefore, the age of the books and journals cited, particularly those not owned by KU, was an important data point to determine if backfiles should be purchased. The authors were also interested in discovering the most popular publishers to make sure those publishers were supported by the Libraries. The data collected was also used to determine if the journals were available via electronic journal package, full-text aggregator database, or via single electronic or print subscription. This information could be used to make a case for continuing to subscribe to expensive journal packages and full-text aggregator databases. In addition, the authors used the analysis of call numbers to identify trends in cross-disciplinary research to make sure the KU Libraries were supporting researchers across the university.

The Ulrich's Periodicals Database was consulted to determine the open access status of the journals cited in the grant applications. An item-level determination of OA status for materials published in non-

OA journals was necessary due to three factors: (1) the rise of author self-archiving in institutional repositories or on websites, (2) the availability of the option with subscription-based journals that an author pay a fee to make an article freely available and (3) grant funder policies that require public sharing of works based on funded research.

To further determine the open access status of articles, the authors conducted searches for the article's title in Google Scholar. The searches were performed on a computer that did not have a campus-based IP address and was not logged-in to campus authentication services. These searches were performed to determine if the full-text was freely accessible on the Internet. Google Scholar has been used by other citation analysis researchers to determine an item's OA status.[21][22] Google Scholar searches have been shown to be more effective at capturing OA materials than searches through OAIster and OpenDOAR, two major institutional repository aggregators. Prior to the introduction of Google Scholar, other researchers publishing in this area used web crawlers, likely similar in style to Google Scholar, to determine whether an article was freely available on the web.[23] If the full-text of the article was available through Google Scholar, the item was considered OA.

Results

Overall, KU Libraries provided access to 88% to the journal articles and books cited in the NIH and NSF applications sampled for the study. Journal articles represented 81% of the total sample, while books comprised only 7% of the sample. The average publication date for all items was 2002, with a median publication date of 2005.

Format Usage

Journal articles were the most often cited format for both NIH (93%) and NSF (70%) grant applications (see Chart 2). Only a small number of books were cited in NIH applications (2%). Books were cited more frequently in NSF applications (11%). NSF applications also included a much greater proportion of

alternative resources (19%) such as conference proceedings, websites, governmental reports, and court cases than NIH applications (5%).

Chart 2: Format of Cited Resources (by agency application)
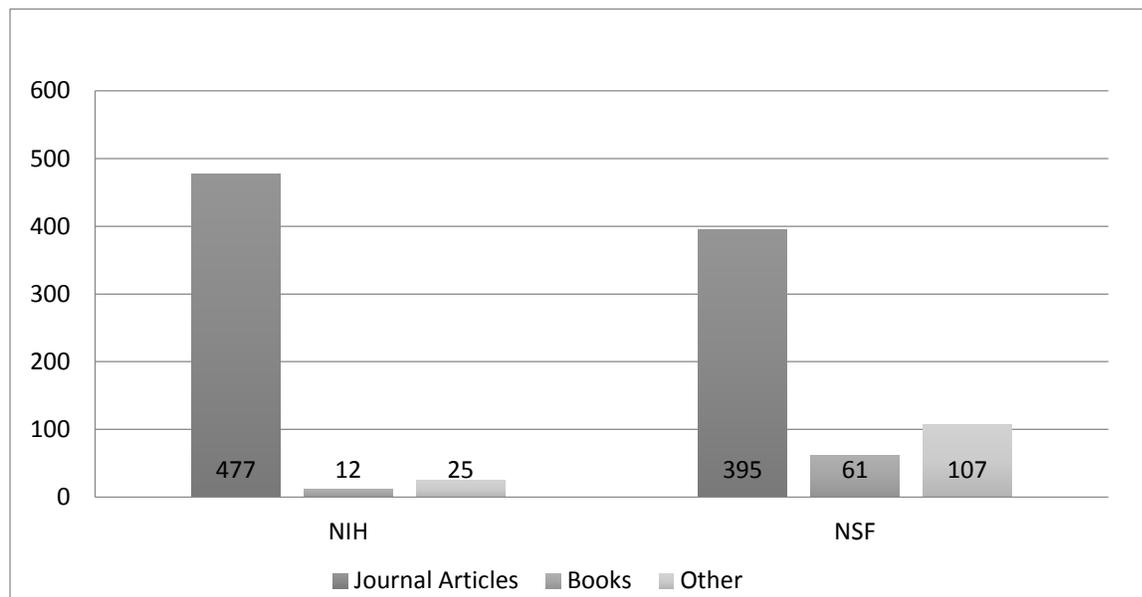


Access to Cited Resources

Overall, KU Libraries provided access to 93% of these items in NIH applications and 86% of these items in NSF applications. Holdings of the cited journals were nearly comprehensive. KU Libraries provided access to 93% of journal articles in NIH applications and 90% of articles in NSF applications.

KU Libraries' holdings of books was less comprehensive. For both NSF and NIH applications, KU Libraries provided access to 66% of cited books. The average publication year of the books not owned by KU was 2001, with a median publication year of 2004. There was no dominant publisher or call number range for the books analyzed, so no weakness in the collections at KU could be readily identified.

Focusing on journal articles, there was some variation in the methods of access that KU Libraries provided (see Chart 3). Only a small number of journal articles were provided solely in print. (NIH, 3%;

NSF, 7%). For most of the articles cited in NIH applications, access was only provided electronically (63%), while articles cited in NSF applications were offered either in electronic format (45%) or in both electronic and print format (47%).

Chart 3: Available Formats for Journal Articles
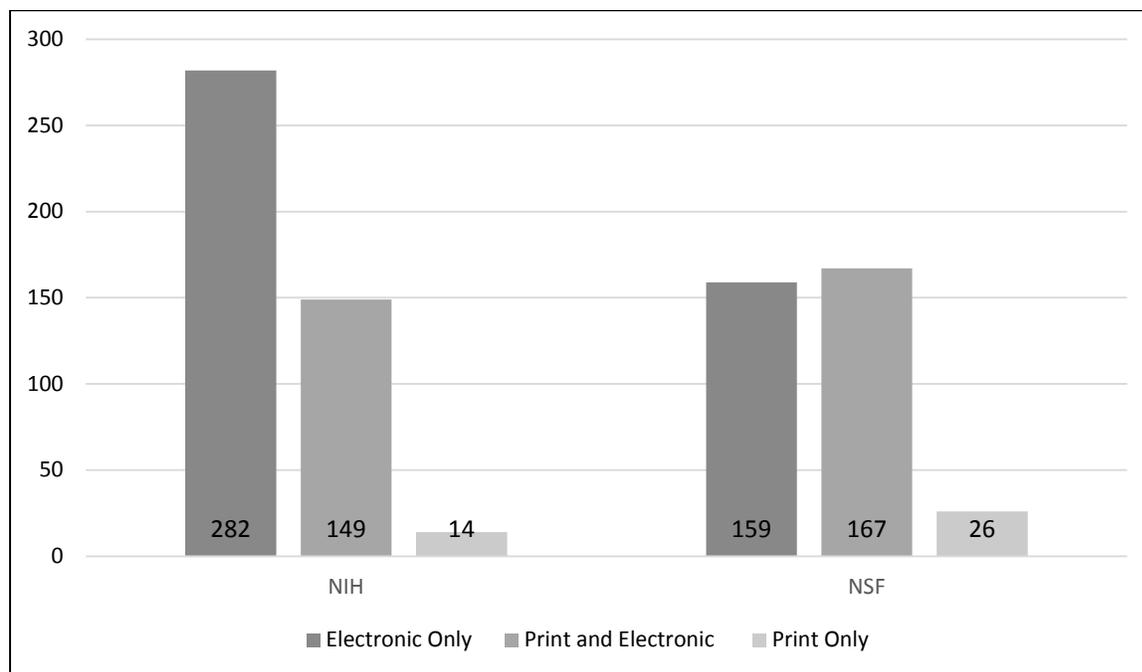
Type of Electronic Access

Electronic access to journal articles is most commonly provided through journal packages, rather than database aggregators (see Chart 4). For NIH applications, only 6% of articles were available through database aggregators. The remainder were available either through journal packages and database aggregators (22%) or journal packages alone (72%). A larger, but still relatively small percentage of articles in NSF applications were available solely through database aggregators (17%), with greater percentages available through a journal package and a database aggregator (19%) and journal packages alone (65%). These findings have implications for collection management decisions regarding the continuation of journal package acquisitions.

Chart 4: Type of Electronic Journal Article Access (NSH/NIH Combined)
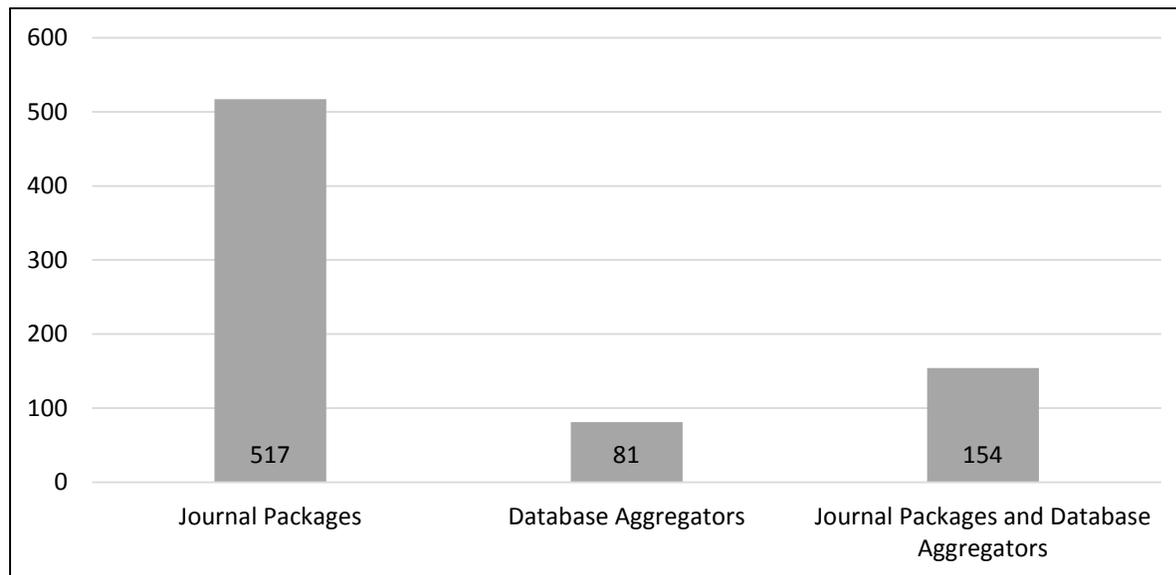
Publishers

The predominant publisher type for the NIH grant applications came from society and association publications, representing 21% of the total journal article sample. Among the NIH citations, the American Chemical Society was the publisher for 8% of the journal citations. The percentage is higher for NSF journal citations at 35%, suggesting that journals from these types of publishers are also important in the grant writing process. For example, the American Chemical Society was the publisher of 9% of the NSF journal citations and the American Institute of Physics was the publisher of 7% of the NSF journal citations.

Call Number Ranges

Unsurprisingly, the largest number of materials cited in both grants applications fall within the Q call number range, which is the broad science category (see Table 2). For NSF applications, 80% of journal articles cited fall under the Q range. Within the Q call number range, four subclasses comprised 68% of Q citations:

Table 2: NSF Journal Citations in the Q Call Number Range

Call Number	# of Citations	% of Total Q Citations
Q	14	4%
Q1	21	6%
QA	50	15%
QB	11	3%
QC	37	11%
QD	70	20%
QE	26	8%
QH	75	22%
QK	12	4%
QL	19	6%
QP	4	1%
QR	2	1%

The subclasses within the Q call number range did demonstrate variation within the sciences resources cited within NSF applications, it does appear that, overall, there is not a great amount of cross-disciplinary work, specifically outside of the science fields.

The call number results were not surprising for the NIH applications. For journal articles, 52% cited fell within the Q range and. 42% fell within the R range (see Table 3). The R range, which is the medicine call number classification, 42% of the citations fell within the RC subclass which is internal medicine. The NIH results also suggest there is little cross-disciplinary work outside of the medicine and scientific fields.

Table 3: NIH Journal Citations in R Call Number Range

Call Number	# of Citations	% of Total Q Citations
R11	7	3%
R31	2	1%
R5	1	0%
R856	9	4%
R857	20	10%
RA	5	2%
RB	5	2%
RC	85	42%
RD	19	9%
RE	1	0%
RH	2	1%

Journal Impact and Open Access

In order to determine what types of articles researchers were citing, the authors looked at both a traditional measure of journal importance using the Journal of Citation Reports (JCR) and the open access status of the journal cited. Out of the 871 total journal citations, 511 unique journals titles were cited. Out of the unique titles, 69% (353) are indexed in the JCR. This is in stark comparison to the 9 unique titles (2%) that were defined as open access by Ulrich's Periodical database. Even though a small percentage of the journals cited were open access journals, versions of 219 (25%) individual articles were available on the Internet. This potentially indicates growth in the use of institutional repositories and other open access services. These results indicate that currently researchers are not utilizing open access journals and are still relying on journals that are indexed in the JCR. However, the data collected from this study can provide a benchmark for future studies to see if this changes over the next five to ten years as open access journals gain acceptance and federal agencies push for more open access to the results of publicly funded research.

Discussion and Conclusions

The authors were quite pleased to find out that KU Libraries provided such a large percentage (88%) of the resources cited in the grant proposals. The only possible weakness in the collections in terms of assistance to NIH/NSF grant writers were those publications by association and society presses, which will need to be investigated further. Compiling a list of book titles not held by the Libraries can also lead to future purchases to help support grant writers.

For applicants to both NIH and NSF, journal articles remained the most commonly cited resource, which is understandable given the importance placed on publishing in journals among the academic community. However, for NSF applications, in particular, books and other resources are also important sources of information. Nearly one out of five items cited in NSF applications were non-journal articles. This may indicate that NSF reviewers are more willing to accept the authority of non-journal resources or that more of the information needed by NSF applicants exists outside of the traditional arena of journal publishing, such as websites, computer programs and conference proceedings.

Electronic format provides a convenient method of accessing journal articles, mostly through the Libraries' subscriptions to bundled journal packages. The results of this analysis will help librarians make a case to renew journal packages in the future. The authors were somewhat surprised to find that full-text database aggregators provided so few of the journal articles used by the researchers, making them question the high cost of providing this access. In recent years, database aggregators have been criticized for their increasing costs. This criticism may be well-founded, particularly if grant writers are primarily relying on resources available through journal packages. A thorough review of database usage will take place in the upcoming year based on these results.

With so few resources cited outside of the Q and R call number ranges, it appears that very few of the NSF/NIH grant writers venture outside of the sciences when conducting research. Further analysis will need to be conducted to see if the grant writers' use resources across multiple science disciplines.

Seven out of every 10 articles that grant applicants cited were published in journals indexed in the JCR, the traditional compilation of "quality" journals. For the journal articles cited, these results demonstrate that traditional metrics of importance continue to maintain their relevance, despite repeated statements about the decline or the upset of traditional academic publishing.

Only nine open access journals were cited. From these results alone, it is impossible to determine why open access journals are cited less frequently. It may be that these journals contain fewer articles that have a significant impact; or that grant applicants are concerned about the quality of OA journals; or that the journals are so new that researchers are unaware of them. There is also a possibility that there were not enough high quality OA journals to access. Nevertheless, it is an interesting result given that the funding agencies themselves have encouraged more open access of research results in recent years. As the number of open access publications grows, it will be interesting to track the number of open access journals cited in the future.

Overall, the authors found that citation analysis provides substantial evidence that the KU Libraries' collection provides the necessary support for science and medical researchers at the University of Kansas. By way of the foregoing data and observations, the authors were able to satisfactorily address each of the eight questions the study intended to probe, as outlined in the introduction. The data that was collected can be used in the future to compare data collected in five to ten years to see if publishing patterns change over time and to assess to see that KU Libraries continue to serve the needs of successful grant writers at KU.

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