Fall 2014

The effects of academic libraries' resource, expenditure, and service decisions on library use: An analysis of ACRL and NCES data

Jody C. Fagan
James Madison University

The Effects of Academic Libraries' Resource, Expenditure, and Service Decisions on Library Use: An Analysis of ACRL and NCES Data

Jody Condit Fagan

A dissertation submitted to the Graduate Faculty of

JAMES MADISON UNIVERSITY

In

Partial Fulfillment of the Requirements

For the degree of

Doctor of Philosophy

School of Strategic Leadership Studies

December 2014

Acknowledgements

The author would like to thank James Madison University Libraries & Educational Technologies for access to the ACRLMetrics database, other subscription resources, and a supportive work and research environment.

Table of Contents

List of Tables

List of Figures

Abstract

Academic libraries are key contributors to the instructional and research missions of their parent institutions, but often struggle to demonstrate specifically what they do and how that affects institutional outcomes. High-impact educational practices are one area where libraries make a difference, but where explicit connections between activities and outcomes are not always articulated. Faculty and graduate student research is another area where libraries' contribution makes logical sense, but specific relationships are not necessarily drawn. Libraries may place different emphasis on these two areas, effectively choosing different business strategies, to support their institutions' missions. Two national surveys collect data about library expenditures, staffing, services, and use of resources. This study aims to explore the extent to which a library's business strategy might be visible through patterns in these national data sets. What can the data we already have tell us about differences between libraries and how those differences affect library services and use? To what extent can library use data predict an institution's external research dollars? By using a variety of statistical techniques, including structural equation modeling, MANCOVA, and multiple regression, the researcher explores these questions. The study also explores ways in which current data falls short in being able to connect library activities with high-impact educational practices and faculty and graduate research productivity, and proposes new ideas for measuring library activities such that they could be connected more clearly with institutional outcomes.

Chapter 1: Purpose

People generally like libraries. Universities often include library buildings on brochures to convey an image of scholarship, although this may mean glass and steel at one school and ivy-covered stone at another. These days, it is common for university faculty to involve librarians in their teaching and research. But library patrons and university administrators are generally unclear about what libraries actually *do* to provide their services and collections, and whether they will continue to be relevant.

What libraries do has changed dramatically in the past 20 years. The creation of the internet meant information would increasingly be shared online. The advent of the World Wide Web—the graphical interface to the internet—meant that searching and finding online information became activities the general population felt they should be able to perform. Users' expectations related to accessing information online skyrocketed. Meanwhile, the information marketplace underwent a series of dramatic changes, most notably with efforts to protect intellectual property and ensure profitability. Libraries have navigated a series of dramatic swings in assumptions and implications. The idea that "all information will be free online" was swiftly quashed by publishers enforcing digital protections and by challenges with digitizing historical information. The idea that library patrons would be able to easily find information themselves, with no library instruction, seemed plausible until the patron moved past needing "any ten journal articles" to needing specialized information sources like psychological measurement instruments, historical financial data, or Congressional hearings. The list of changes goes on, illustrating that libraries face ongoing challenges when trying to understand just what it is that they are doing and how to explain their service and collections models to stakeholders.

The Association of American Colleges & Universities and others have recently identified a number of “high-impact practices” in higher education (National Leadership Council for Liberal Education & America’s Promise, 2007; Kuh, 2008). First-year seminars, learning communities, service learning, undergraduate research, and capstone experiences have been found valuable for students and their institutions, increasing persistence, academic performance, critical thinking, and engagement (Brownell & Swaner, 2009). In 2013, a survey of business and non-profit leaders by the National Leadership Council for Liberal Education & America’s Promise (LEAP) found that 93% of employers said “a demonstrated capacity to think critically, communicate clearly, and solve complex problems is more important than [a candidate’s] undergraduate major” (LEAP, 2013, p. 1). Furthermore, employers endorsed several college activities as key to workplace success, including conducting research and using evidence-based analysis.

What is the library’s relationship to these high-impact practices? Riehle and Weiner (2013) found that information literacy is often included in discussions of high-impact practices in educational literature, but often not by that name. Librarians know they play an important role in first-year seminars, learning communities, research methods, and capstone courses. Some of their activities show up quantitatively in counts of library presentations to groups, but many other activities go uncounted or unconnected. The current work to revise the Association of College and Research Libraries’ Information Literacy Framework represents an exciting new opportunity to articulate the specific ways in which libraries may contribute to high-impact educational practices, but additional effort will be required to assess how the new framework connects to outcomes (ACRL, 2014).

Additionally, libraries' contributions to high-impact practices go beyond information literacy instruction. The learning commons environments libraries develop in their buildings provide spaces for students and faculty to think, communicate, and collaborate in an academic setting. These activities may be one driver of library building “gate counts.” In some libraries, professional staff provide educational technology support, working with faculty to make better pedagogical use of online course management systems, new media, and classroom technologies. Libraries are highly relevant to this area of high-impact practices and employer-endorsed skills, but the connections may not be obvious to others.

Libraries need to demonstrate how activities they are already doing connect with student learning outcomes (e.g., Dahlen & Baker, 2014). To do so, they may need to re-think how they measure their services and activities or how to re-interpret existing metrics. ACRL has received a collaborative planning grant from the Institute of Museum and Library services to explore how to demonstrate the value of academic libraries, and the project team is currently focused on how library factors affect high-impact practices (Malenfant & Brown, 2014).

Libraries also contribute to the university’s mission through the licensing, acquisition, and provision of electronic and print materials necessary for faculty and student research. For the humanities, this has historically meant collecting monographs, primary sources, and special collections. For the sciences, electronic journals have become pre-eminent. For business and social sciences, a variety of source types are important. People know libraries offer such collections. But it is unclear just what work is required to provide them in our modern information marketplace.

Before brainstorming a list of new measures, it is important to learn what some of the current data about libraries can tell us. Historically, U.S. academic libraries have measured and reported three common "outputs" to provide benchmarks of their work: circulation, full-text articles, and gate count (building use). Looking at just doctoral institutions in 2012, there are large differences on these metrics across libraries. For the bottom 25% of doctoral institutions, 4 or fewer books circulated, 52 or fewer full-text articles were requested, and there were 1 or fewer library building visits per full-time student and faculty member.[1] Meanwhile, the top 25% of doctoral schools saw more than 114 full-text articles requested, 10 books circulated, and 2 or more library building visits per full-time student and faculty member. What could be the reasons for these differences? If comparing baccalaureate schools to doctoral universities, these differences might not be surprising—but doctoral schools have comparatively similar missions. While counts of circulation, full-text articles, and gate count are not measures of high-impact educational practices or faculty research support, perhaps they begin to tell a story about how much the library is used. They may also be useful as indicators of the success of library business strategy.

One possible reason for the disparity between libraries may be found in differences among libraries' service offerings—the ones which *do* relate to high-impact practices and research support. Academic libraries do not merely provide information passively. Professional librarians market resources to students and faculty, instruct them

---

[1] ACRLMetrics, http://acrlmetrics.com. Sample used was the 2012 Doctoral sample described later in this study (*N*=169).

in their use, answer reference questions, and partner with them in research. Libraries have also been changing their building programs to promote higher levels of student engagement, which could result in increased library use. Social media provides new channels for librarians to connect with their user communities. Most libraries offer interlibrary loan services, but some go further than others. With extra investment, libraries have set up systems that fulfil requests in the evening and on weekends, and provide article delivery services so patrons can get digital copies of print journal articles. Libraries may also invest proportionally more in ongoing resource expenditures (e.g., databases and journals) or in one-time expenditures (e.g., monographs and videos). These are just some of the ways libraries make different choices that can affect use.

Exploration of hypotheses in this area is just beginning, meaning that as libraries allocate their budgets, the proportions spent on services, collections, and the building are largely dictated by historical practices, anecdotal evidence, and use statistics of specific services, collections, and buildings. Librarians may see increases in use of disciplinary materials after relevant library instruction classes and logically, spending more on library materials would result in higher use, but there are few holistic examinations investigating how library services and expenditures might influence library use.

This research aims to explore patterns in U. S. academic libraries' data to learn the extent to which various library services and expenditures affect collection and service use when controlling for size of institution. Relationships between library variables and external research dollars will also be investigated. Because little research of this kind has been conducted, this study will necessarily be exploratory, but will provide information about the relative strength of relationships.

In an age where so much information is discoverable with Google, it might be easy for a university administrator to question the need for library services. He or she may not see a connection between library activities and high-impact practices, or library activities and external research dollars. Why are so many staff resources allocated to answer reference questions, teach library instruction classes, and support faculty? Is all the hubbub surrounding “information commons” in the library buildings (Lippincott, 2010; Turner, Welch, & Reynolds, 2013) just hype, or does it result in increased library use? Wouldn’t it be better for the library to spend these funds on more full-text journals? Furthermore, to what extent does money spent on librarians and library staff even affect engagement with library services? As technology provides methods for people to connect asynchronously and more efficiently, couldn’t a smaller number of librarians and support staff handle the library’s service programs? As library deans converse with college administrators, they need better answers to such questions.

At the highest levels, this study is situated with in strategic management theory, specifically, business strategy. In the private sector, business strategy is defined as “how the firm competes within a particular industry or market,” or competitive strategy (Grant, 2010, p. 19). In the public sector, business strategy may usefully be thought of as how an organization or unit aligns itself with its parent organization’s strategic plan. Grant describes the task of business strategy as “how the firm will deploy its resources within its environment and so satisfy its long term goals, and how to organize itself to implement that strategy” (2010, p. 12). For libraries, a strategy may be visible through patterns in how the money coming in supports the collections and services that support the institutional mission and strategic plan in a way that leverages library-specific capabilities.

Individual concepts within strategic management have been applied in academic libraries, such as SWOT analyses (Atkinson, 2003; Johnson, 1994), and Balanced Scorecard (Mengel & Lewis, 2012; Taylor & Heath, 2012). The overall concept of business strategy as the private sector knows it has not generally been applied to libraries, but recent library conference presentations have begun urging libraries to consider institutional priorities and higher education trends more deliberately, and provide evidence showing how libraries are aligned with university strategy (Gilchrist, 2014).

Academic libraries may lack interest in business strategy theory because of its emphasis on competition, shareholders, and profit. Although libraries have conceived of themselves as "competing" for users' attention in the information marketplace (Bell, 2014), and as competitors for institutional resources, they do not conceive of themselves as competing with one another. However, it could be useful for libraries to compare themselves to one another to learn which strategies are working well. They could also think about needing to compete with and differentiate themselves from other units on campus. Similarly, while "shareholder interests and profit" are not directly relevant to academic libraries, these concepts can potentially be modified to "stakeholder interests" (the interests of library customers, campus peer groups, and senior administration) and to the outputs and outcomes specified in the library's mission.

In the context of competing for users' attention in the information marketplace, theories related to resource-based strategy are relevant for academic libraries. The resource-based view moves beyond traditional strategy analysis, which focused on the organization's identity and purpose, and emphasizes how a firm's distinctive resources and capabilities enable it to fit the environment's challenges. Peteraf (1993) reviewed theory development research in the 80's and 90's, and proposed a general model describing the theoretical conditions that supply resource-based competitive advantage which I have interpreted here in the context of academic libraries. For this discussion, "full-text articles" is used as an example of a resource libraries offer. Not only was full-text articles one of the dependent variables in the present study, their use is a major component of the return on investment for libraries. Full-text journals compose a very large proportion of academic libraries' ongoing expenditures, and are valuable to library stakeholders (faculty and students). While full-text articles can cost $20-30 per use for the public, library license agreements and bulk purchasing make each full-text article use cost just $1-2, demonstrating the savings accrued to library users.

The first theoretical condition that supplies resource-based competitive advantage is that heterogeneous resources and capabilities provide the ability to exploit differences. Thus, the goal is to develop superior resources and capabilities to others in the marketplace. Peteraf notes that "resources" may include knowledge-based competencies that involve collective learning (e.g., Pralahad & Hamel, 1990). Thus, libraries' expertise in information organization and research skills provide them with superior capabilities for helping students and faculty find relevant full-text articles than do public search engines. By way of contrast, public search engines have higher visibility and simpler user interfaces, which are useful for many other kinds of searching.

A second theoretical condition is limits to *ex post* competition, including "imperfect imitability" and "imperfect substitutability." (Peteraf, 1993, p. 182). This condition exists because of a monopoly-like condition, such as libraries' monopoly on "free" access to electronic resources because of the licensing work that they do on behalf of the institution. An entrepreneurial student could not simply set up a competing academic library, because it would be extremely difficult for her to negotiate any agreements with publishers. It would be more possible, but still challenging, for another unit on campus to imitate the library's information literacy instruction program. Barney's (1991) description of social complexity seems to fit libraries and provide an explanation for why even a big player like Google may not be able to compete with academic libraries: "Several firms may possess the same physical technology, but only one of these firms may possess the social relations, culture, traditions, etc. to fully exploit this technology in implementing strategies" (p. 110).

A third condition for resource-based competitive advantage is limited resource mobility: valuable resources and capabilities remain with the firm. Although traditional library services that support access to full-text articles have a lot of inertia, newer areas in library organizations like support for online learning are less "attached" to the library per se.

A final condition for resource-based competitive advantage is ex ante limits to competition: the costs of implementing strategy do not exceed the profits. For libraries, rising costs of journal subscriptions threaten competitive advantage in this area, although so far the publishers value the library market enough that they cannot push things too far. Peteraf notes that the resource-based strategy can be applied by administrators wishing to determine which of the organization's resources and capabilities are stronger contributors to competitive advantage than others. The resource-based view provides a broad perspective of how an academic library's allocation of resources relates to library use.

Although libraries may not have thought of themselves as "competing" on campus or aligning their resources to execute a strategy, observing the decisions they have made in allocating their budgets and staff time are one way to explore their strategy. The present study seeks to look for patterns in how libraries have invested in staffing, how that investment supports library services, and the extent to which various library services contribute to library use.

Although this research does not directly examine how library use affects an institution's research outcomes or student learning outcomes, it increases libraries' ability to be able to do so in the future. The findings of this research suggest new data that should be gathered in order for libraries to connect inputs not only with library outputs, but to better connect library use with meaningful indicators of research outcomes and student learning outcomes. While some of the metrics libraries currently gather may provide some indication of the library's role, they may not provide evidence for the logical connections library leaders need to make between the work libraries do and the high-impact practices and research productivity metrics that are now a major focus of higher education. However, libraries should first take stock of what they can already learn from the vast amount of information they have been gathering over the years.

Chapter 2: Literature Review

While not usually situating their studies within strategic management theories, libraries have taken a variety of approaches to explaining "what libraries do" based on use data. Many have focused on their own institutions, offering "how we did it" case studies to inform other practitioners. Several studies have demonstrated methods for correlating cost data with use data to inform specific purchasing decisions or demonstrate single-institution effectiveness (e.g., Killick, 2012; Zappen, 2010). Others have studied use of electronic resources to determine curricular relevance of the library's collections (e.g., Kennedy, 2006; Miller, 2012). Likewise, librarians have studied the effectiveness of instruction (e.g., Bluemle, Makula, & Rogal, 2013; Hsieh & Holden, 2010) and reference services (e.g., Mu, Dimitroff, Jordan, & Burclaff, 2011) at their institutions. These studies are all examples of what composes the majority of library literature: case studies focusing on a single aspect of library services.

Other scholars have focused their eyes on the forest rather than the trees. Especially in recent years, there has been an increase in research examining the influence of library data on institutional outputs such as student enrollment, retention, and graduation rates (e.g., Hinchliffe, Oakleaf, & Malenfant, 2012; Schwieder & Hinchliffe, 2012; Soria, Fransen, & Nackerud, 2013; Stemmer & Mahan, 2012). This trend began in response to the shift in higher education to a focus on outcomes-based assessment. Such research is important for learning how to connect library outputs with institutional outputs. However, libraries still need to understand what happens within their own organizations to produce the library outputs.

Somewhere between the forest and the trees, another body of research has attempted to study libraries across institutions—and not just one aspect of library services, but libraries as complex organizations. This level of focus offers more generalizability than the case study research, but perhaps more practical, specific implications than the current research connecting library outputs with institutional outputs. It is within this body of research that the present work is situated.

Some of the more notable studies in this category are reviewed here in reverse chronological order. Regazzi (2012) analyzed U.S. academic library spending, staffing, and utilization trends from 1998 to 2008, and concluded that despite a feeling of constraint, libraries are actually receiving increases in resources over time. He also found that use of physical library assets has declined. His findings varied by type, size, and Carnegie class of institution, which suggests these institutional variables should be explored when investigating similar research questions.

Hunter and Perret (2011) correlated ACRL data with LibQUAL+ scores across 73 universities to examine bivariate relationships between library expenditures, usage statistics, and library patron satisfaction scores on LibQUAL+. LibQUAL+ (2014) is an instrument used by over 1,000 libraries to measure satisfaction across three dimensions of library services: library as place, information control, and affect of service. Hunter and Perret (2011) hoped to discover correlations that suggested which areas of library services were “the most cost-effective to fund when attempting to increase user satisfaction” (p. 407). They adjusted some variables to control for institution size, for example, dividing reference transactions by student FTE, but did not do so systematically. They found evidence that higher ACRL statistics correlated with higher patron expectations for information control, but these increases were not matched with higher perceived satisfaction scores. Furthermore, more expenditures and larger collections correlated with lower overall satisfaction. Their study is intriguing, but it also reveals the limitations of bivariate correlations in exploring relationships among data.

Martell (2008) examined ARL university libraries' circulation rates, reference counts, and gate counts over time and illustrated an overall decline in the use of physical collections and services and an increase in use of electronic resources. While impressive for its historical trend analysis, his study points at the importance of attempting to link inputs, which were not examined, with outputs. For example, the study did not appear to control for the change in expenditures or in volumes held over time, which could have a direct effect on circulation rates.

Jones (2007) examined NCES Academic Library Survey (ALS) data for those liberal arts colleges chosen by U. S. News and World Report as the top 50 "Best Liberal Arts Colleges." She examined the input variables Total Library Expenditure, Librarians & Other Professional Staff, Total Staff, and Books as a proportion of combined faculty and student FTE, and the output variables Annual Circulation Transactions per FTE, Annual ILL Provided, Annual ILL Received, Reference Transactions per Week, and Gate Count per Week. She determined that $2,000 was spent per FTE on library resources among the top third of best-ranked libraries; $1,400 in the middle third, and $1,000 for the bottom third, whereas only $200-$400 per FTE was spent by all academic libraries. She also noted that the "best-ranked" colleges had higher annual circulation transactions per FTE. Although it was unclear why the study chose to use FTE to normalize some variables but not others, her study illustrates an interesting method for using ALS data to compare libraries.

As the previous studies demonstrate, there is still uncertainty about the extent to which variables internal to the library affect the use of the library. Researchers have made some initial forays into that problem space, but have not fully leveraged statistical techniques. This study will attempt to build on previous research by using structural equation modeling (SEM) to explore relationships among library variables. Standard regression techniques allow researchers to predict a dependent variable using a linear combination of independent variables. Regression does not provide information about the measurement error inherent in the variables. SEM, however, allows researchers to specify both measurement models and structural models simultaneously, meaning the researcher can examine error due to measurement of the variables as well as the factor structure in the same model.

Although SEM is powerful, it only offers the ability to test how well data fits a theoretical model. Therefore, it is important to have a strong theoretical basis for which variables are included in SEM models. For the data internal to libraries, the researcher believes she has found sufficient theoretical basis to use SEM. Even if overall models do not fit, analysis of the residuals may prove fruitful. However, much less work has been done examining the relationships between institutional variables such as external research dollars and library use. Therefore, different techniques were employed. Multiple regression models attempted to describe the relative contribution of library use variables to external research dollars, while MANOVA was used to describe group differences across institution types.

This literature review will now turn to examining the theoretical support for the inclusion of variables in the models and the relationships among them.

Institutional variables

This study's central exploration concerns how libraries' decisions influence library use. However, academic libraries exist within an institutional context. Some decisions about how to handle institutional and demographic characteristics need to be made, even for the SEM models that primarily focus on the libraries' data.

Institutional size

One of the most logical covariates to include is one relating to institutional size: A university with 50,000 students is going to have higher circulation, full-text article downloads, and gate counts than one with 500 students. However, there are many ways to count students. IPEDS / ACRL data offer student counts split up by full-time, part-time, graduate, and undergraduate. There are also faculty and staff to consider: they also use the library. Unfortunately, library use statistics do not usually separate counts by patron type.

Studies have taken different approaches when including this variable depending on the research questions of interest. Regazzi (2012) segmented libraries by Carnegie size classes (<1,000, 1,000-2,999, 3,000-9,999, and 10,000+) and described groups' characteristics, but did not perform statistical tests of group differences. Jones (2007) used combined total student and faculty full-time equivalents to normalize total library expenditures, libraries and other professional staff, books and other paper, and annual circulation transactions, but did not use any FTE variable to normalize interlibrary loans, reference transactions, or gate count. Weiner (2005) used the number of faculty, graduate, and undergraduate students as independent variables, along with number of library staff and total library expenditures, to predict reference transactions, group presentations, and attendees at presentations. While she found that 31% of the variance in her dependent variables was due to the independent variables, it was difficult to determine whether there were interaction effects among the independent variables. Davis (2004) used the number of unique IP addresses to represent the size of the readership community in their study investigating whether requests can predict the number of total users. The disadvantage of Davis's approach for the present study (in addition to the data not being available) is that non-users would not be represented in the concept of size.

The number of full-time students, undergraduate and graduate, plus the number of full-time faculty, was hypothesized for use as a general control variable for institutional size in this study using data from the ACRL ALTS survey. Disadvantages to this variable include limiting information about part-time versus full-time and undergraduate versus graduate student enrollment. Because the researcher did not have theories to test involving part-time students, and adding the ACRL part-time students variable would have meant additional cases with missing data, part-time students were not included in the covariate. In retrospect, the IPEDS variable "Estimated full-time equivalent undergraduate enrollment academic year" could have been a useful way to include full and part-time undergraduates without a significant loss of data.

Average expenditures per student

The level of resources available to an institution may also be relevant to the services libraries are able to provide. In this study's 2010 dataset (*N*=330), the lowest quartile of institutions spent $19,830 or less per student and the highest quartile spent

$31,030 or more per student. Even within one state, there may be an intentional hierarchy of postsecondary institutions with very different levels of resources, which has been suggested to relate to student quality (Sallee, Resch, & Courant, 2008). Researchers have previously included expenditures per student in models predicting efficiency and effectiveness (Powell, Gilleland, & Pearson, 2012) and when investigating relationships between institutional characteristics and rankings (Lee, Sanford, & Jungmi, 2014). Therefore, average expenditures per student was tested as a possible covariate to control for the variability between a resource-poor institutions and resource-rich institutions.

Carnegie Classification

Scholars at the Carnegie Foundation note that the Carnegie Classifications are based on "secondary analysis of numerical data collected by other organizations" (McCormick & Zhao, 2005). They note that "Colleges and universities are complex organizations that differ on many more dimensions than the handful of attributes used to define the classification's categories" (p. 55). Yet, researchers still feel like it's a good idea to test for differences among different types of institutions, and the Carnegie Classifications provide a consistent way to do that. In library literature, Jaggars, Smith, and Heath (2009) found statistically significant differences between faculty *expectations* and *perceptions* of service quality between research universities and masters-level universities, but did not find differences in faculty ratings of service *adequacy* — that is, the "extent to which faculty perceive that a library meets their expectations" (p. 317). Smith (2011) charted median library expenditures per FTE student by Basic Carnegie Classification, and showed an increase along the continuum from Master's (smaller) to Research Universities (very high research activity). Fagan (2014a) reported that the Basic

Carnegie Classifications contributed statistically to regression models predicting full-text articles and database searches, but added a comparatively small amount of predictive ability beyond that of student FTE. Because the research seems inconclusive, some basic statistical tests were conducted in this study to investigate the potential differences among Carnegie Classification groups.

The specific nature of the potential effect of Carnegie class is unknown. For example, one might hypothesize that undergraduate-focused institutions would have larger library instructional programs proportional to FTE, because of a mission focused more on teaching than research. Yet Williams (1995) and Owen (1992) posited that small undergraduate universities may have heavier teaching loads, which "may result in an undeveloped research culture, and teaching and learning which do not integrate library use" (Williams, 1995, p. 46). Although error variance exists within the Carnegie categories, it would be useful to describe differences among the groups and to note the potential effect of their exclusion on interpretation of the results. The current Carnegie Classifications were assigned based on data from 2008 and 2010 (Carnegie Foundation, 2014).

Effects of graduate programs and research emphasis

The degree to which an institution focuses its resources on its graduate programs has a variety of effects on the library. Nackerud, Fransen, Peterson, and Mastel (2013) found that graduate students at the University of Minnesota were the highest users of the library in proportion to their population size across most colleges. Graduate research is generally more specialized than undergraduate research, requiring deeper disciplinary collections and heavy use of interlibrary loan (Du & Evans, 2011; Egan, 2005; Frank &

Bothmann, 2007; Herrera, 2003; Vezzosi, 2009). Graduate students must act more independently and benefit from library instruction as they become scholars in their disciplines (Rempel, 2010). One question explored in this study was "How do libraries differ on the variables in this study in relationship to their institutions' focus on graduate programs?"

Regazzi (2012) found that Carnegie-classed doctoral institutions offer the highest salaries to librarians and library staff. He also noticed that while expenditures on print books decreased at Master's and Baccalaureate degree-granting institutions, Doctoral institutions experienced increasing expenditures on books between 1998 and 2008. Doctoral institutions also increased spending on overall collections and staff. Although Regazzi did not examine ongoing resource expenditures by Carnegie class, one would expect that libraries at institutions with graduate programs would need stronger full-text collections, meaning higher ongoing resource expenditures. Full-text article requests, circulation, and interlibrary loans could be higher because of the more exhaustive nature of their information use. Some libraries focus on library instruction programs to graduates, but many do not (Rempel & Davidson, 2008), and because of their smaller numbers, these may not make much difference in the count of "participants in group presentations" in the aggregate. Likewise, the smaller numbers of graduate students may limit the magnitude of their effect on gate count, reference transactions, reserves, and social media use.

Because of the mystery surrounding how graduate programs might affect library data patterns, and because they certainly would have meaning for library planning, this study explored the effect of graduate program emphasis on the variables in this study using the Carnegie "Graduate Instructional Program" Classification.

Dependent Variables: Circulation, Full-Text Articles, and Gate Count

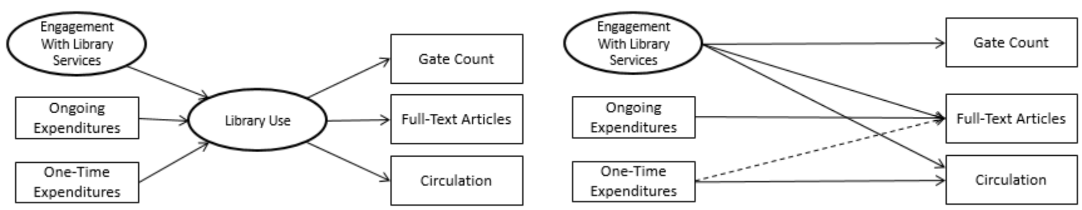
Researchers have measured the idea of library use in several ways over time. Grimes and Charters (2001) used the number of hours spent in the library by the student as their dependent variable. The use of "hours spent" ended up being somewhat confusing to interpret, because library instruction correlated with *less* time spent in the library, which the researchers thought indicated efficiency, while reference interactions resulted in *more* time spent, which the researchers thought indicated an investment of "library-specific human capital" by students.

Whitmire (2001) defined library use as including any of the following activities: using computers for library searches, using indexes to journal articles, developing a bibliography, using card catalog or computer, asking librarian for help, reading in reserve or reference section, checking out books, checking citations in things read, reading basic references or documents, or finding material by browsing in stacks (p. 532). Haddow (2013) measured library use by counting log-ins to authenticated resources and borrowed physical items.

The present study's models used three indicators of library use: initial circulations of physical items, full-text article requests, and gate count. The researcher also explored these indicators' correlations with one another. It was hypothesized that gate count and circulation would be positively correlated, gate count and article requests uncorrelated, and article and requests and circulation slightly positively correlated. Although it seems logical that online use would rise as physical item use falls, the evidence is mixed.

Longitudinal studies have suggested declines in circulation accompanied by increases in electronic resource use (Martell, 2008), but studies focused on student groups have shown that students who use more electronic resources also check out more items, and vice versa (Haddow, 2013, p. 135; Goodall & Pattern, 2011). Alternative models were tested: one with a latent variable "library use" measured by these three variables, and one with these three dependent variables predicted separately by Engagement With Library Services, Ongoing Expenditures, and One-Time Expenditures (Figure 1).

Figure 1. Two options for testing the dependent variables Circulation, Full-Text Articles, and Gate Count.



Circulation

Checking out books has often been chosen as an indicator of library use (e.g., Harrell, 1988; Martell, 2008). Although there is some evidence that overall circulation in libraries is declining, Martell (2008) demonstrated that the trend is not universal and that selecting specific groups or years of libraries may reveal circulation increases. In a study of "the library brand," the nonprofit library organization OCLC (2010) found that the association in peoples' minds between libraries (of all types) and books is stronger than ever. In a single-institution study, Soria, Fransen, and Nackerud (2013) found that checking out books had a positive correlation with academic achievement.

Library delivery services, ranging from mailing physical items to distance learners to delivering items to faculty mailboxes on campus, have proliferated in the last decade and add to circulation counts (King & Pendleton, 2009; Long, 2009; Schoonover, Siriwardena, & Jones, 2013). Although the use of such services is growing, the trend does not yet seem large enough to affect the use of circulation as an indicator of physical engagement. For example, at Florida State University, deliveries accounted for 2.3% to 4% of circulations from 2010 to 2012, while at Auburn University, deliveries accounted for 1% to 1.3% from 2006 to 2008.

ACRL (2012) explains that the count of initial circulations excludes reserves (materials circulated for intentional use inside the library) and renewals. Although most circulations are books, the count also includes circulation of other physical items such as CDs, videos, kits, and even equipment. Circulations to and from remote storage facilities for library users are included, but those supporting transfers or stages of technical processing are not. Some studies have included renewals (Regazzi, 2012; Soria, Fransen, & Nackerud, 2013), and the count of all circulations including renewals is available from NCES ALS. However, since this indicator is one of physical engagement, and users do most renewals online, just initial circulations were used (referred to as “Circulation”) in this study.

Full-Text Articles

Borin and Yi (2011) included full-text articles among the metrics for indicating user interest in the collection. COUNTER standards have improved the reliability of this metric by curtailing technology-related artifacts, for example, by ensuring multiple requests for the same article within 30 seconds are disregarded (Davis, 2004). Davis

(2004) demonstrated with regression that full-text requests can predict the number of e-journal users, even after controlling for institutional effects and the time of year. This suggests the relationship between full-text requests and number of users is not skewed by users with extreme behaviors, although such users are present in the data. Davis (2004) also found this relationship held across journal subjects, popularity, and size.

It is important to note that the number of full-text requests does not show *how* items were used, or how valuable they were to the user (Grogg & Fleming, 2011; Nicholas & Huntington, 2006). However, there is some indication that requests relate to usefulness in some way: Duy and Vaughan (2006) found significant, positive correlations between full-text requests per journal and citation patterns at Concordia University, suggesting a relationship between e-journal full-text requests and usefulness. In single-institution studies, Goodall and Pattern (2011) and Soria, Fransen, and Nackerud (2013) found positive correlations between online library usage and academic achievement. New research is exploring ways to measure journal article sharing (as opposed to downloading) using social media, institutional repositories, and bibliographic tools like Mendeley (Tenopir, 2014).

This study uses the “Number of successful full text article requests” variable from ACRL’s ALTS, which uses the Project COUNTER (2012) definition, and refers to this variable as “Full-Text Articles.”

Gate Count

Gate Count is collected by NCES as part of the Academic Library Survey as “the number of persons who physically enter library facilities in a typical week” (NCES, 2012, p. 9). Libraries are instructed to collect data during any seven consecutive calendar days that are neither unusually busy nor slow, with no vacation periods. Libraries that count a year's worth of data may divide it by the number of weeks the library was open. From year to year, gate count can be dramatically affected by things unrelated to library services, such as the opening or renovation of library buildings and installation of nearby or in-library coffee shops.

Even beyond such events, gate count has been somewhat mysterious to libraries. Greenwood, Watson, and Dennis (2013) noticed a spike in gate count at the University of Mississippi, but were unable to determine any specific service changes that could have been responsible, even when examining their LibQUAL+ survey results from the years bracketing the event. Opperman and Jamison (2008) noticed an increase in gate count in the Ohio State University Science and Engineering Library from 1999-2006 was accompanied by decreases in many traditional on-site activities such as photocopying and checkouts. They speculated that students increasingly used the facility for studying as well as accessing online library resources. In their words, "the physical library is transformed from a print-focused collection into a more inviting campus destination dedicated to discovery and learning" (p. 571). Researchers are currently exploring ways to at least split up gate count by type of patron to get more demographic details (Bailey & Slemons, 2014).

Related to gate count are studies of library building use. Yoo-Lee, Lee, and Velez (2013) conducted a survey of 100 undergraduates at North Carolina State University, and found that students used the library frequently in their everyday life, mostly on weekday nights with friends or in a group. Communal and social spaces in library buildings and the idea of a "Learning Commons" are becoming increasingly important, while interactions with librarians may be becoming less correlated with physical library use. Yoo-Lee, Lee, and Velez urged future research to include use of library space in studies of library use in addition to other metrics. Chang (2014) analyzed graduate students' use of library spaces and found that graduate students generally used the library building at least 2 days per month, and that they used the building for both solo and group work.

A question surrounding gate count is whether to normalize it in some way by the number of hours the library is open (a statistic that is available in the ALS dataset). Regazzi (2012) normalized gate count by both enrollment and hours open. Although this may have been appropriate for his investigation, this study does not normalize by hours open. Because of varying demand in a 24-hour period, extending or reducing hours may not have a dramatic effect on gate count. As just one example, Oakland University and University of Massachusetts, Boston have a similar gate count per full-time FTE (0.67 and 0.69). Yet because Oakland University's library is open almost twice as many hours as UM Boston (156 to 84), its gate count per FTE per hour is half that of UM Boston. It would seem invalid to say that Oakland's students are half as engaged with the library as UM Boston's due to this numerical difference. Libraries determine which hours to be open be based on evaluation of patron expectations and use. Gate count per hour would be useful to examine if trying to determine whether to open or close earlier. When looking at a national sample of libraries and using gate count as an indicator of library engagement, this study will assume each library has already made the determination of the appropriate hours to be open for their campus.

Table 1 lists the independent and dependent variables used in this study; the reader may wish to print it for reference when interpreting the tables and charts.

Table 1. List of primary independent and dependent variables.

Variable Name	**Data Source**	**Variable Name in Data Source**	**Definition**
LOG_PartGrpPrez	ACRL Library Trends & Statistics	Participants in Group Presentations	Includes library instruction, other planned class presentations, orientation sessions, and tours
LOG_Ref	ACRL Library Trends & Statistics	Reference Transactions	"An information contact … involving the use … of one or more information sources by ... library staff." (ACRL, 2012)
LOG_ILL	ACRL Library Trends & Statistics	Total Items Borrowed	The number of filled requests received from other libraries, including print and electronic.
LOG_ResCirc	NCES Academic Libraries Survey	508 Reserve Circulation Transactions	Reserve transactions of all types, both initial transactions and renewals
LOG_ProfFTE	ACRL Library Trends & Statistics	Professional Staff (FTE)	Includes librarians and professional staff (e.g., computer experts, systems analysts, or budget officers)
LOG_StaffFTE	ACRL Library Trends & Statistics	Support Staff (FTE)	Staff FTE not included in Professional Staff
LOG_AvgProf	Calculated from ACRL data	NA	Salaries & Wages Professional Staff / Professional Staff (FTE)
LOG_AvgStaf	Calculated from ACRL data	NA	Salaries & Wages Support Staff / Support Staff (FTE)
LOG_Ongoing	ACRL Library Trends & Statistics	Ongoing Resource Purchases	Subscription expenditures for serial and other publications (e.g., journals, databases, some e-books)
LOG_Onetime	ACRL Library Trends & Statistics	One-Time Resource Purchases	All non-subscription library materials (e.g. books, journal backfiles)
LOG_PCT2	Calculated from ACRL and IPEDS data	NA	Total Library Expenditures (ACRL) / Total Expenses of Institution (IPEDS)
LOG_Purpose	ACRL Library Trends & Statistics	Calculated from ACRL	How many of the 9 types of "social media purposes" the library uses

Predictors of Circulation and Full-Text Articles: Ongoing Expenditures and One-Time Expenditures

Database searches and ongoing expenditures are two variables that seem to predict full-text requests. Fagan (2014a) found relationships among these variables in her study predicting full-text requests from database searches, ongoing expenditures, and other variables. Soria, Fransen, and Nackerud (2013) found a positive correlation between database use and academic achievement. However, numerous problems have been found with the measurement of database searches (Coombs, 2005). The count of database searches in libraries includes reports from numerous vendors, and libraries are challenged to assemble the counts into a single number. This decentralized reporting results in a large amount of missing data and high, construct-irrelevant variance. Database searches is also a new variable: ACRL began collecting data about database searches in 2012. Because of these issues, database searches was not used in this study.

The indicator "ongoing expenditures" signifies a library's current investment in its collections. Borin and Yi (2011) noted that expenditures is superior to "volumes added" or "number of titles owned" to provide an idea of investment in library resources because of the increase in consortially-purchased titles, package deals, and the confusion of ownership and access. This trend is one reason why in 2012, ACRL began counting specifically "ongoing library materials expenditures," which was defined as subscription expenditures for serial and other publications including "paid subscriptions for print and electronic journals and indexes/abstracts available via the Internet, CD-ROM serials, and annual access fees for resources purchased on a "one-time" basis" (p. 4). Previously, ACRL had counted print and online ongoing materials expenditures separately.

One-Time expenditures are defined by ACRL as "all library materials that are non-subscription, one-time, or monographic in nature." The library's books are included in this figure, but so are one-time purchases of electronic journal backfiles. Therefore, alternative models was tested where One-Time Expenditures predicts both Full-Text Articles and Circulation.

In this study, the variables Ongoing Expenditures and One-Time Expenditures were thought to be predicted by Library Expenditures as a Proportion of Institutional Expenditures with the idea that better-funded libraries would be able to afford more resources. Ongoing Expenditures was hypothesized to predict Full-Text Articles, and One-Time Expenditures was hypothesized to predict Circulation and possibly Full-Text Articles.

Engagement With Library Services

Libraries have long been the most active champions for information literacy on college campuses, which has received new attention in light of employer surveys showing an interest in skills that cross discipline boundaries, including evidence-based research (LEAP, 2013). Yet, libraries have not always articulated this connection as a strategic advantage that distinguishes them from other units on campus (Barney, 1991). Riehle and Weiner (2013) found that information literacy is often included in discussions of high-impact practices in educational literature, but often not by that name. For example, librarians are often engaged in first-year seminars, learning communities, research methods, and capstone courses through the creation of online tutorials, library instruction classes, and collaboration with students and faculty. Showing how libraries contribute to these practices is critical for demonstrating the relevance of the modern academic library. A modern academic library's services are rapidly changing and in fact, are targeting student engagement, critical thinking, and problem solving. Libraries now sponsor hackathons, provide support for integrating resources with course management systems, and offer expertise with digital preservation, to name just a few activities. Because of this study's focus at the institutional level, it is necessarily limited to the services for which data is tracked. Yet, there are still counts of how much use students are making of some relevant library services. In this study's primary theoretical model, Engagement With Library Services was measured by the number of Participants in Group Presentations, Interlibrary Loans, Reference Transactions, Reserves Circulation, and libraries' use of social media.

Engagement With Library Services—Participants in Group Presentations

Fagan (2014a) found a small but statistically significant effect of Participants in Group Presentations on Full-Text Articles in two models. Based on data from a sample of business students, Booker, Detlor, and Serenko (2012) found that library instruction had a positive effect on users' intentions to use the online library in the early stages of research. However, they also proposed that there is a "saturation point" after which additional library instruction does not help. This suggests the number of participants instructed could be a more useful variable than class sessions, which could include repeat participants. In a survey of over 4,000 continuing education students at a Canadian undergraduate university (with a response rate greater than 80%), Williams (1995) found students who had library instruction reported using the library twice as much as those who did not. This study uses ACRL's count of participants in group presentations, which is defined as "the total number of attendees in all group presentations," including "formal bibliographic instruction programs" and "other planned class presentations, orientation sessions, and tours" (2012, p. 6).

Engagement With Library Services—Interlibrary Loans

Most research using interlibrary loan statistics has involved single-institution studies and focused on programmatic improvements. Yet, the studies provide some insight to the validity of this variable as an indicator, and identify possible sources of variance. For example, Leykan (2008) reviewed the publication date, subject headings, and requestor's academic status in conjunction with library liaison services. Although interlibrary loan was available to all faculty, staff, and students, the majority of users were from a limited number of academic departments, and use by department seemed to vary with liaison activity. Therefore, overall librarian liaison activity at an institution could influence interlibrary loan use. Several studies have reviewed lists of items borrowed via interlibrary loan to inform acquisitions practices (e.g., Ruppel, 2006), suggesting that some libraries may have reduced interlibrary loan statistics because they have implemented buy-instead-of-borrow programs. Unfortunately, there is no data about whether the libraries in these datasets have implemented such programs.

ACRL counts interlibrary loan statistics for the number of requests for materials *provided* to other libraries separately from the number of filled requests *borrowed* from other libraries or providers (ACRL, 2012). While materials provided to other libraries may be a sign of collection quality, interlibrary loans *borrowed* is a sign that a library's patrons are engaged with research. Interlibrary loans may include the loan of physical items, photocopies, and digital PDFs. It does not include any locally owned items (some libraries offer services to scan in print articles for patrons; these would not be included).

Soria, Fransen, & Nackerud (2013) found statistically significant correlations between interlibrary loans and database, electronic journal, electronic book usage, reference, and library instruction classes. This provides support for including ILL as an indicator of Engagement With Library Services.

Engagement With Library Services—Reference Transactions

ACRL defines a reference transaction as "an information contact that involves the knowledge, use, recommendations, interpretation, or instruction in the use [or creation of] one or more information sources by a member of the library staff" (p. 6). Because library search tools are usually visible only to authenticated users, many students may not discover them unless shown by a professor or reference librarian. In Grimes and Charter's (2001) study, reference transactions was positively correlated with more hours spent in the library; and in Fagan (2014a), reference transactions had a small but statistically significant effect on Full-Text Articles in two models. Reference transactions may also relate to physical activity in the library.

Any library public service staff member would be quick to point out that these days, reference transactions may occur via chat or email. ACRL (2012) specifically notes that e-mail, web form, and chat transactions, and transactions of any length are counted with this metric. However, virtual reference transactions represent only a small proportion of total reference transactions (Mu, Dimitroff, Jordan, & Burclaff, 2011; Radford & Kern, 2006). Virtual reference transactions are not counted as a separate metric by ACRL or NCES.

Engagement With Library Services—Reserves Circulations

Reserves Circulations is also collected by NCES as part of the Academic Library Survey. Unlike the ACRL "Initial Circulations" statistic, reserve transactions include both initial transactions and renewals. Libraries that effectively market Reserves services to faculty should see a higher Reserves Circulation count (even if the trend over time is a decrease in Reserves Circulation across libraries). Because the patron must usually visit a library desk to renew reserves materials, and they must be used in the library, reserves activity may increase use of gate count. Martell (2008) reported this statistic as declining for academic libraries from 1995 to 2006.

Engagement With Library Services—Social Media

Social media is also proposed as a sign of Engagement With Library Services. ACRL just added the social media questions in 2012. Libraries were asked whether they used specific social media technologies (e.g., blogs, Facebook) and for what purpose (e.g., Community building, Friends of the Library). This study used the "purpose" aspect to determine the extent of social media use, since a library using one technology for numerous purposes better fits the idea of high social media use than a library using many technologies for a single purpose. For this study, Social Media score was calculated by giving libraries one point for each "Yes" answer to each "Social Media – Purpose" question. Since there were nine questions, that meant a library could score from 0-9 on this indicator.

The question of whether social media use by libraries has an effect on library use is still under debate. Special Collections departments are heavy users of social media: Griffin and Taylor (2013) found that 73% of ARL libraries' special collections departments had profiles on at least one social media site (p. 262). A few studies have found that promoting digital special collections through social media increases use (Bagget & Gibbs, 2014; Elder, Westbrook, & Reilly, 2012). However, Wu et al. (2014) surveyed 1,513 first-year students at seven institutions and found many were unaware of or did not use social media technologies other than Facebook. Furthermore, over half their respondents said they were unlikely or extremely unlikely to friend the library on Facebook (p. 127). It is therefore unclear if libraries' social media use has affected any variables in this model.

Library Budget as a Proportion of Institutional Expenditures

In order to pay library staff, provide library services, and acquire resources, a library needs a budget. There are many ways to capture the institution's investment in the library, including library budget as a proportion of institution's budget, library budget as a proportion of academic support budget, and total library expenditures as a proportion of instructional expenditures. All these options were explored for use in these models, but the first was chosen since it has commonly been used in other studies. Also, it seemed that the way in which an institution might classify expenses as "academic support" or "instruction" and where the library's budget line fit in an institution's budget could introduce large amounts of construct-irrelevant variance to this model.

Weiner (2009) examined how library expenditures related to institutional reputation of doctoral institutions. She found that total library expenditures contributed significantly to all her models predicting reputation, including those where institutional variables were entered into the model first. There seemed to be only a small amount of variance in the proportion of institutional budget devoted to the library across institutions.

Applegate (2007) found that the library's allocation proportion varied across institutions by institutional type: libraries accounted for less than 2% of associates institutions' budgets, while private, ARL libraries accounted for 2.8% of their institutions' budgets. The proportional budget appears to be decreasing over time: in a 2005 study, Weiner found that the average allocation of university expenditures to ARL libraries decreased from 3.91% in 1982 to 3.32% in 1992. As of 2012, the average was 2.1% for pubic, four-year institutions that reported data for both library and total institutional expenditures (*N*=988, ACRLMetrics, 2012).

Investment in Library Staff

Garvin (1988) discussed two contrary theories concerning quality and staffing costs, both of which are relevant to libraries. One set of theories posited a positive relationship between cost and quality: that is, you get what you pay for. If you invest more money in library staff, whether by hiring more staff or paying them better (or both), you will get higher quality library services. The opposing theory is that as quality increases, costs decrease because high-quality products and services result in greater satisfaction, meaning reduced follow-up costs. In libraries, one might hypothesize that if libraries invest in developing excellent online search interfaces, reference questions will go down because students and faculty can find what they need on their own. Therefore, the cost of staffing reference desks could go down.

Garvin also discusses the relationship between quality and productivity. A traditional management view is that to do better work, workers will need to slow down. However, he cites many studies suggesting there is a positive correlation between quality and productivity, although there may be an initial period of learning where things do take longer. Libraries implementing online instruction programs have faced this: it requires an enormous initial investment to develop and launch online tutorials and to test and improve them. But as the online materials are refined, more students can be reached.

Specific research concerning the effect of staffing levels on organizational performance is seemingly nonexistent in libraries, and has shown mixed results in the business world. Investigations related to the effects of fewer staff often focus on downsizing. Williams, Khan, and Naumann (2010) found that downsizing immediately and negatively impacts customer satisfaction and retention. Iverson and Zatzick (2011) found that the negative influence of downsizing on labor productivity in high-performance work systems was mitigated by showing consideration for employees' morale and welfare. Love and Nohria (2005) found that downsizing is contingent on the circumstances for the reduction. Tsai and Shih (2013) suggested that a "responsible downsizing strategy" can result in the development and enhancement of dynamic capabilities (a firm's "ability to integrate, build, and reconfigure internal and external competences for addressing rapidly changing environments," according to Teece, Pisano, and Shuen, 1997). In other words, "it depends." Although the research is ambiguous, this study hypothesizes that a greater investment in staff increases a library's ability to provide library services.

The ALS and ACRL surveys differ in the instructions for counting staff. The ALS specifically separates librarians ("the total FTE of staff whose duties require professional education (the master's degree or its equivalent) in the theoretical and scientific aspects of librarianship") from other professional staff ("the total FTE of staff whose duties require education and/or training in related fields (e.g., academic disciplines, archives, media, computing)") (NCES, 2012). The ACRL survey items related to staff haven't changed since 2006; they combine librarians and other professional staff into one category:

> Since the criteria for determining professional status vary among libraries, there is no attempt to define the term "professional." Each library should report those staff members it considers professional, including, when appropriate, staff who are not librarians in the strict sense of the term, for example computer experts, systems analysts, or budget officers. (2012, p. 5)

Support staff are simply defined as staff who "are not included in Professional." The NCES ALS definitions provide more granularity and have been commonly used by researchers investigating staffing; however, there was more missing data for the ALS salary variables than for ACRL in this study's datasets. Thus, the ACRL staff-related variables were used in this study. Additionally, the benefit of the ALS's granularity would have been lost in this study because the ALS does not track librarian salaries separately from other professional staff salaries.

Using the NCES ALS data, Regazzi (2012) performed an inflation-adjusted longitudinal analysis of staffing patterns in academic libraries from 1998 to 2008. He found that large and doctoral institutions have increased both collection and staff spending well above the mean for all libraries, while small libraries have decreased in expenditures on staff. Across all institutions, librarian staff levels have increased by 9%, while other professional staff (non-librarians with professional qualifications) have increased 51%. Overall, "Other paid staff" have declined by 6% and student assistants have declined by 15%. The increase in use of "other professional staff" is most visible when looking at libraries grouped by Carnegie Classification: "for every one staff FTE added as Librarian staff to Doctoral research institutions, 13 other professional FTEs were added." Expenditures per staff, however, have remained about the same from 1998 to 2008.

Applegate (2007) also used NCES ALS data to explore librarian distribution among large, medium, and small institutions. She investigated staffing ratios by size, type, and Carnegie Basic classification. For investigating size, she created groups "derived from a connection between size and Carnegie Classification" (p. 64). Her groups were: small libraries, 1-9 staff; medium libraries, 10-24; and large, greater than 24. She found that public institutions generally have a greater proportion of non-librarians and had larger librarian-to-student ratios. Small schools had more students per librarian than large schools. For example, on average, at large public schools, each librarian served 466 students, while at small public schools, the librarian-to-student ratio was 574 to one (p. 66). At large private schools, each librarian served an average of 223 students, while at small privates, the ratio was 423 to one. Across Carnegie classes at public institutions, the librarian-to-student ratio varied, but non linearly; the greatest librarian-to-student ratio was found at Baccalaureate - Associates institutions (914), but the second highest was at Master's-I institutions (585). While the lowest was at Doctoral-Extensive (454), the next-lowest was Baccalaureate-Liberal Arts (470). Based on these studies, it is not clear how staffing levels at libraries relate to other institutional characteristics.

The relationships between salaries and institutional characteristics are also unclear. Regazzi (2012, Table 6) found that doctoral institutions had the highest average librarian/professional salaries in 2008 constant dollars, rising from $55,538 to $58,448 from 1998 to 2008, but Associates schools had the next highest, although they decreased from $54,739 to $53,778 during the period he examined. Masters' institutions ranked next, followed by Baccalaureate, each of which increased a small amount from 1998 to 2008. Other paid staff followed a similar pattern, except associates' institutions saw a decrease in average salary from $32,138 to $30,783 while all other Carnegie Classifications saw an increase in average staff salary during the period.

Arranged in the overall model, the researcher hypothesized that all these variables provide a framework in which libraries' business strategy choices can be seen. Administrators divide the incoming library budget into staff, one-time materials expenditures, and ongoing materials expenditures. Investment in staff enables the provision of library services. The Engagement with Library Services variables join One-Time Expenditures and Ongoing Expenditures in producing the library use variables Circulation, Full-Text Articles, and Gate Count.

Chapter 3: Methodology

Instruments

Academic libraries have two national sources of data about library services, expenditures, and outputs: the NCES Academic Library Survey (ALS) and the ACRL Academic Library Trends & Statistics survey (ALTS). A strength of these datasets is the number of institutions which participate and the number of available years of data. Thus, the sophistication of statistical analysis is not likely to be limited by sample size even after dealing with missing information. Having multiple years of data provides additional options for cross-validation of models. The IPEDS identifier means the two data sources can be linked with each other using ACRLMetrics online software (http://www.acrlmetrics.com/) and with other IPEDS datasets.

The NCES Academic Library Survey (ALS) has been conducted every two years since 1988 and offers descriptive statistics for approximately 3,700 U.S. degree-granting institutions and their academic libraries (NCES, 2013). The primary audience for the data is Congress and federal grant agencies, including the Institute of Museum and Library Services, National Library of Medicine, and the Library of Congress (NCES, 2011). State education agencies and library administrators also use the data to plan funding, and library researchers use survey results "to determine the status of academic library operations and the librarian profession" (NCES, 2011, p. 1). The NCES publishes a "First Look" report that summarizes results for each year (NCES, 2010).

The ACRL Library Trends and Statistics (ALTS) survey has been conducted since 1999 and the most recent dataset (2012) included responses from 1,689 libraries. There have been two reports presenting a comprehensive, historical look at the ALS data, one for the period 1974-1996 (Cahalan, et al., 2001), and one covering 1994-2004 (Lu, 2007). ALS and ACRL survey data from 2000-2012 are available through a subscription product called ACRLMetrics, which was described in detail by Stewart (2011, 2012). The tool offers reports for commonly desired ratios, rankings, and crosstabs, and datasets can be created and downloaded for use with statistical software.

Additional data regarding external research dollars was obtained from the NSF's HERD database from the most recent year available, 2011 (see Appendix A).

Samples

The population of interest for this study is non-profit four-year U.S. colleges and universities with academic libraries. The ALS variable "Sector of Institution" was used to limit to the categories "Public, 4-year or above" and "Private nonprofit, 4-year and above." The ALTS variable "Country" was used to limit to U.S. schools.

This study will use datasets from 2010 and 2012 (the ALS is conducted in only even-numbered years). Because this study is exploratory, the 2010 datasets were used for conducting preliminary analysis and testing models, and the 2012 dataset was reserved for testing final models. This approach involved a tradeoff: reserving the 2012 data would allow cross-validation but prevent the ability to analyze changes from 2010 to 2012.

Procedures

Data Screening

In her study of the effects of several variables on full-text articles, Fagan (2014a) included libraries meeting a minimum level of service and removed libraries with fewer than 100 participants in group presentations, 100 items borrowed via interlibrary loan, or 365 reference transactions. Because this study evaluated both a structural component and a measurement component using SEM, cases were not limited in this manner. However, cases with missing or zero values were listwise deleted. Table 2 shows the number of cases deleted because of missing values for each dataset. There were 730 cases in 2010, and 450 cases in 2012 missing one or more of the dependent variables. Looking at the 450 deleted cases from 2012, about 300 were Carnegie-classified as being small or very small schools. Small schools may not have adequate library staff to report data on such surveys. An 89 additional schools were Carnegie-classified as special-focus institutions—law schools and seminaries being two examples. Therefore, removing the missing data limited the generalizability of this study's findings to exclude these types of schools. The remaining 61 schools with missing data were a mix of large, medium, and small, and many probably just did not report one or more pieces of data that particular year.

Table 2. Cases deleted due to missing data.

	2010	2012 (all datasets)
2012 U.S. non-profit four-year institutions	1194	1148
Missing Data: Full-text Articles, Circulation, or Gate Count	730	450
Missing data: Any other variable (except Social Media)	92	95
Total Cases Remaining	372	538

Cases with no "Yes" answers to the Social Media question were not removed, because an additional 116 additional libraries did not report data for this variable set. By not removing these cases, the researcher had the option to run models with and without this new variable.

The 2012 dataset had several different variables than 2010. First, the Social Media questions were not added to the ACRL survey until 2012. So the Social Media answers from 2012 were added to 2010 by matching on the IPEDS identifiers. Second, library materials expenditures were tracked differently prior to 2012: instead of two variables, one-time and ongoing expenditures, there were four: monographs, current serials, other library materials, and miscellaneous. Appendix 2 discusses the specific definitions of these variables. After deleting missing data for Monographs and Current Serials, the researcher computed new variables: One-Time Expenditures 2010 summed monographs plus Other Library Materials, and Ongoing Expenditures 2010 summed Current Serials plus Miscellaneous.

After the first round of SEM models, a third dataset was created from the 2012 dataset with 1,148 cases to test some simpler path models with just Carnegie-classified doctoral institutions. Because fewer variables were needed, fewer cases needed to be deleted due to missing data. This 2012 set had 181 cases after limiting to doctoral institutions with the variables Full-Time Students, Full-Time Faculty, Full-Text Articles, Ongoing Expenditures, Participants in Group Presentations, and Interlibrary Loans. The 2010 dataset did not have sufficient cases with all these variables to provide a cross-validation sample, so just 2012 was used. A fourth dataset was also created from the 2012 dataset to test the same path models with Master's and Baccalaureate institutions combined. This Master's plus Baccalaureate dataset had 381 cases after limiting in the same way as the 2012 Doctoral dataset.

After removing cases with missing data, the datasets were screened for univariate and multivariate outliers. Univariate outliers were detected through the use of boxplots. The researcher only deleted extreme outliers that showed a clear separation from the data. Multivariate outliers were detected by using a regression on all variables in the model (except Social Media) to predict the id number of the case. While many outliers in these datasets come from clerical errors, other outliers may be correct values but represent a specific, unusual circumstance that still justifies the case being deleted. For example, a library that closes its building for renovation one year may report an extremely low gate count. In such a case, the building closing may have affected other variables in a way that is not so obvious. There were also some cases where the institution was simply one of the biggest or smallest institutions. Table 3 shows how many cases were deleted for outliers for each of the variables in the primary model in this study.

Table 3. Cases deleted due to univariate and multivariate outliers (listwise delete).

	2010	2012	2012-Doctoral	2012-Baccalaureate + Master's
2012 U.S. non-profit four-year institutions (cases with missing data deleted)	374	538	181	381
Outliers – Univariate	39	89	11	14
Outliers – Multivariate	5	2	1	0
Total Cases Remaining	330	447	169	367

The required sample size for SEM models is a topic of much debate (Weston & Gore, 2006). Kline (2011) recommends at least 10 cases, preferably 20, per parameter estimated, but also notes that most published literature uses a minimum of 200 cases. More complex models, non-normal data, or a need for more statistical power increases the requirements for sample size. For this study, the final number of cases in each sample provided sufficient data for all the measurement models in this study (the most complex has 27 estimated parameters), but only the 2012 data was close to sufficient for testing the most complex of the initial hybrid models, which had 36 estimated parameters. However, 2010 was still used to perform initial tests of the measurement models.

For the path models with just doctoral schools, and Baccalaureate + Master's schools, the most parameters estimated was 12, meaning a minimum of 120 cases was needed. The 169 cases available for the Doctoral dataset fell short of the ideal 20 cases per parameter guideline, which limited the power of these model tests. However, the 367 cases in the Baccalaureate + Master's was more than sufficient.

Normality, heteroscedasticity, and linearity of the data

Fagan (2014a) found that most ACRL data appears to be non-normal in shape, and used a log transformation prior to performing regression analyses. The transformation made interpretation more difficult; however, the extreme shape of the data could have caused problems for running the models in this study. Because this study is exploratory, the overall fit of models was of more interest than interpreting parameter estimates. Also, the sample sizes for some of the datasets were at the lower end of the recommended guidelines, pointing to a need for more normal data. Therefore, a log transformation was applied to the variables in this study. A constant (1) was added to the variable "Library Expenditures as a percent of Institutional Expenditures" before applying the log transformation to avoid negative numbers.

Even after performing a log transformation, the data demonstrated non-normality according to Mardia's Normalized Multivariate Kurtosis. Among the measurement models, values ranged from 14 for the model with the fewest variables (Model A-3) to 38 (for models C-3 and C-5) for the 2010 dataset. For the 2012 Doctoral and 2012 Baccalaureate plus Master's datasets, the values ranged from -35 to -59. Bentler (1998) noted there was no real cut-off point for kurtosis, but that in his experience a value of 10 was a good indication that the data are not normal. Therefore, maximum-likelihood (ML) estimation with the Satorra-Bentler adjustment to standard errors and fit indices was used. This method rescales the x^2 test and standard errors by the amount of kurtosis. PRELIS 2.80 was used to prepare the covariance matrixes (Jöreskog & Sörbom, 2007b), and LISREL 8.80 was used for the SEM analyses (Jöreskog & Sörbom, 2007a).

Basic descriptive information about the 447 cases in the 2012 dataset, the 330 cases in the 2010 dataset, the 169 cases in the 2012 doctoral set, and the 367 cases in the 2012 master's and Baccalaureate set is provided in Tables 4 through 7.

SEM models are affected by violations of homoscedasticity (the variability in one variable across the values of the other variables) and linearity, therefore homoscedasticity was evaluated using residual plots and linearity was evaluated using bivariate scatterplots between all variables in the model. Other than the issues with multivariate normality discussed earlier, these assumptions seem to have been met after log transformation of the data.

Table 4. Descriptive information for the 2010 dataset.

	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness	Kurtosis
LOG_Circ DV	2.09	5.29	4.28	0.48	.226	-.53	.67
LOG_FT DV	1.38	6.63	5.11	0.69	.471	-1.28	4.38
LOG_Gate DV	1.92	4.83	3.68	0.48	.233	-.53	.42
LOG_PartGrpPrez	1.70	4.14	3.28	0.45	.203	-.61	.31
LOG_Ref	1.70	4.98	3.57	0.57	.329	-.36	.40
LOG_ILL	1.28	4.58	3.26	0.65	.425	-.44	-.19
LOG_ResCirc	.30	5.26	3.60	0.69	.477	-.30	1.22
LOG_Ongoing	3.85	6.71	5.43	0.59	.347	-.26	-.54
LOG_Onetime	1.53	6.08	5.06	0.52	.268	-1.18	5.74
LOG_ProfFTE	0.00	1.72	0.89	0.35	.126	-.20	-.31
LOG_StaffFTE	-.12	1.70	0.88	0.41	.167	-.23	-.57
LOG_AvgProf	4.42	5.01	4.74	0.10	.010	-.02	.64
LOG_AvgStaff	4.04	4.88	4.45	0.13	.016	-.20	.86
LOG_PCT2	.002	.042	0.01	0.00	.000	3.62	19.96
LOG_FTStuFac	2.15	4.35	3.46	0.42	.177	-.23	-.20

Note. N=330. Standard Error for skewness=.134; Standard error for kurtosis=.268

Table 5. Descriptive information for the 2012 dataset.

	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness	Kurtosis
LOG_Circ DV	3.18	5.58	4.45	0.50	0.25	-0.02	-0.67
LOG_FT DV	3.33	6.75	5.39	0.62	0.38	-0.33	-0.15
LOG_Gate DV	2.57	4.93	3.90	0.46	0.21	-0.27	-0.38
LOG_PartGrpPrez	2.26	4.49	3.49	0.46	0.21	-0.23	-0.47
LOG_Ref	2.11	5.09	3.76	0.57	0.32	-0.04	-0.41
LOG_ILL	1.52	4.72	3.49	0.65	0.42	-0.42	-0.24
LOG_ResCirc	2.00	5.64	3.76	0.72	0.52	0.16	-0.43
LOG_Ongoing	4.48	6.96	5.80	0.60	0.36	0.04	-0.85
LOG_Onetime	3.78	6.52	5.21	0.57	0.33	0.06	-0.55
LOG_ProfFTE	0.18	2.02	1.08	0.40	0.16	0.24	-0.64
LOG_StaffFTE	-0.30	2.04	1.05	0.47	0.22	-0.02	-0.50
LOG_AvgProf	4.26	5.06	4.76	0.10	0.01	-0.08	1.75
LOG_AvgStaff	3.65	5.07	4.49	0.15	0.02	-1.12	6.11
LOG_PCT2	0.00	0.04	0.01	0.00	0.00	1.98	14.78
LOG_FTStuFac	2.56	4.53	3.67	0.45	0.20	-0.02	-0.96
Social Media	0.00	9.00	3.72	2.39	5.73	-0.29	-1.01

Note. N=447. Standard Error for skewness=.115; Standard error for kurtosis=.230

Table 6. Descriptive information for the 2012 Doctoral dataset.

	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness	Kurtosis
LOG_FTStuFac	3.66	4.79	4.24	0.25	0.06	-0.21	-0.58
LOG_FT	5.29	7.18	6.16	0.40	0.16	0.14	-0.50
LOG_Ongoing	5.93	7.21	6.68	0.30	0.09	-0.54	-0.52
LOG_ILL	3.19	4.92	4.23	0.37	0.14	-0.57	-0.08
LOG_Part	3.28	4.79	4.06	0.31	0.09	-0.31	-0.18

Note. N=169. Standard Error for skewness=.187; Standard error for kurtosis=.371

Table 7. Descriptive information for the 2012 Masters and Baccalaureate dataset.

	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness	Kurtosis
LOG_FTStuFac	2.60	4.46	3.48	0.39	0.15	0.23	-0.51
LOG_FT	3.73	6.62	5.18	0.53	0.28	-0.01	0.02
LOG_Ongoing	4.20	6.63	5.53	0.45	0.20	-0.11	-0.34
LOG_ILL	1.83	4.60	3.28	0.56	0.31	-0.44	-0.22
LOG_Part	2.23	4.36	3.32	0.42	0.18	-0.19	-0.24

Note. N=367. Standard Error for skewness=.127; Standard error for kurtosis=.254

Correlations among the data

Bivariate correlations among the data controlling for full-time students and faculty show no extreme multicollinearity, which would imply variables were redundant (See Tables 8-11). The variables Average Librarian / Professional Salary, Average Staff Salary, Reserves Circulation, and Social Media variables did not appear to correlate highly with anything, so the SEM models were tested with and without these variables.

Table 8. Bivariate partial correlations for the 2010 dataset.

	LOG Circ	LOG FT	LOG Gate	LOG PartGrp	LOG Ref	LOG ILL	LOG ResCirc	LOG Ongoing	LOG Onetime	LOG ProfFTE	LOG StaffFTE	LOG AvgProf	LOG AvgStaff	LOG PCT2
LOG_Circ														
LOG_FT	0.21													
LOG_Gate	0.37	0.22												
LOG_PartGrp	0.16	0.18	0.18											
LOG_Ref	0.21	0.08	0.13	0.18										
LOG_ILL	0.47	0.33	0.29	0.11	-0.03									
LOG_ResCirc	0.45	0.07	0.37	0.20	0.14	0.26								
LOG_Ongoing	0.33	0.27	0.38	0.21	0.05	0.49	0.35							
LOG_Onetime	0.44	0.26	0.27	0.28	0.02	0.37	0.30	0.42						
LOG_ProfFTE	0.33	0.27	0.33	0.35	0.32	0.31	0.36	0.58	0.41					
LOG_StaffFTE	0.31	0.21	0.27	0.22	0.27	0.22	0.31	0.55	0.36	0.55				
LOG_AvgProf	0.14	0.13	0.15	0.21	0.11	0.10	0.23	0.22	0.21	0.12	0.23			
LOG_AvgStaff	0.17	0.14	0.14	0.12	0.08	0.15	0.18	0.16	0.17	0.17	0.05	0.37		
LOG_PCT2	0.28	0.24	0.25	0.32	0.27	0.29	0.31	0.58	0.43	0.61	0.50	0.27	0.24	

Note. *N*=330; Controlling for LOG_FTStuFac

Table 9. Bivariate correlations for the 2012 dataset.

	LOG Circ	LOG FT	LOG Gate	LOG PartGrp	LOG Ref	LOG ILL	LOG ResCirc	LOG Ongoing	LOG Onetime	LOG ProfFTE	LOG StaffFTE	LOG AvgProf	LOG AvgStaff	LOG PCT2	Social Media
LOG_Circ															
LOG_FT	0.15														
LOG_Gate	0.33	0.10													
LOG_PartGrp	0.19	0.19	0.24												
LOG_Ref	0.16	0.10	-0.03	0.17											
LOG_ILL	0.40	0.28	0.23	0.18	-0.03										
LOG_ResCirc	0.35	0.15	0.22	0.21	0.05	0.21									
LOG_Ongoing	0.32	0.30	0.20	0.15	0.10	0.57	0.25								
LOG_Onetime	0.47	0.21	0.25	0.19	0.01	0.36	0.22	0.45							
LOG_ProfFTE	0.34	0.30	0.22	0.28	0.22	0.34	0.28	0.65	0.43						
LOG_StaffFTE	0.35	0.13	0.23	0.19	0.23	0.28	0.22	0.55	0.38	0.49					
LOG_AvgProf	0.11	0.06	0.11	0.03	0.07	0.06	0.12	0.09	0.15	-0.04	0.16				
LOG_AvgStaff	0.02	0.07	0.04	0.09	-0.01	0.06	0.02	0.08	0.07	0.10	-0.02	0.22			
LOG_PCT2	0.33	0.07	0.23	0.13	0.05	0.22	0.17	0.40	0.37	0.37	0.33	0.05	0.05		
SocialMedia	0.13	0.07	0.08	0.09	-0.04	0.15	0.10	0.12	0.14	0.12	0.09	0.13	0.03	0.05	

Note. *N*=447. Controlling for LOG_FTStuFac

Table 10. Partial bivariate correlations for the 2012 Doctoral dataset.

	LOG_FT	LOG_Ongoing	LOG_ILL	LOG_Part
LOG_FT				
LOG_Ongoing	0.57			
LOG_ILL	0.36	0.48		
LOG_Part	0.30	0.36	0.20	

Note. *N*=169; Controlling for LOG_FTStuFac; All correlations were significant (*p*<.05).

Table 11. Partial bivariate correlations for the 2012 Baccalaureate and Master's dataset.

	LOG_FT	LOG_Ongoing	LOG_ILL	LOG_Part
LOG_FT				
LOG_Ongoing	0.28			
LOG_ILL	0.25	0.49		
LOG_Part	0.13	0.20	0.26	

Note. *N*=367; Controlling for LOG_FTStuFac; All correlations were significant (*p*<.05).

Procedures—Structural equation modeling

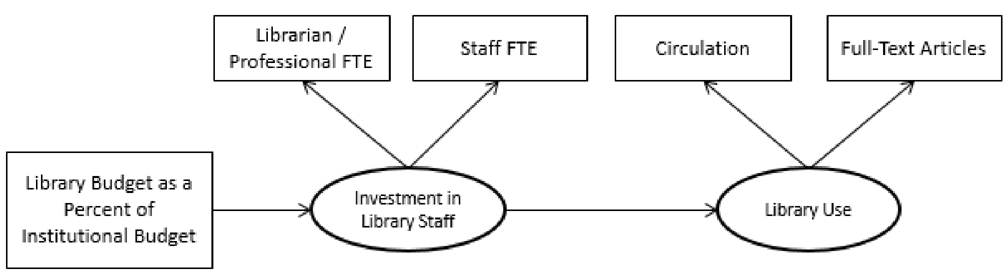
Structural equation modeling is a family of statistical techniques permitting the evaluation of models including both observed and latent variables (Kline, 2011). Latent variables are constructs such as "intelligence" that cannot be observed directly but are instead measured by two or more indicators that the researcher hypothesizes are appropriate to measure the construct. As MacKenzie (2001) explained, latent variables can broaden the scope of theoretical models by helping researchers think "in terms of entire systems of conceptual relationships that better represent the complex environments to which [they] hope [their] theories apply" (p. 159). Latent variables test whether indicators group together to make meaningful factors.

In Figure 2, “Investment in library staff” is a latent variable measured by two indicators, the number of librarians and the number of professional staff. Observed and latent variables can be connected with paths that represent relationships, or structures, among the variables. The latent variable “Investment in Library Staff” is hypothesized to predict another latent variable, “Library Use,” which is observed through the indicators Circulation and Full-Text Articles. Such models are often called confirmatory factor analysis (CFA) models.

SEM models can also include only observed variables; these are called path models. Models may combine both CFA and path models. These are called hybrid models or full structural regression models.

Although SEM paths are often drawn with arrows, the direction of any path is based entirely on theory. There is no statistical way to evaluate which direction is more appropriate for a path. In summary, SEM allows a measurement model to be combined with a structural model.

Figure 2. A structural equation model.

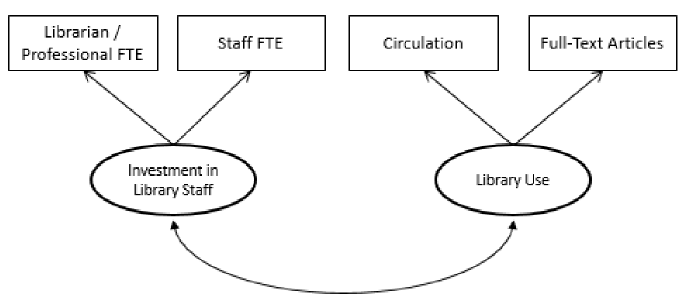


Many scholars have described historical abuses of SEM (Kline, 2011, 189). To avoid those pitfalls, this study was sure to:

- Make model specification decisions based on theory (Kelloway, 1998; MacCallum & Austin, 2001).
- Test alternative models (Kline, 2011).
- Use fit indexes critically, examining both model fit and approximate fit indices (Kline, 2011, p. 194-195).
- Report and describe residuals to help diagnose areas of model misfit.

Anderson & Gerbing's (1988) two-step approach was chosen for testing alternative, nested models. In their approach, saturated CFA models are used to test various measurement models. For example, the measurement model for Figure 2 appears in Figure 3. The structural paths are removed and all latent variables are set to correlate so the error in measurement between latent variables and their indicators can be examined.

Figure 3. A measurement model.



Depending on the fit of the measurement model(s), then following Anderson & Gerbing, a null model (with all relationships between latent constructs fixed to zero) would be tested. This tests the null hypothesis that none of the latent constructs are related. The second of Anderson & Gerbing's two steps is to test the theoretical model and any alternative theoretical models.

For models that are nested, chi-square difference tests can test whether they are significantly different from one another. A model is said to be nested within another if a free parameter can be fixed (usually, set to zero) to form the other model. For non-nested models, the Aikake's Information Criteria (AIC) was used for comparisons (Kline, 2010, p. 220).

The x^2 test was used to evaluate the models' fit to the data using a critical value of $p< .05$ (Bryant & Satorra, 2012). Satorra-Bentler (S-B x^2) was calculated as described in Bryant and Satorra (2012) because LISREL 8.80 incorrectly uses Normal Theory Weighted Least Squares x^2 instead of S-B x^2 when calculating the S-B x^2. Several additional fit indices were used to provide additional information about the degree of difference in fit between models. The root-mean-square-error-of-approximation (RMSEA) and standardized root-mean-square residual (SRMR) were chosen from the family of absolute fit indices. The RMSEA addresses the parsimony of the model by estimating the proportion of specification error per degree of freedom (Raykov & Marcoulides, 2000), while the SRMR summarizes the average covariance residuals. The comparative fit index (CFI) was chosen as this study's incremental index; it compares the fit of the hypothesized model against an independence model where all observed variables are uncorrelated. Hu and Bentler (1998, 1999) recommended these model-data fit indices because they are sensitive to misspecified factor loadings and misspecified factor correlations.

This study followed Fagan's (2014b) approach to interpreting fit indexes: a RMSEA cutoff value of .06 or less to indicate close fit (Hu & Bentler, 1999), with .10 or greater indicating bad fit (Browne & Cudeck, 1993); a CFI value of .95 or above (Hu & Bentler, 1999); and an SRMR cutoff value of .08 or less (Hu & Bentler, 1998, 1999). This study also examined standardized covariance residuals: high positive residuals suggest a model is underestimating relationship between items, while negative residuals indicate items are less related than the model implies.

Because the measurement models included a covariate which affected as many latent variables as were specified, they were not nested and were therefore compared with AIC. Some path models were nested, and these were compared with the Satorra-Bentler x^2 difference test (Bryant & Satorra, 2012).

Procedures—MANCOVA

Groups of libraries were created using the Carnegie Classifications Basic, Size & Setting (Residential Status), Undergraduate Instructional Program, and Graduate Program. Undergraduate Instruction Program was further divided into its two component parts, Balance between Arts & Sciences vs. Professional Programs ("Program Balance"), and Graduate Program Coexistence ("Graduate Coexistence").

Multivariate analysis of covariance (MANCOVA) was conducted using SPSS 20 to determine the extent to which these groups varied in terms of Circulation, Full-Text Articles, and Gate Count. Separately, MANCOVAs were conducted to determine the extent to which these groups varied across the independent variables Participants in

Group Presentations, Reference Transactions, Interlibrary Loans, Reserves Circulations, Ongoing Expenditures, One-Time Expenditures, Librarian / Professional FTE, Staff FTE, Average Librarian / Professional Salary, Average Staff Salary, Library Expenditures as a Proportion of Institutional Expenditures, and Social Media.

MANCOVA is a statistical test building off the principles of analysis of variance (ANOVA), which uses a linear model to compare differences between the means of more than two groups. Both MANCOVA and ANOVA test the ratio of systematic variance to unsystematic variance (the F-ratio) and compare groups to determine if the group means are statistically different. If the groups are statistically different, follow-up tests can be performed to determine which of the groups are different. MANCOVA is different than ANOVA because it 1) includes a covariate in the model, allowing the researcher to control for factors such as age (or in this study's case, full-time students and faculty) and 2) allows the model to predict *multiple* dependent variables simultaneously. By performing a MANCOVA instead of an ANOVA, Type-I error is reduced by the number of dependent variables included in the model. Also, MANCOVA accounts for relationships between the dependent variables. Thus, MANCOVA allows researchers to detect whether groups are different on a combination of variables, controlling for a covariate.

To determine whether the sample size provided adequate statistical power, the procedures proposed by D'Amico, Neilands, and Zambarano (2001) were followed. Because the sample size for 2010 was so much smaller than 2012, only the 2012 sample was used for the MANCOVAs. The SPSS MANOVA procedure was used on a data matrix containing the mean and cell size values for each IV and covariate, the average standard deviation, and a correlation matrix. For models with three dependent variables, sample sizes were more than sufficient, however for the models with twelve IVs, power estimates were sufficient for multivariate tests and for most (but not all) univariate tests. For the most complex model (twelve IV and five groups), the power estimate for multivariate tests was .95, and most power estimates for univariate tests were .90 or above. Low power levels for univariate tests were discussed when less than .75.

Univariate and multivariate outliers had previously been removed from the datasets used for the MANCOVAs and assumptions of normality (after log transformation) linearity, and multicollinearity had previously been supported (see Data Screening section). While sample sizes across cells were uneven, multivariate normality for each cell was supported by having more cases than DVs in each cell (Tabachnick & Fidell, 2007). SPSS's default method was used to adjust for unequal *n.* Box's *M* provided an initial sign of whether the covariance matrices are homogenous (a significant Box's test suggests the matrices are *not* homogenous). However, Tabachnick and Fidell (2007) noted that Box's test is very sensitive to unequal group sizes. When Box's M is significant, the researcher further evaluated homogeneity of variance-covariance matrices by comparing sample variances for each DV across the groups; all were found to be well below the recommended ratio of 10:1 (Tabachnick & Fidell, 2007). A scatterplot of predicted values and standardized residuals for each dependent variable further supported normality of the data.

Since some of the Box's M tests were significant, Pillai's Trace was chosen as the multivariate test to report for each MANCOVA based on recommendations by Tabachnick & Fidell (2007), because it is more robust to unequal group sizes. For each

MANCOVA analysis, univariate tests were also examined. These tests show what the results would have been from an ANCOVA using the same groups, but with only the individual dependent variable. It is important to keep in mind that these univariate results therefore do not include any effects of correlation among the DVs.

For the significant univariate results, graphs of means for each dependent variable, adjusted for the covariate, were generated in the original units of measurement. The procedure was to take the inverse log of the adjusted means and 95% confidence intervals (Bland & Altman, 1996b). It is important to note that reversing a log transformation of a mean produces the geometric mean of the original data. The geometric mean is still a measure of central tendency, but is different from the value of the arithmetic mean. Also, confidence intervals around the geometric mean may be asymmetrical after reverse transformation. Thus, the graphs are useful for interpreting the magnitude and significance of mean differences, but the mean values may not match arithmetic means calculated directly from the original data.

The effect size partial eta squared ($\square^2$) was calculated to enable comparison across MANCOVAs. Partial eta squared is the proportion of variance explained in the dependent variable(s) that is explained by the independent variable(s). Stevens (1996) continues to recommend the following guidelines based on Cohen's (1977) experience with small, medium, and large effects for $\square^2$, respectively: .01, .06, and .14. Careful readers will note a seeming disparity between the magnitude of the effect sizes for the DVs and the differences in adjusted means. This is because the effect sizes include consideration of the correlation between DVs. For example, the correlations between Gate Count and Full-Text Downloads, Gate Count and Circulation, and Full-Text

Downloads and Circulation (controlling for the covariate) were .16, .34, and .20, respectively. While the multivariate effect sizes treat the three DV multivariately, and are reduced based on these correlations, the adjusted means are based on simple pairwise comparisons of adjusted means between the DVs and do not take the correlations into consideration.

Procedures—Regression

After determining the extent to which groups of libraries differ, a series of sequential regressions were conducted to determine how well the amount of external research dollars could be predicted by the library use variables Circulation, Full-Text Articles, and Gate Count. Selected Carnegie Classifications were also entered as predictors using dummy coding, as well as the interactions between the library use variables and Carnegie Classification variables. Full-Time Students Plus Faculty was used as the covariate to control for institutional size.

The Carnegie Classifications chosen for the regression models included Carnegie Classification – Basic, Graduate Coexistence, and Graduate Instruction Program. The eleven Graduate Instruction Program categories were collapsed into four groups based on the MANCOVA results related to this Classification: Doctoral Schools-Comprehensive, Doctoral Schools-STEM, Other Doctoral, and Master's Schools. For example, the MANCOVAs suggested there were differences between the Doctoral Comprehensive groups and the Master's schools, but little difference among the Master's school groups themselves. The two other Carnegie Classifications (Undergraduate Programs, Arts & Sciences vs. Professional Program Balance and Size & Setting) were not examined because there was no hypothesized effect of these group differences on the variables of interest with respect to external research dollars.

In general, regression procedures fit a linear model to a dataset and use the model to predict a dependent variable from one or more independent variables (also known as predictor variables). If theory suggests predictors could interact, then "interaction variables" can be created by multiplying the two independent variables together and entering the interaction variables as additional parameters in the model. Results of a regression analysis provide an overall test of the fit of the model as well as estimates of the contributions individual predictors and interactions make to the model. Overall fit is evaluated with the F-ratio, which is a proportion of how much the model has improved the prediction of the outcome variable to the level of inaccuracy of the model.

Sequential regression (sometimes called hierarchical regression) allows one or more predictors to be entered into the model in "steps." In this study, sequential regression was used to enter the covariate, Full-time Students Plus Faculty in a first step, thus allowing an estimate of how much influence it has on the outcome. The predictor variables of interest were entered in Steps 2 and 3, and all interactions were entered in Step 4.

Following recommendations from Cohen, Cohen, West, and Aiken (2003), all continuous predictors were centered so they could be entered into analyses containing interactions. Centering allows effects of individual predictors to be interpreted at the mean of the sample, provides the average effects of individual predictors across the range of the other variables, and eliminates multicollinearity between the individual predictors and the interaction effects containing those predictors. The basic procedure for centering is simply to subtract the mean of each variable from the value of each case's value for that variable.

As with the library data, the distribution of External Research Dollars was extremely skewed, and was therefore log transformed for both 2010 and 2012 datasets. Linearity of the data was examined using bivariate scatterplots and homoscedasticity was examined by examining residual plots.

2010 Merged Dataset

The ACRL 2010 dataset (originally 330 institutions) was merged with 2010 data from HERD by mapping IPEDS identifiers to FICE identifiers. This process left 142 cases in the combined dataset. As shown in Table 12, the merged dataset had lower representation from Baccalaureate Colleges-General and higher representation from Doctoral/Research Universities-Extensive. Interpretation of results therefore applied to a somewhat different population of institutions than the other models in this study.

Mahalanobis distance was evaluated using a linear regression of all predictor variables on ID, and six cases were deleted (two Baccalaureate, two medical schools, a masters school, and a law school), bringing the total to 136.

2012 Merged Dataset

The ACRL 2012 dataset (originally 447 institutions) was merged with 2012 data from HERD by mapping IPEDS identifiers to FICE identifiers. This process left 214 cases in the combined dataset. As shown in Table 13, the merged dataset had lower representation from Baccalaureate Colleges-General and higher representation from Doctoral/Research Universities-Extensive and Doctoral/Research Universities-Intensive.

Table 12. Comparison of institutional representation after merging ACRL and NSF data, 2010 dataset.

	n in Original Dataset (*N*=330)	*n* in Merged Dataset (*N*=142)	% in Original Dataset (*N*=330)	% in Merged Dataset (*N*=142)	Difference (%)
Baccalaureate Colleges-General	74.0	9.0	22.4	6.3	-16.1
Baccalaureate Colleges-Liberal Arts	40.0	25.0	12.1	17.6	5.5
Baccalaureate/Associates Colleges	7.0	1.0	2.1	0.7	-1.4
Doctoral/Research Universities-Extensive	10.0	9.0	3.0	6.3	3.3
Doctoral/Research Universities-Intensive	29.0	28.0	8.8	19.7	10.9
Masters (Comprehensive) College and Universities II	10.0	3.0	3.0	2.1	-0.9
Masters Colleges and Universities I	125.0	60.0	37.9	42.3	4.4
Schools of Art, Music and Design	6.0	0.0	1.8	0.0	NA
Special Faith-related Institutions	6.0	0.0	1.8	0.0	NA

Table 13. Comparison of institutional representation after merging ACRL and NSF data, 2012 dataset.

	n in Original Dataset (*N*=447)	*n* in Merged Dataset (*N*=214)	% in Original Dataset	% in Merged Dataset	Difference (%)
Associates Colleges	9.0	0.0	2.0	0.0	NA
Baccalaureate Colleges-General	62.0	9.0	13.9	4.2	-9.7
Baccalaureate Colleges-Liberal Arts	48.0	14.0	10.7	6.5	-4.2
Doctoral/Research Universities-Extensive	62.0	50.0	13.9	23.4	9.5
Doctoral/Research Universities-Intensive	56.0	50.0	12.5	23.4	10.8
Masters (Comprehensive) College and Universities II	16.0	3.0	3.6	1.4	-2.2
Masters Colleges and Universities I	163.0	79.0	36.5	36.9	0.5

Mahalanobis distance was evaluated using a linear regression of all predictor variables on the case id, and three cases were deleted (a Medical School, a Baccalaureate Colleges-General school, and a Doctoral/Research Universities-Intensive school), bringing the total to 211. Linearity of the data was examined using bivariate scatterplots and homoscedasticity was examined by examining residual plots.

For linear regression, Tabachnick and Fidell (2007, p. 123) suggest a sample size of $50 + 8m$, where m is the number of IVs for testing the overall regression equation, and $104 + m$ for testing individual predictors, assuming a medium effect size, α=.05 and β=.20. For the Carnegie Classifications with 3 groups, there were 7 IVs (including the covariate), meaning a sample size of 74 was required for testing the overall regression and 111 for testing individual predictors, so both 2012 and 2010 samples were sufficient for this series of models.

Hypotheses

Speaking in general terms, this study's underlying theory was that a university that believes in the value of its library invests increased resources in staff, and that in turn, those staff support the library's role in providing services. The proportion of money spent on Ongoing Expenditures (subscription journals) and One-Time Expenditures (books and journal backfiles) was also hypothesized to have an effect on the levels of library use. Because of the exploratory nature of this study, the researcher has posed several alternate models to explore.

For almost all the models in this study, it was theorized that Full-Time Students Plus Faculty would make an effective covariate because of high correlations with the indicator variables. For models with the Carnegie Size & Setting classification, an alternative covariate, Part-Time Students Plus Full-Time Students and Faculty, was tested because the classification uses part-time status as part of the group membership criteria.

Hypotheses—Covariates

Covariate Hypothesis 1a: There will be no meaningful correlation between Full-Time Students Plus Faculty and the dependent variables Circulation, Full-Text Articles, and Gate Count.

Covariate Hypothesis 1b: There will be no meaningful correlation between Average Expenditures Per Student and the dependent variables Circulation, Full-Text Articles, and Gate Count.

Covariate Hypothesis 1c: There will be no meaningful correlation between Basic Carnegie Classification and the dependent variables Circulation, Full-Text Articles, and Gate Count.

Covariate Hypothesis 2: After controlling for Full-Time Students Plus Faculty, there will be no meaningful group mean differences between institutions' Carnegie Classifications.

The covariate Full-Time Students Plus Faculty will be specified in SEM models following Markell and Frone (1998) and Bengt and Muthén (1989). As with Markel and Frone (1998), this study's covariate consisted of a single item (Full-Time Students Plus Faculty) and reflected objective demographic information, so no adjustments were made for random measurement error. Thus, to include the covariate into the measurement model, its factor loading was fixed to 1 and its measurement error was fixed to zero.

Hypotheses—SEM Model Family A: Dependent Variables as Observed Variables

In model family A (Figure 4), it was hypothesized that Gate Count is predicted by Engagement With Library Services because those services are what attract patrons to the library building. Full-Text Articles and Circulation were hypothesized to be predicted by Engagement With Library Services, but also to be influenced by ongoing and One-Time Expenditures. Thus, a key attribute of this model family was treating Circulation, Full-Text Articles, and Gate Count as observed variables rather than combining them into a latent variable. Because One-Time Expenditures includes journal article backfiles and one-time fees, variants of this model were tested with and without a path between One-Time Expenditures and Full-Text Articles (as shown by the dotted lines). Engagement With Library Services was thought to be predicted by Investment in Library Staff. Finally, Investment in Staff and the two expenditure variables were all thought to vary based on Library Expenditures as a Proportion of Institutional Expenditures. The measurement portions of this model were tested with and without the salary variables, reserves, and social media variables because of the suspiciously low bivariate correlations.

Measurement Model A-1: The one factor model

Measurement Model A-1, The one factor model (Figure 5) was tested mostly for comparison purposes. There was no real theoretical basis to this model other than that these are all indicators of library activity. Since the more complex models are based on theory, if they did not fit significantly worse than this model, that would support their use in a hybrid SEM model.

Figure 4. Hybrid model for Model Family A.

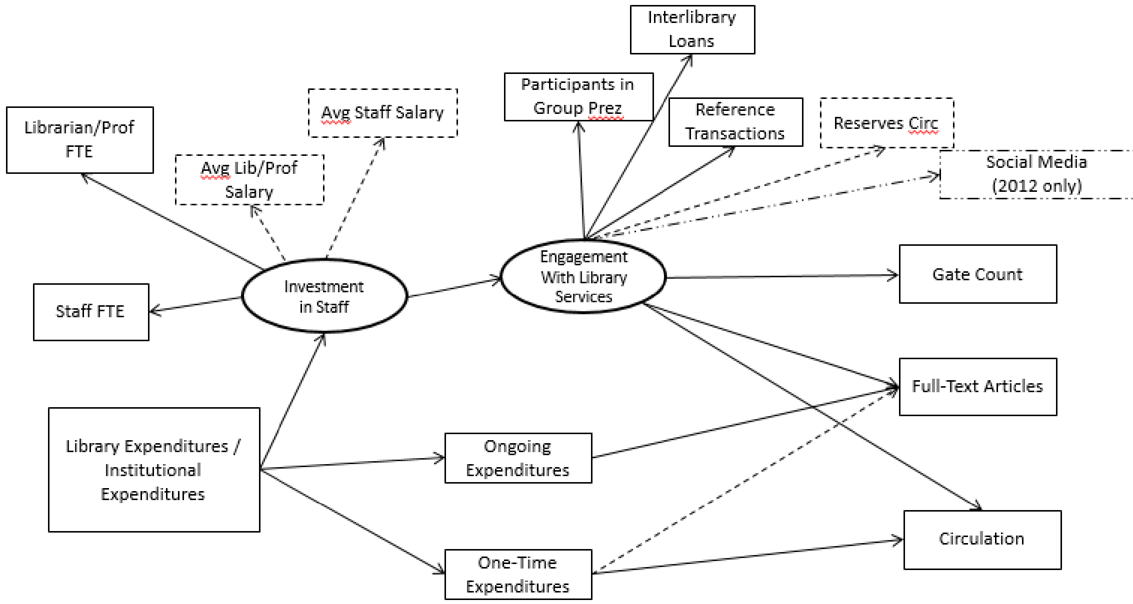


Figure 5. Measurement Model A-1: One factor.

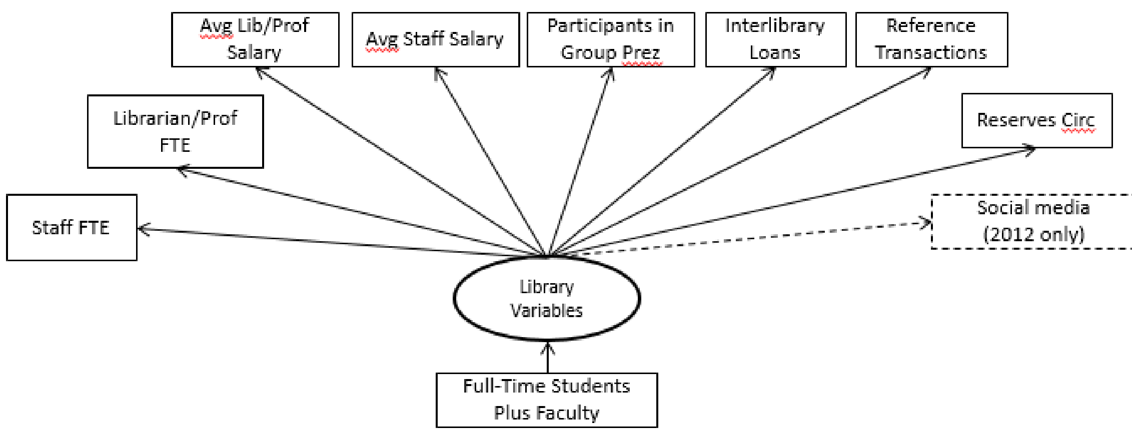
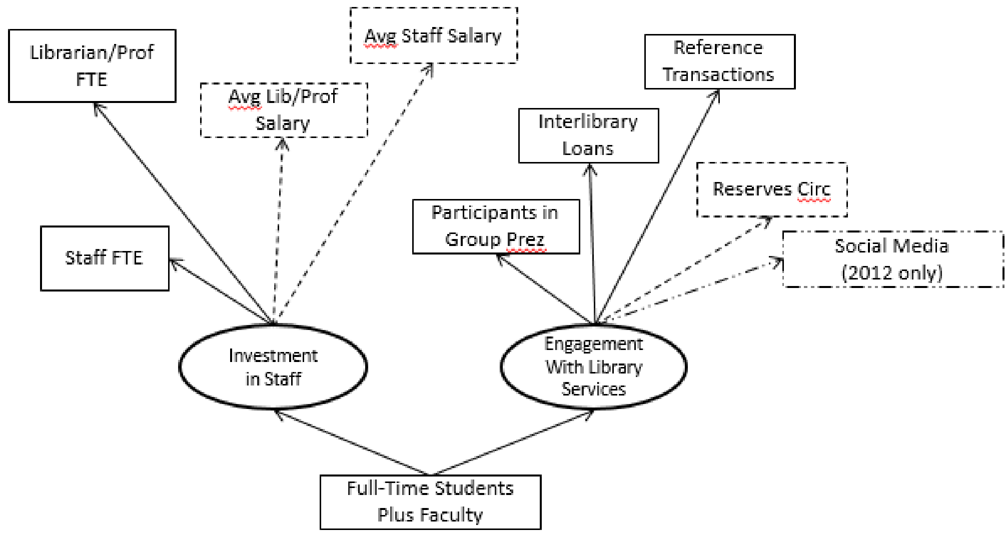


Figure 6 shows the full measurement model for Model A, with two factors.

Figure 6. Measurement model A-2: Two factors.



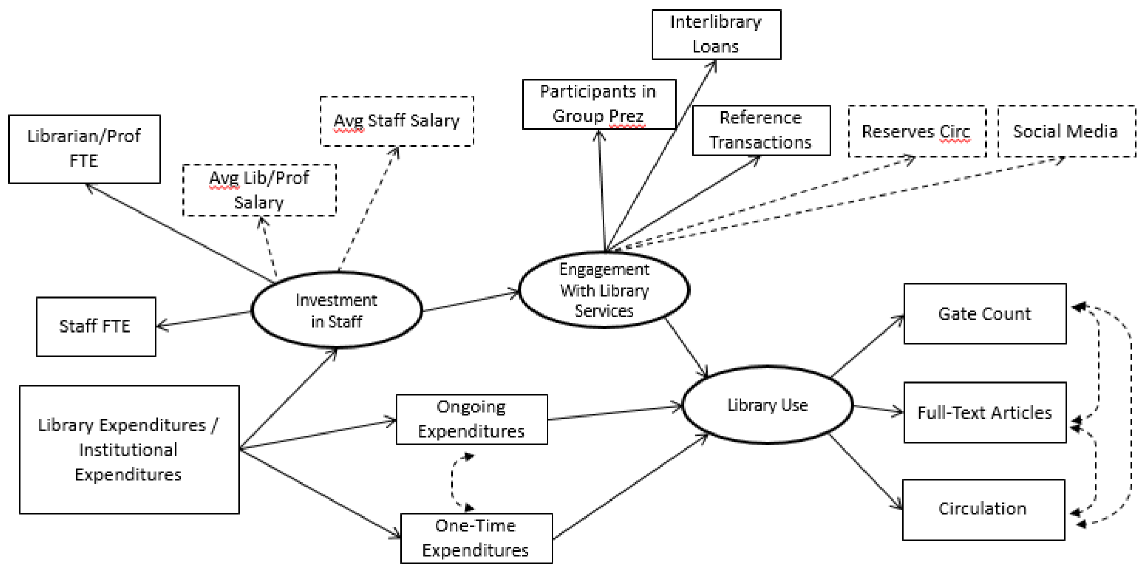
Engagement With Library Services can be measured with five indicators: Participants in Group Presentations, Reference Transactions, Reserves Circulation, Social Media, and Interlibrary Loans. Investment in staff is measured with the indicators Librarian / Professional FTE, Staff FTE, Average Librarian / Professional Salary, and Average Staff Salary.

A third measurement model, A-3, tested the model-data fit without the variables Average Librarian / Professional Salary, Average Staff Salary, and Reserves Circulation.

Hypotheses—SEM Model Family B: Dependent Variables as Latent Variable

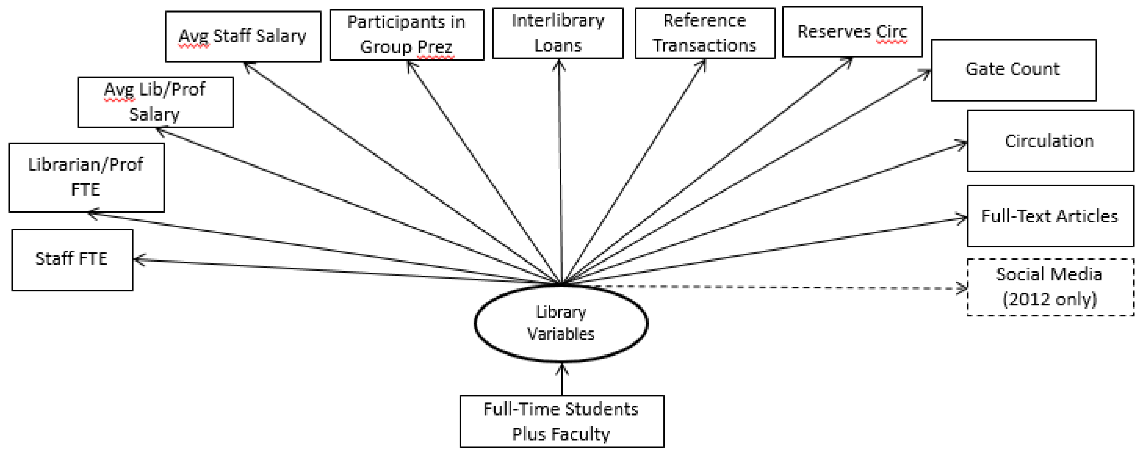
The only difference between model family A and model family B was that rather than measuring Gate Count, Full-Text Articles, and Circulation as observed variables, they were combined in one latent variable, Library Use, specified as predicted by Engagement With Library Services, Ongoing Expenditures, and One-Time Expenditures (Figure 7).

Figure 7. Hybrid model for Model Family B



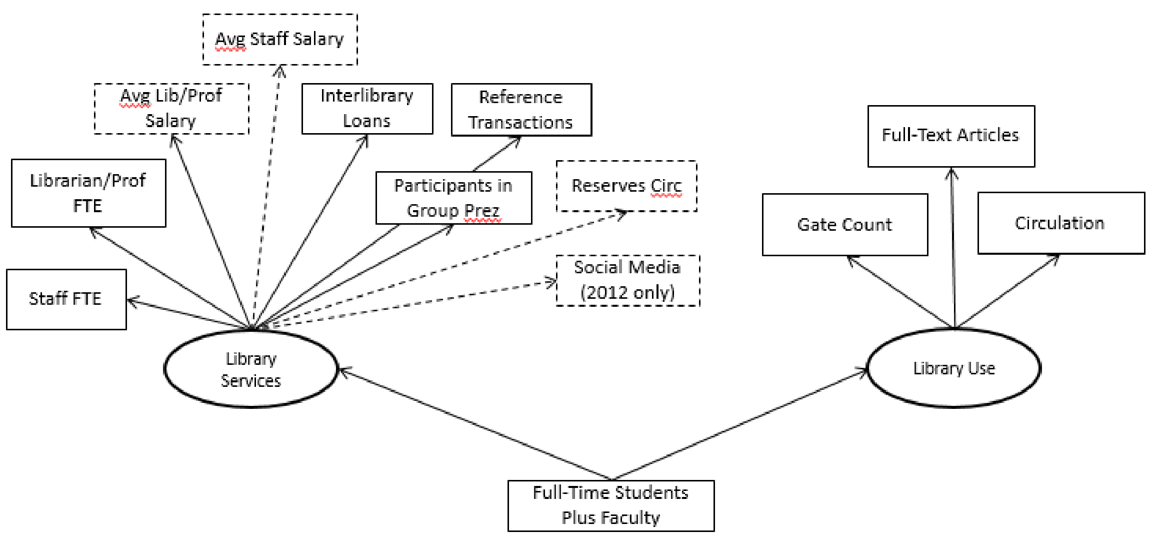
Because an additional latent variable was specified, there were additional measurement models to test. The one-factor measurement model added the three indicators Gate Count, Full Text Article Requests, and Circulation to Model A-1 to form the one-factor measurement model for Model Family B (Figure 8).

Figure 8. One-factor measurement model for Model Family B



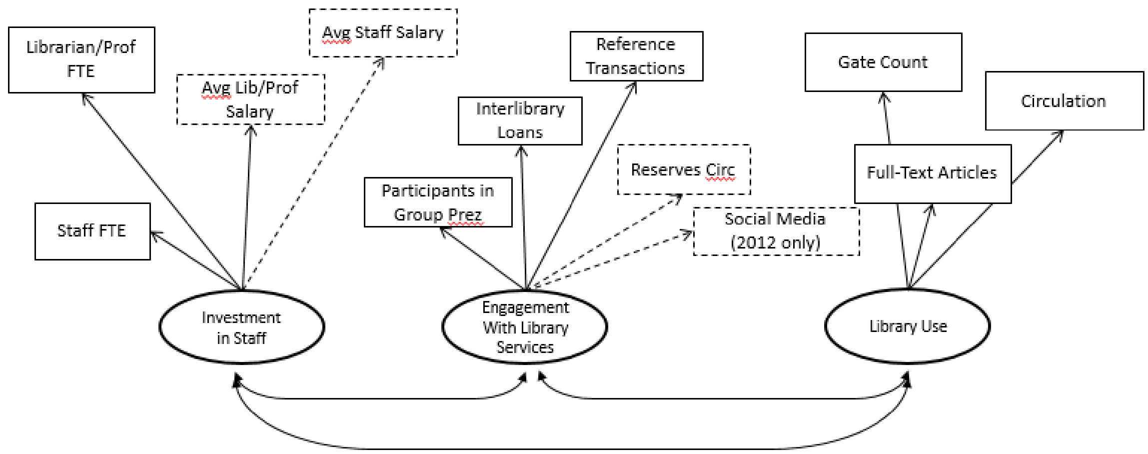
A two-factor measurement model to be tested loaded the "Engagement With Library Services" indicators on "Investment in Staff" to form an "Investment" variable (Figure 9).

Figure 9. Two-factor measurement model for Model Family B



The measurement model for Model Family B with all three factors is shown in Figure 10, and was tested with and without the indicators shown with dotted lines.

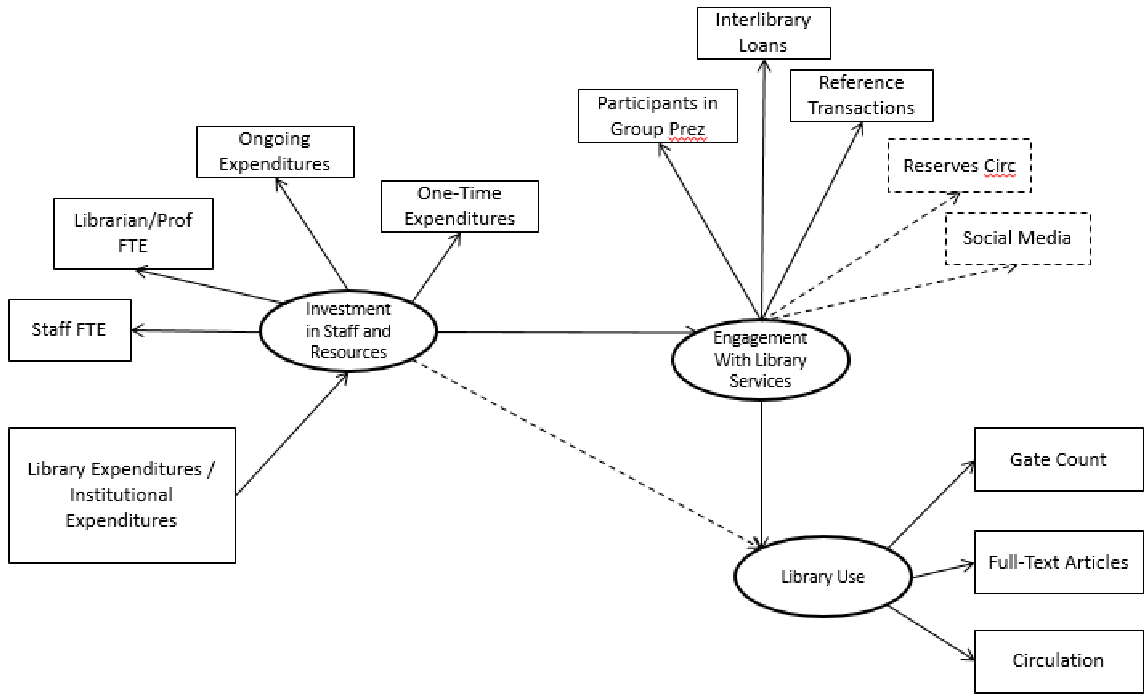
Figure 10. Three-factor measurement model for Model Family B



Hypotheses—SEM Model Family C: Combining Staff and Resources

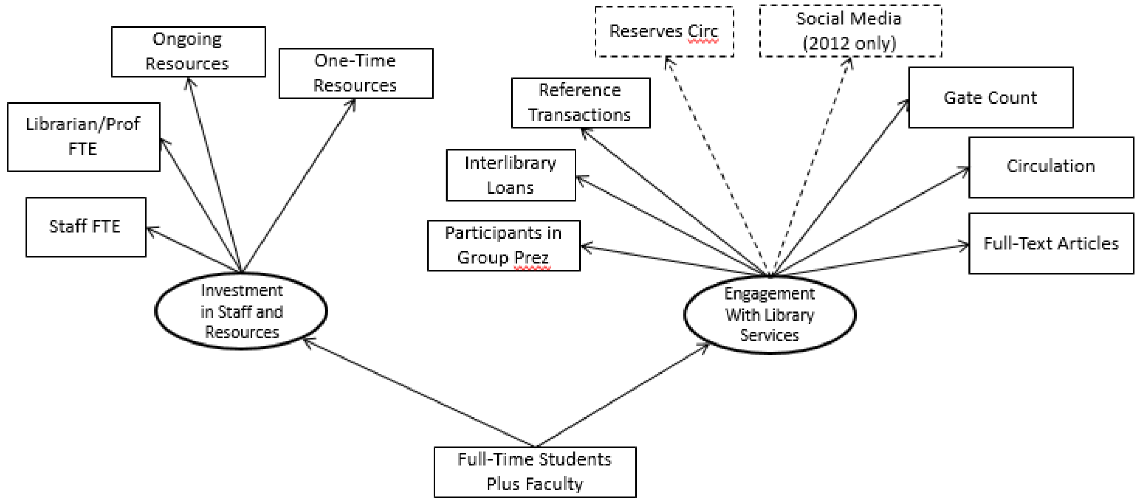
Model Family C experimented with creating a latent variable "Investment in Staff and Resources" measured by Staff FTE variables and both One-Time and Ongoing Expenditures (Figure 11). This was to reflect the reality that the two overwhelming categories in an academic library's budget are personnel and collections. Perhaps they were both indicators of the institution's investment in the library. Alternative hybrid models are planned with this latent variable predicting Library Use directly as well as through Engagement With Library Services, and also with this latent variable predicting Library Use ONLY through Engagement With Library Services (with the dotted line to Library Use removed).

Figure 11. Hybrid model for Model Family C



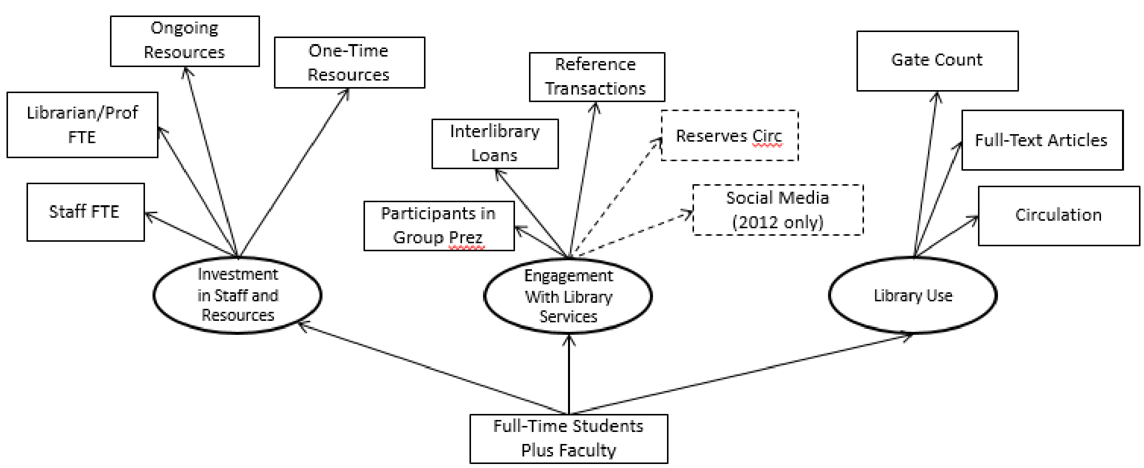
The one-factor measurement model for Model Family C (Figure 12) was the same as for A and B, however the two-factor model differed by having the two expenditures variables join the Staff FTE variables in measuring Investment in Staff and Resources. The library salary variables would be specified as indicators of Investment in Staff and Resources if they were retained in models A and B.

Figure 12. Two-factor measurement model for Model Family C



The three-factor measurement model for Model Family C separated the Library Use factor from Engagement With Library Services (Figure 13). The model was tested with and without the indicators shown with dotted lines. (Again, the library salary variables would be specified as indicators of Investment in Staff and Resources if they were retained in models A and B).

Figure 13. Three-factor measurement model for Model Family C

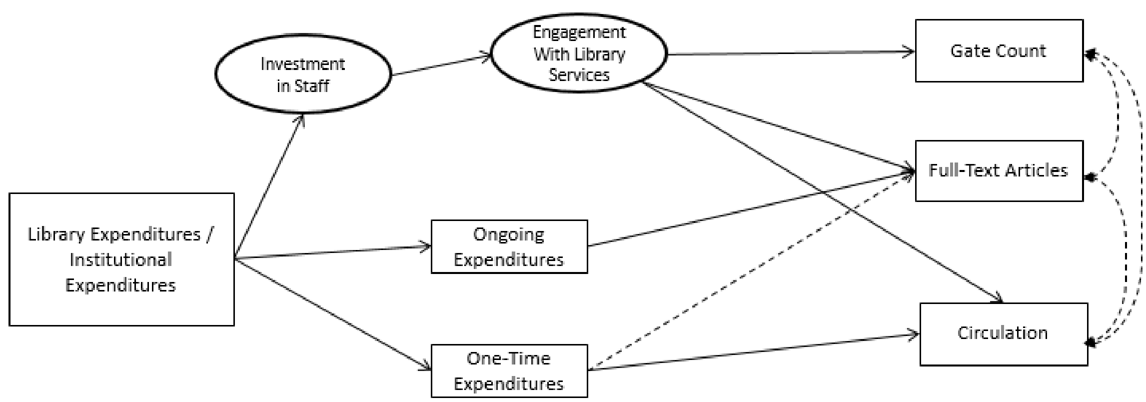


Hypotheses—SEM Structural Models

Evaluating the structural models depended on the success of evaluating the measurement models. If the measurement models indicated the structural models should be evaluated, the structural models would be tested with some variants.

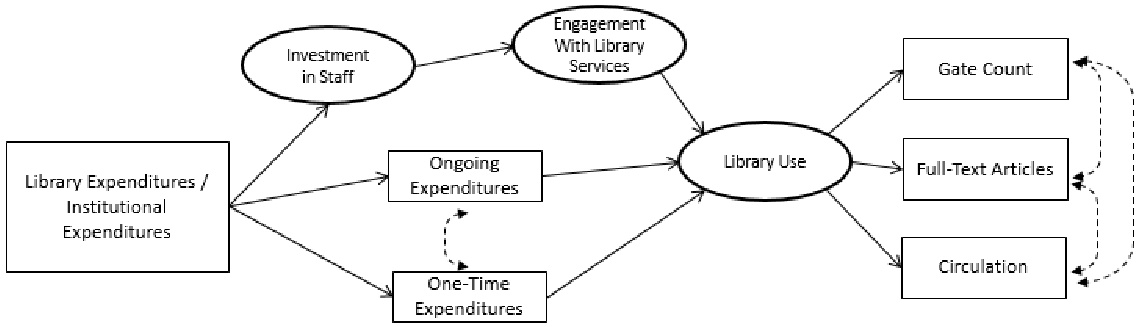
For model family A, structures with and without the path between One-Time Expenditures and Full-Text Articles were specified (Figure 14). Models with and without paths between the expenditures variables were specified, as were models with and without correlations between the three variables Circulation, Full-Text Articles, and Gate Count.

Figure 14. Structural model for Model Family A



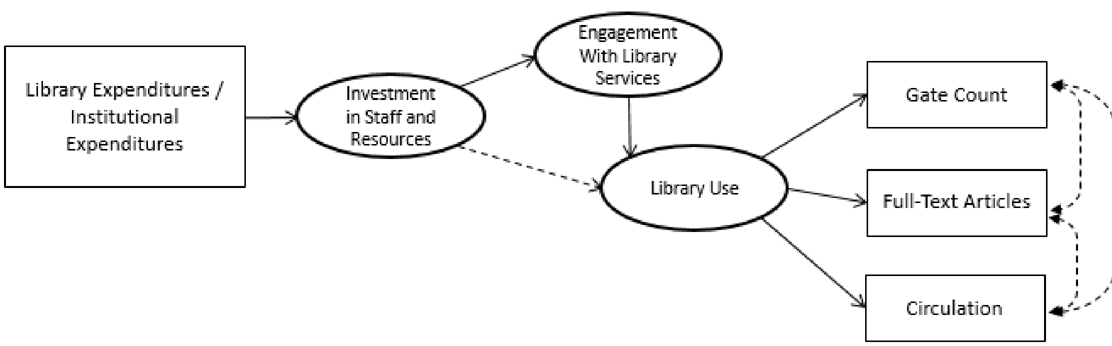
Similar variants with correlations between the expenditure variables and the three indicators of library use in Model family B were also specified (Figure 15).

Figure 15. Structural model for Model Family B



For Model Family C, variants with correlations set between the three indicators of library use were also specified, as were structural models with and without the path between Investment In Staff and Resources and Library Use (Figure 16).

Figure 16. Structural model for Model Family C



Hypotheses—SEM Additional Models

Because this study is largely exploratory, it was unlikely for the measurement models to reproduce the relationships found in the covariance matrixes with close fit. For this reason, the researcher anticipated the need for several path models to be tested based on analysis of the residuals in the models that do not fit, and on the other investigations in this study.

Hypotheses—MANCOVA

MANCOVA Hypothesis 1: There will be no meaningful group mean differences on a multivariate combination of Circulation, Full-Text Articles, and Gate Count between institutions grouped by Carnegie Classification – Basic, Carnegie Classification – Size & Setting (Residential Status), Carnegie Classification – Undergraduate Instruction Program (Arts & Science vs. Professional Program Balance), Carnegie Classification – Undergraduate Instruction Program (Graduate Coexistence), or Carnegie Classification – Graduate Instruction Program.

MANCOVA Hypothesis 2: There will be no meaningful group mean differences on a multivariate combination of Participants in Group Presentations, Reference Transactions, Interlibrary Loans, Reserves Circulations, Ongoing Expenditures, One-Time Expenditures, Librarian / Professional FTE, Staff FTE, Average Librarian Salary, Average Staff Salary, Library Expenditures as a Proportion of Institutional Expenditures, and Social Media between institutions grouped by Carnegie Classification – Basic, Carnegie Classification – Size & Setting (Residential Status), Carnegie Classification – Undergraduate Instruction Program (Arts & Science vs. Professional Program Balance), Carnegie Classification – Undergraduate Instruction Program (Graduate Coexistence), or Carnegie Classification – Graduate Instruction Program.

Hypotheses—Regression

Regression Hypothesis 1: There will be no significant effect of Circulation, Full-Text Articles, and Gate Count on External Research Dollars after controlling for Full-Time Students plus Faculty.

Regression Hypothesis 2: There will be no significant effect of Carnegie Classification – Basic, Carnegie Classification – Undergraduate Instruction Program, Graduate Coexistence, and Carnegie Classification – Graduate Instruction Program on predicting External Research Dollars after controlling for Full-Time Students plus Faculty.

Regression Hypothesis 3: There will be no significant interaction effect between Circulation, Full-Text Articles, and Gate Count and the Carnegie Classifications on External Research Dollars after controlling for Full-Time Students plus Faculty.

Limitations

This study's design had several limitations. First, because libraries do not separate statistics by patron type, almost all the variables in this study included a blend of student, faculty, and community patrons. Furthermore, the proportion of students to faculty within each variable may vary dramatically. For example, although students outnumber faculty, faculty may be responsible for more full-text article downloads than students because faculty research generally spans longer periods of time and often is of greater intensity and focus. The proportion of students to faculty may also vary across libraries. Although many libraries' data for participants in group presentations will represent only students, the official ACRL definition is not limited to students, and is broad in its conception. So it is entirely plausible that a library with a workshop series designed for faculty has a larger proportion of faculty in the reported count than a library that thinks of this count as "just bibliographic instruction." This study controlled for institutional size by using full-time students and faculty. However there could have been variance in the model unaccounted for related to the fluctuations among patron types.

Although this study was limited to four-year institutions, there are many other institutional variables that might have affected the variables in this study (as discussed in the literature review). While exploring research questions related to institutional differences seems like an important area for future research, it was considered to be beyond the scope of the present study. However, when interpreting results from this study, it is important to keep in mind that this study's findings will not account for variance by institutional type. The examination of differences between Carnegie Classification variables should at least provide some evidence of whether future studies should examine institutional differences more closely.

Chapter 4: Results

Results—Covariates

As a first step to exploring the relationships of the covariates on the dependent variables, bivariate correlations of the covariates and the three dependent variables were conducted. Dummy coding was used for the variable Carnegie Classification – Basic to create three groups: Baccalaureate, Master's, and Doctoral institutions.

Dummy coding is a method for using categorical variables (i.e., nominal variables) as independent variables (Cohen, Cohen, West, & Aiken, 2003). One category, usually the first or last, is chosen as the comparison group, and coded variables are created to represent different aspects (or levels) of the independent variable. In this case, Baccalaureate institutions were chosen as the comparison group. When interpreting results involving dummy codes, statistics are interpreted as "difference from the comparison group." If one wishes to compare differences between groups and neither was selected as the comparison group, one can create a second set of dummy variables using a different group as the comparison group.

Based on Hemphill's (2003) meta-analysis of correlation coefficient guidelines (which include a review of the famous Cohen guidelines) and his cautions in using such guidelines, the following criteria were used to classify correlation coefficients: small (<.20), medium (.20 to .40), and large (>.40).

Correlations between the Full-Time Students Plus Faculty and the three dependent variables were large, ranging from .62 for Circulation to .70 for Full-Text Articles in 2010, and from .73 for Circulation to .82 for Gate Count in 2012 (Tables 14 and 15). Thus, Full-Time Students Plus Faculty was retained for further analysis. Covariate

Hypothesis 1a, "There will be no meaningful correlation between Full-Time Students Plus Faculty and the dependent variables Circulation, Full-Text Articles, and Gate Count," was rejected.

Table 14. Correlations between covariates and dependent variables, 2010 dataset.

	LOG AvgExpStu	Master's	Doctoral	Other	LOG FTStuFac	LOG Circ	LOG FT	LOG Gate
LOG_AvgExpStu								
Master's	-0.19							
Doctoral	0.14	-0.31						
Other	0.19	-0.29	-0.13					
LOG_FTStuFac	-0.26	0.34	0.44	-0.39				
LOG_Circ	0.08	0.17	0.33	-0.27	0.62			
LOG_FT	0.01	0.33	0.33	-0.37	0.70	0.55		
LOG_Gate	0.08	0.26	0.31	-0.28	0.69	0.64	0.60	

Note. *N*=330.

Table 15. Correlations between covariates and dependent variables, 2012 dataset.

	LOG AvgExpStu	Master's	Doctoral	Other	LOG FTStuFac	LOG Circ	LOG FT	LOG Gate
LOG_AvgExpStu								
Master's	-0.32							
Doctoral	0.30	-0.49						
Other	0.11	-0.24	-0.18					
LOG_FTStuFac	-0.05	0.04	0.62	-0.26				
LOG_Circ	0.10	-0.07	0.54	-0.22	0.73			
LOG_FT	0.15	0.03	0.54	-0.28	0.79	0.64		
LOG_Gate	0.01	-0.03	0.51	-0.25	0.82	0.73	0.68	

Note. *N*=447.

Correlations between Average Expenditures Per Student and the three dependent variables were small in both the 2010 and 2012 data (Tables 14 and 15). Hypothesis 1b, “There will be no meaningful correlation between average expenditures per student and the dependent variables Circulation, Full-Text Articles, and Gate Count,” was supported. Therefore, Average Expenditures Per Student was excluded from further use as a covariate.

The correlations between the Carnegie Basic classifications and the three dependent variables were low to moderate in size for the 2010 sample, ranging from .17 to -.37. These were dummy-coded variables, so the correlation indicates the increase in relationship strength above that of the reference group, Baccalaureate institutions. For example, in 2010, master’s institutions had .17 *sd* higher library circulation than Baccalaureate institutions, while Doctoral institutions had .33 *sd* higher library circulation than Baccalaureate institutions. In the 2012 sample, the change in correlation from Baccalaureate to Master’s institutions were much smaller (.03 to -.07), while the change in correlation between Baccalaureate and Doctoral was large (.51 to .54). Based on these results, Covariate Hypothesis 1c, “There will be no correlation between Basic Carnegie Classification and the dependent variables Circulation, Full-Text Articles, and Gate Count,” was rejected.

To further analyze the covariates, a series of sequential linear regressions was performed by entering each of the covariates in separate blocks, then adding all the independent variables in a third block. The independent variables were Participants in Group Presentations, Reference Transactions, Interlibrary Loans, Reserves Circulations, Ongoing Expenditures, One-Time Expenditures, Librarian FTE, Staff FTE, Average Librarian Salary, Average Staff Salary, and Library Expenditures as a Proportion of

Institutional Expenditures. Then, each of the three dependent variables was predicted in turn.

When Full-Time Students Plus Faculty was entered in the first block, and Carnegie Classification – Basic was entered in the second block, the only significant F-change was when predicting Full-Text Articles, and the value of the change in R^2 was very small (0.02). Because of the increased sample size in 2012, the F-changes were all statistically significant, but the effect sizes were similarly small. Because the additional variance predicted by Carnegie Classification was so small, it was not used as a covariate in the SEM analyses. However, Carnegie Classification was still explored in the MANCOVAs to examine mean differences across institutional types.

As a side note, in all three equations the independent variables explained a statistically significant amount of additional variance in the dependent variables: 25.5% (Circulation), 7.7% (Full-Text Articles), and 12.5% (Gate Count). In 2012, the R^2 changes were 16.1% for Circulation and 5.5% for both Full-Text Articles and Gate Count. Tables 16 and 17 show the results from the 2010 and 2012 regression analyses.

Social Media – Purpose was not entered into the 2012 regression equations used to analyze covariates so that 2010 and 2012 could be compared. However, an additional three regressions were run with the Social Media – Purpose variable included for 2012 to explore the effects of adding this variable. The results from the final step of the model are shown in the fourth row for each of the dependent variables in Table 17. The R^2 change values increased slightly for the models predicting Circulation and Full-Text Articles (1.4% and 1.1%) and decreased slightly for the model predicting Gate Count (-0.2%).

Table 16. Sequential regression models to analyze covariates, 2010 dataset.

Dependent Variable	Model	*R*	R^2	Adjusted R^2	Std. Error	R^2 Change	*F* Change	*df1*	*df2*	Sig. *F* Change
Full-Text Articles	FTStuFac	0.70	0.49	0.49	0.49	0.49	314.84	1	328	<.01
	FTStuFac, Carnegie Class	0.72	0.51	0.51	0.48	0.02	5.49	3	325	<.01
	FTStuFac, Carnegie Class, IVs	0.77	0.59	0.57	0.45	0.08	5.34	11	314	<.01
Circulation	FTStuFac	0.62	0.38	0.38	0.38	0.38	199.38	1	328	<.01
	FTStuFac, Carnegie Class	0.62	0.38	0.38	0.38	0.01	1.15	3	325	0.33
	FTStuFac, Carnegie Class, IVs	0.80	0.64	0.62	0.29	0.26	20.27	11	314	<.01
Gate Count	FTStuFac	0.69	0.48	0.47	0.35	0.48	298.38	1	328	<.01
	FTStuFac, Carnegie Class	0.69	0.48	0.47	0.35	0.00	0.29	3	325	0.83
	FTStuFac, Carnegie Class, IVs	0.78	0.60	0.58	0.31	0.12	8.95	11	314	<.01

Note. *N*=330.

Table 17. Sequential regression models to analyze covariates, 2012 dataset.

Dependent Variable	Model	*R*	R^2	Adjusted R^2	Std. Error	R^2 Change	*F* Change	*df1*	*df2*	Sig. *F* Change
Full-text Articles	FTStuFac (*N*=447)	0.79	0.62	0.62	0.38	0.62	726.85	1	445	<.01
	FTStuFac, Carnegie Class (*N*=447)	0.80	0.63	0.63	0.38	0.01	4.81	3	442	<.01
	FTStuFac, Carnegie Class, IVs (*N*=447)	0.83	0.69	0.68	0.35	0.06	6.87	11	431	<.01
	FTStuFac, Carnegie Class, IVs (including Social Media) (*N*=357)	0.83	0.70	0.68	0.34	0.07	6.14	12	340	<.01
Circulation	FTStuFac (*N*=447)	0.73	0.54	0.54	0.34	0.54	520.14	1	445	<.01
	FTStuFac, Carnegie Class (*N*=447)	0.75	0.55	0.55	0.33	0.02	5.12	3	442	<.01
	FTStuFac, Carnegie Class, IVs (*N*=447)	0.85	0.72	0.71	0.27	0.16	22.24	11	431	<.01
	FTStuFac, Carnegie Class, IVs (including Social Media) (*N*=357)	0.85	0.72	0.71	0.26	0.18	17.81	12	340	<.01
Gate Count	FTStuFac (*N*=447)	0.82	0.67	0.66	0.27	0.67	882.23	1	445	<.01
	FTStuFac, Carnegie Class (*N*=447)	0.82	0.68	0.67	0.26	0.01	5.27	3	442	<.01
	FTStuFac, Carnegie Class, IVs (*N*=447)	0.86	0.73	0.72	0.24	0.06	8.06	11	431	<.01
	FTStuFac, Carnegie Class, IVs (including Social Media) (*N*=357)	0.85	0.72	0.70	0.24	0.05	5.27	12	340	<.01

Results—SEM

The SEM measurement models were first tested on the 2010 dataset using Full-Time Students Plus Faculty as a covariate. The 2012 dataset was held in reserve as a potential cross-validation dataset for re-testing models that fit, or for testing alternative models based on modifications to ill-fitting models from the tests with 2012 data.

Model Family A: Dependent Variables as Observed Variables

Measurement models A-1 and A-2 both failed the S-B x^2 test, as shown in Table 18. Only Model A-1 met the chosen guidelines for fit. Looking at the Akaike Information Criterion (AIC), Model A-3 (the one without the salary variables and Reserves Circulation) is the most likely to replicate among these measurement models (Kline, 2010, p. 220). However, the RMSEA values of .12 and .14 suggest that the latent constructs are a not a good fit with the data as specified.

Table 18. Measurement model fit, Model Family A: Dependent variables as observed variables.

Model	S-B x^2	*df*	*p*-value	CFI	SRMR	RMSEA	AIC
A-1 (One-factor)	115.38	27	<.01	.97	0.055	0.10	146.61
A-2 (Two-factor)	180.36	26	NA	.95	0.087	0.12	196.72
A-3 (Two-factor)	73.94	8	<.01	.97	.068	.14	86.58

Note. S-B=Satorra-Bentler. All of the S-B x^2 values were significant ($p \geq .05$).

Looking at the standardized covariance residuals for Model A-3 reveals potential areas of misfit (Table 19). Librarian / Professional FTE and Staff FTE (indicators on the latent variable Investment in Library Staff) share large standardized covariance residuals with two of the indicators for Engagement With Library Services, namely, Reference

Transactions and Interlibrary Loans, indicating something is shared between them that is not represented by the model.

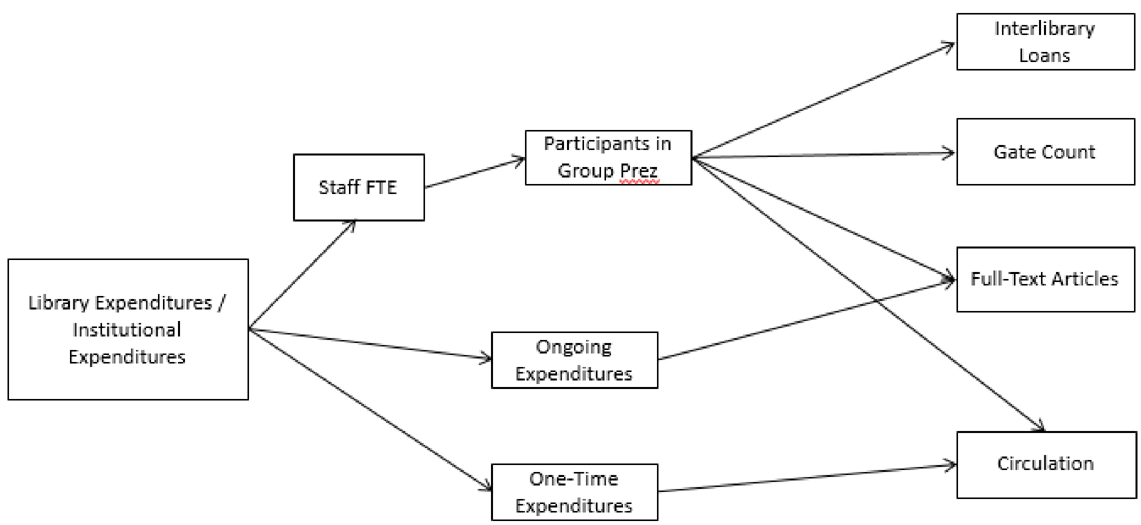
Table 19. Standardized covariance residuals for measurement model A-3.

	LOG_Part	LOG_Ref	LOG_ILL	LOG_Prof FTE	LOG_Staf FTE	LOG_FTSt
LOG_Part	0.00					
LOG_Ref	0.47	0.00				
LOG_ILL	0.27	-1.69	--			
LOG_Prof	--	5.07	5.85	--		
LOG_Staf	--	6.90	4.45	--	--	
LOG_FTSt	-0.11	--	--	--	--	--

Because the measurement models for Model Family A did not fit, and the residuals suggested paths between staff and library service variables, the hybrid model combining a measurement component and path model (A-4) was not tested. Instead, the researcher went on to evaluate a series of path models where just one indicator was tested in place of the latent variables Investment in Staff and Engagement With Library Services. Because Participants in Group Presentations entails direct engagement with students and bears the most relevance to “high-impact practices,” it was chosen to represent Engagement With Library Services. Because librarians are usually the teachers of these classes, the variable Professional FTE was chosen to represent Investment in Staff. Because ILL and Participants in Group Presentations had a very small standardized residual, it was hypothesized that Participants in Group Presentations could predict Interlibrary Loans, as well as Gate Count, Full-Text Articles, and Circulation, During library instruction classes, library services are advertised to students, theoretically increasing use. Ongoing Expenditures and One-Time Expenditures were left in the model as predictors of Full-Text Articles and Circulation. Variations in the model tested for correlations among the DVs Interlibrary Loans, Gate Count, Full-Text Articles, and Circulation, as well as the existence of a path between One-Time Expenditures and Full-Text Articles.

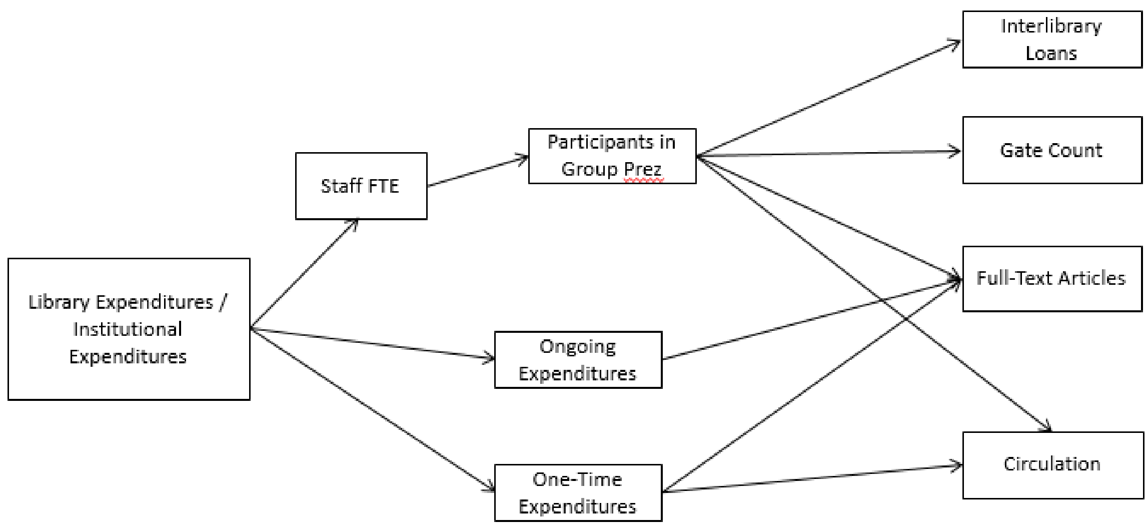
The simplest of these models, Path-A1, had no correlations among the DVs and no path between One-Time Expenditures and Full-Text Articles (Figure 17).

Figure 17. Path Model A-1, Simplest path model predicting Interlibrary Loans, Gate Count, Full-Text Articles, and Circulation, uncorrelated DVs.



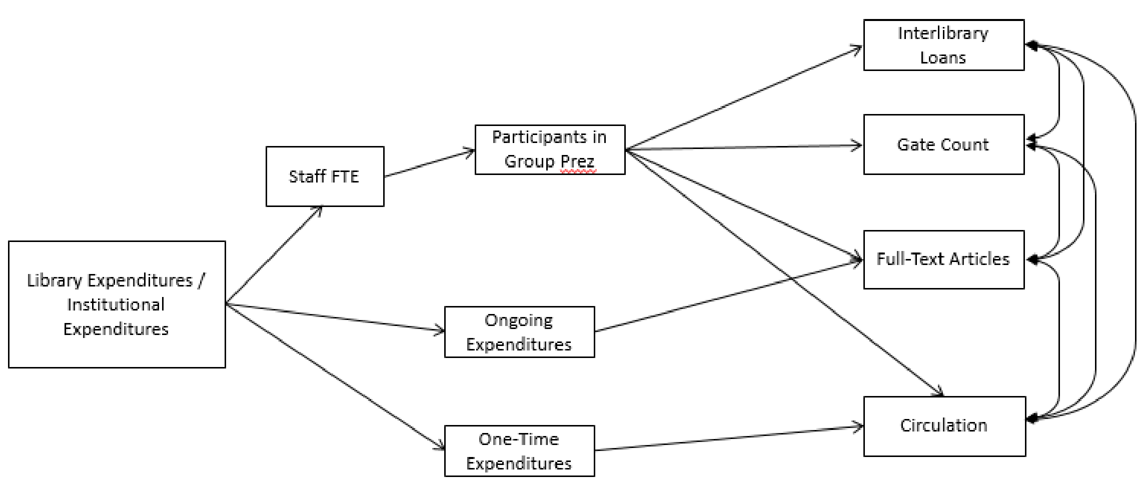
The next model (Path A-2) added a path from One-Time Expenditures to Full-Text Article Requests (Figure 18).

Figure 18. Path Model A-2, Path model predicting Interlibrary Loans, Gate Count, Full-Text Articles, and Circulation with path from One-Time Expenditures to Full-Text Articles



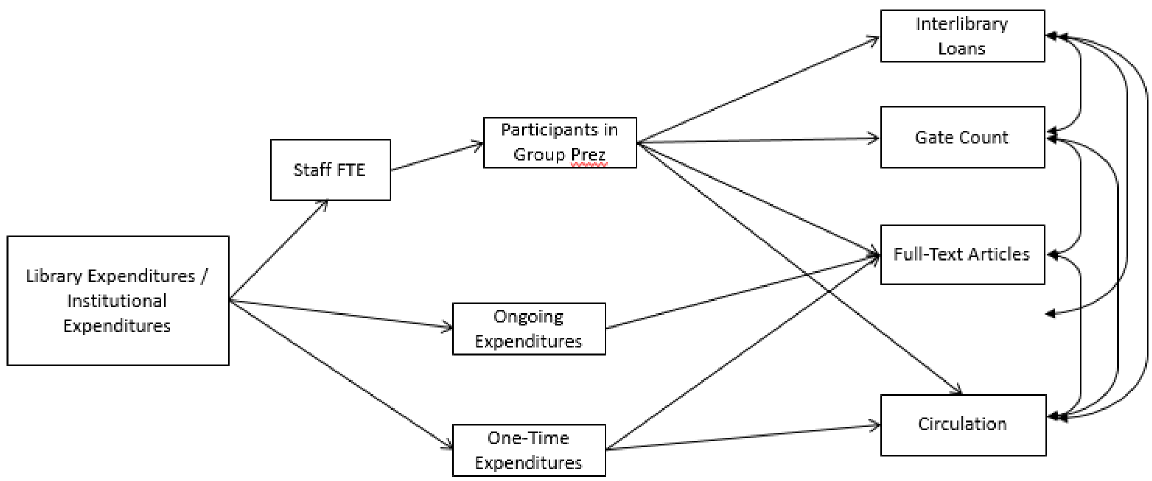
The third model in the series added covariances to the four dependent variables (Figure 19).

Figure 19. Path Model A-3, Path model predicting Interlibrary Loans, Gate Count, Full-Text Articles, and Circulation with correlations between the dependent variables; no path from One-Time Expenditures to Full-Text Articles.



The fourth model in the series added a path between One-Time Expenditures and Full-Text Articles (Figure 20).

Figure 20. Path Model A-4, Path model predicting Interlibrary Loans, Gate Count, Full-Text Articles, and Circulation with correlations between the dependent variables and a path from One-Time Expenditures to Full-Text Articles.



As shown in Table 20, none of the path models fit, whether looking at the S-B x^2 test, SRMR, or RMSEA.

Table 20. Path model fit for Model Family A: All variables as observed variables

Model	S-B x^2	*df*	*p*-value	CFI	SRMR	RMSEA	AIC
Path-A4	142.48	19	<.01	0.97	0.087	0.14	249
Path-A3	131.10	20	<.01	0.97	0.088	0.13	203
Path-A2	187.26	25	<.01	0.95	0.10	0.15	274
Path-A1	204.22	26	<.01	0.95	0.10	0.16	292

Looking at the standardized residuals for these models revealed many large areas of misfit. There were 13 standardized residuals greater than 3 for even the most complex of the models (Path-A4), with no logical pattern among them. Therefore, the researcher moved on to Model Family B.

Model Family B: Dependent Variables as Latent Variable

None of the B-family of models passed the S-B x^2 test or fit the criteria for overall fit set for this study (Table 21). Model B-1 came close, but its RMSEA did not meet the guidelines. In addition, looking at the best-fitting model based on AIC, (B-3) there were 10 standardized residuals greater than 3 and one negative standardized residual. For B-4, the most complex of the B-family of models (Three-factor, with dashed lines), there were 24 standardized covariance residuals greater than 3 and one negative standardized residual.

Table 21. Measurement model fit for Model Family B, dependent variables as latent variables.

Model	S-B x^2	*df*	*p*-value	CFI	SRMR	RMSEA	AIC
B-1 (One-factor)	214.09	54	<.01	0.97	0.054	0.10	267.69
B-2 (Two-factor, with dashed lines)	294.10	53	<.01	0.95	0.087	0.12	338.55
B-3 (Two-factor, w/o dashed lines)	170.55	26	<.01	0.96	0.083	0.12	195.95
B-4 (Three-factor, w/ dashed lines	351.25	52	<.01	0.94	0.10	0.14	418.31
B-5 (Three-factor, w/o dashed lines	201.82	25	<.01	0.95	0.094	0.15	238.38

Model Family C: Combining Staff and Resources

The one-factor model for model C was the same as for model family B (Table 22). Results for B-1 are repeated in Table 21 as C-1 for comparison purposes. Model Family C's measurement models fit even worse than A and B. The best-fitting model according to AIC had 20 standardized residuals larger than 3 and one negative standardized residual.

Table 22. Measurement model fit for Model Family C, combining staff and resources.

Model	S-B x^2	*df*	*p*-value	CFI	SRMR	RMSEA	AIC
C-1 (One-factor)	214.09	54	<.01	0.97	0.054	0.10	267.69
C-2 (Two-factor)	360.52	53	<.01	0.95	0.093	0.14	444.83
C-3 (Two-factor)	315.57	43	<.01	0.95	0.090	0.14	378.65
C-4 (Three-factor)	407.96	52	<.01	0.94	0.11	0.15	500.09
C-5 (Three-factor)	343.71	42	<.01	0.95	0.11	0.15	400.88

This study investigated the possibility of creating latent variables using multiple variables from ACRL and ALS data. However, none of the measurement models tested met the chosen criteria for fit. Thus, the variables chosen do not seem to have formed meaningful constructs. For that reason, the researcher's next step was to continue exploring data through the MANCOVA and regression models detailed in other sections of this study, then return to SEM to propose and test several alternative path models that tested relationships among the data by including only observed variables. Path models are essentially an extension of linear regression but allow multiple mediated relationships to be included in the model.

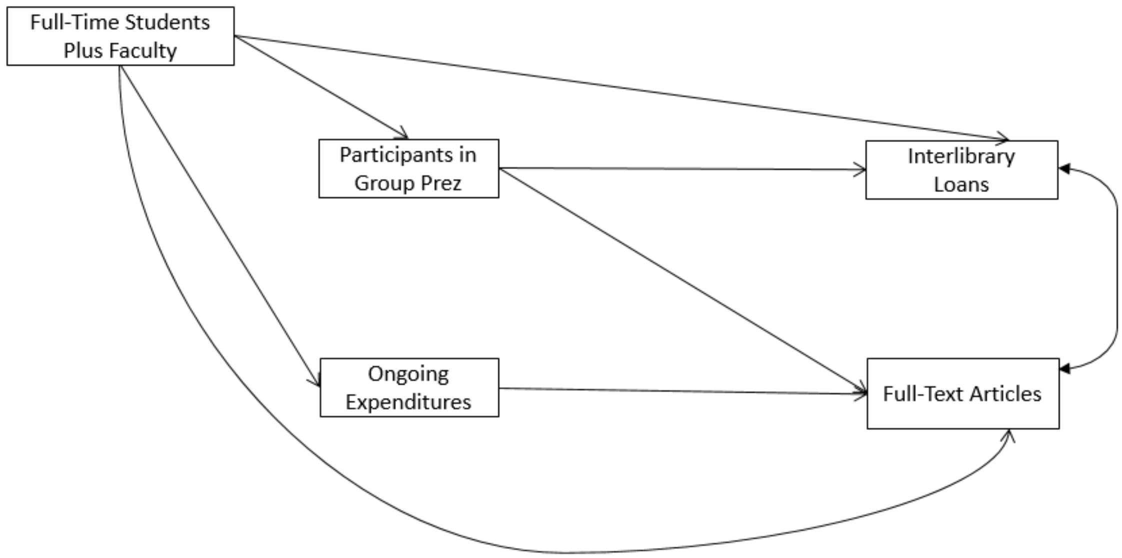
Alternative Path Models / Regressions

The variables to be explored in the alternative path models and the relationships between them were chosen after examining the results from MANCOVA and regression results of this study. A recurring area of interest across the models in this study was the relationship between Full-Text Articles, Interlibrary Loans, Ongoing Resources, and Participants in Group Presentations. Full-Time Students plus Faculty was a meaningful covariate throughout the study, so it was included as a covariate in these alternative path models as well. Because the MANCOVAs showed differences between Doctoral and other institutions, the samples used for these path models were separated into just Doctoral institutions and Master's plus Baccalaureate institutions. As discussed earlier, this limited the sample size and therefore the power of the test; however, the sample exceeded minimum guidelines.

The theory behind these models was that libraries with more Participants in Group Presentations will have greater Full-Text Articles and Interlibrary Loans, because students and faculty will be more aware of library resources and services. Ongoing Expenditures was also thought to predict Full-Text Articles because the more a library spends on its subscriptions, the more articles are available for use by students and faculty. These relationships could be situated in terms of resource dependence theory (Malatesta & Smith, 2014), which describes how one part of an organization (faculty and students) may be dependent on another (the library) for needed resources.

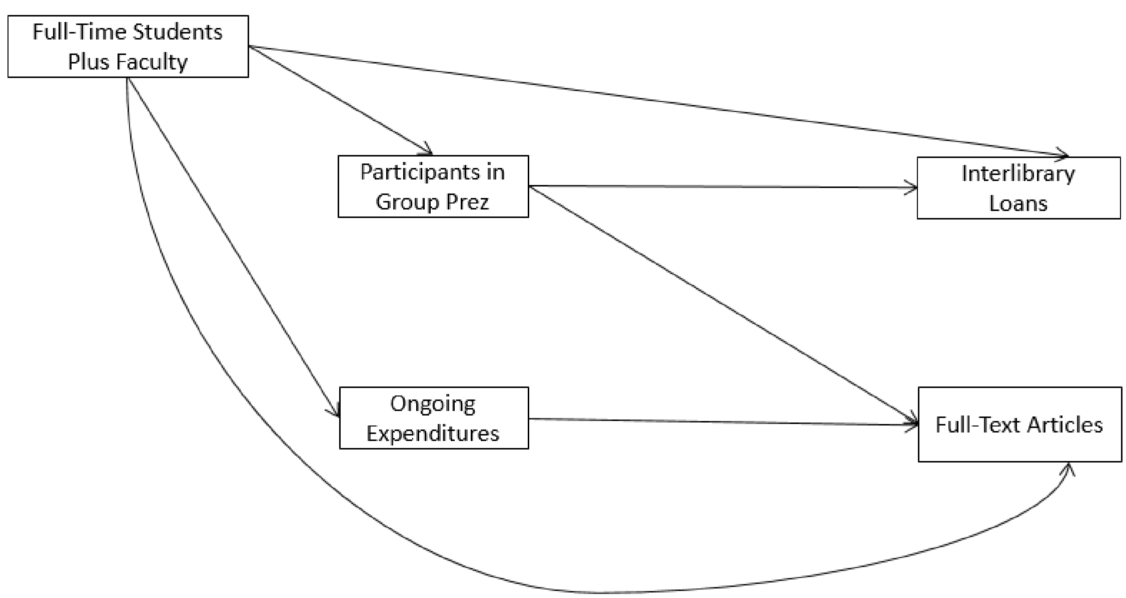
Alternative Path Model 1 specified these relationships, and added a covariance between Interlibrary Loans and Full-Text Articles (Figure 21).

Figure 21. Alternative Path Model 1.



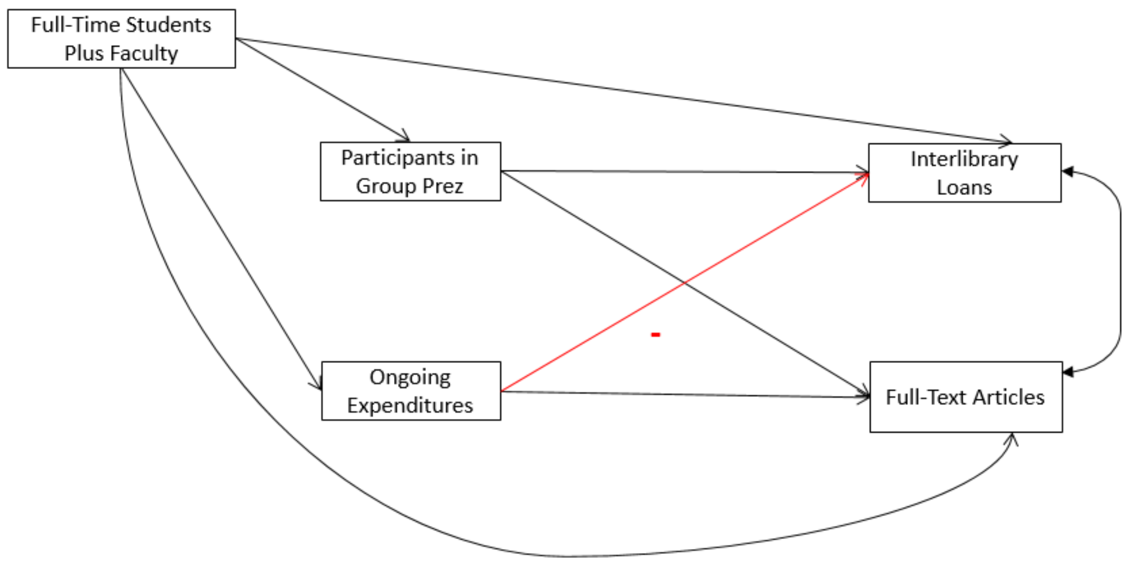
Alternative Path Model 1a was identical, but removed the covariance between Interlibrary Loans and Full-Text Articles (Figure 22).

Figure 22. Alternative Path Model 1a.



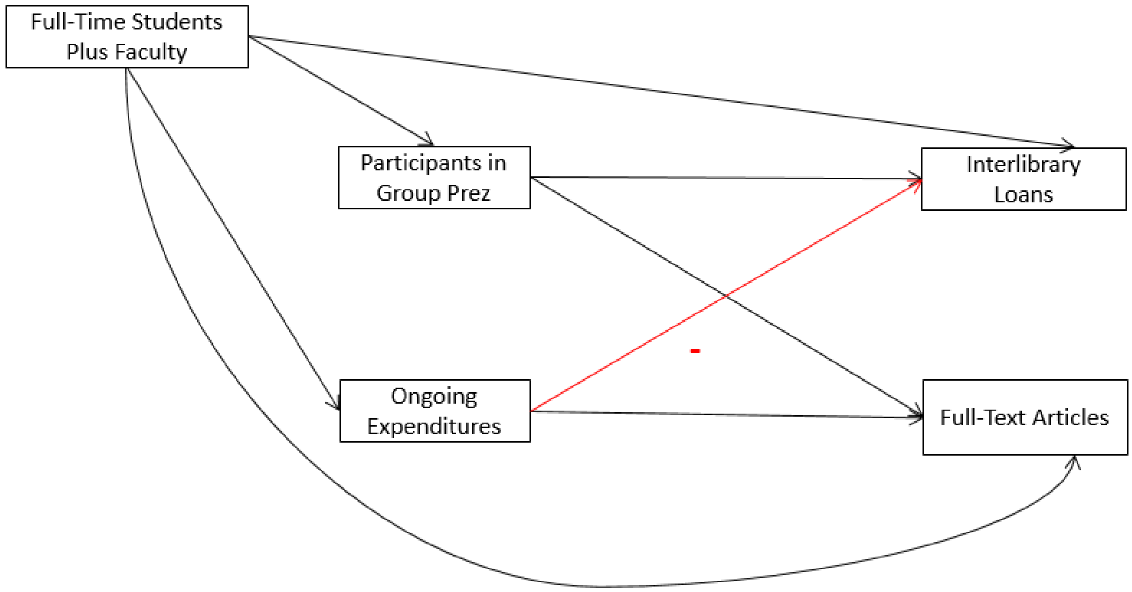
Alternative Path Model 2 proposed that Ongoing Expenditures negatively relates to Interlibrary Loans, because if a library spends sufficient dollars on its subscriptions, then patrons should be finding what they need at their local library and not require so many Interlibrary Loans. Also, the correlation between Interlibrary Loans and Full-Text Articles was added back in (Figure 23).

Figure 23. Alternative Path Model 2.



Finally, Alternative Path Model 2a removed the covariance between Interlibrary Loans and Full-Text Articles (Figure 24).

Figure 24. Alternative Path Model 2a.



Since the degrees of freedom were so small for these models, the RMSEA, which is the specification error per degree of freedom, was not used as a criteria for model-data fit. Mardia's Normalized Multivariate Kurtosis values for the four models tested ranged from -34.5 to -46.1, indicating the data was non-normal (despite the log transformation); therefore, Satorra-Bentler adjustments to the chi-square test and standard errors were used. While none of the models met the S-B x^2 test for absolute fit, two of the models, APM 2 and 2a, met the criteria for SRMR and CFI (Table 23).

Table 23. Model fit for alternative path models (2012 doctoral dataset).

Model	S-B x^2	*df*	*p*-value	S-B x^2 diff	S-B x^2 df diff	*S-B x2* *p*-value	CFI	SRMR	AIC
APM2	20.85	1	<.01				0.97	0.05	47.48
APM2a	23.62	2	<.01	2.33	1	0.13	0.97	0.06	48.19
APM1	45.71	2	<.01				0.95	0.10	64.47
APM1a	48.88	3	<.01				0.94	0.10	65.05

Note. APM1 is compared with APM2

The difference between APM2 and APM 2a was simply the removal of the covariance between the two dependent variables, Full-Text Articles and Interlibrary Loans. Model 2a did not fit significantly worse than Model 2 (S-B $x^{2\ \mathrm{diff}}$ =2.33, *p*=.13), was more parsimonious, and had no theoretically-based advantage, so it is the one championed.

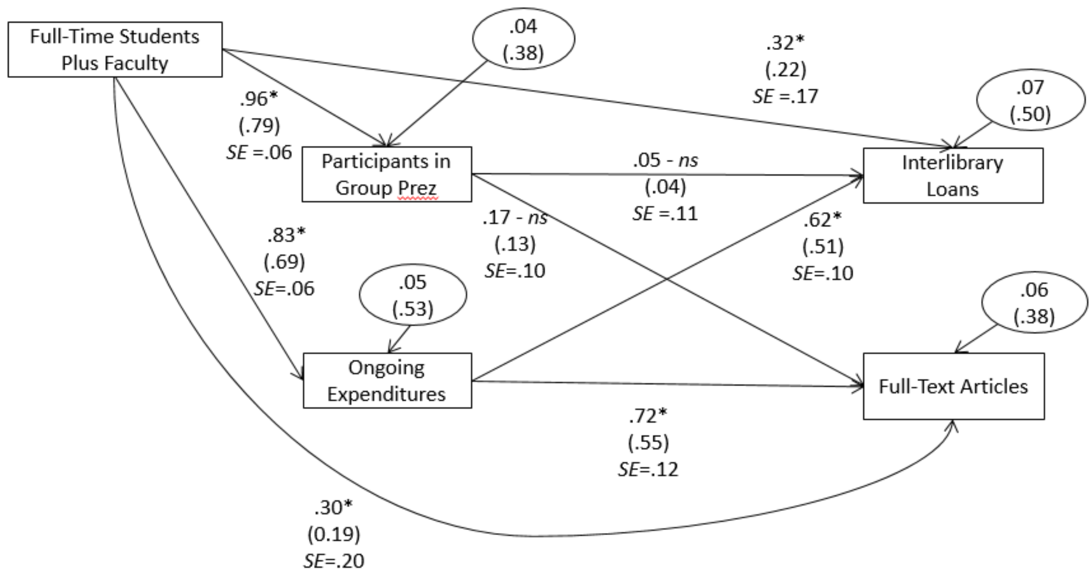
Looking at the structural equations shown in Figure 25, 62% of the variance in Full-Text Articles was explained by the model. For every standard deviation increase in Ongoing Expenditures, Full-Text Articles increased by .55 *sd*. The coefficients for the effect of Participants in Group Presentations on Full-Text Articles are shown for comparison purposes, but were not significant (*t*=1.82, *p*<.05).

With respect to Interlibrary Loans, 50% of the variance was explained by this model. For every *sd* increase in Ongoing Expenditures, Interlibrary Loans increased by .51 *sd.* Again, the coefficients for the effect of Participants in Group Presentations on Interlibrary Loans are shown for comparison purposes, but are not significant (*t*=.42, *p*<.05). 47% of the variance in Ongoing Expenditures and 62% of the variance in Participants in Group Presentations, was explained by this model.

The covariate, Full-Time Students plus Faculty, influenced Participants in Group Presentations and Ongoing Expenditures much more than Interlibrary Loans or Full-Text Articles. For every *sd* increase in Full-time Students and Faculty, Participants in Group Presentations increased by .79 *sd*; Ongoing Expenditures increased by .69 *sd.* The coefficients for the effect of Full-Time Students plus Faculty on Interlibrary Loans and Full-Text Articles were not significant, (*t*=1.86; *t*=1.50, *p*<.05).

There was only one standardized residual noted, between Interlibrary Loans and Full-Text Articles, of 2.18. However, since a model was tested where these two variables were allowed to correlate, and it did not fit significantly better, this residual does not seem meaningful to the model's interpretation.

Figure 25. Path model 2a for Doctoral 2012 dataset with unstandardized coefficients, standardized coefficients (in parentheses), and standard errors.



Note. S-B x^2 (2)=23.62; CFI=0.97; SRMR=0.06; AIC=48.19. *=significant unstandardized coefficient (p<.05); *ns*=non-significant unstandardized coefficient.

Because the MANCOVA tests showed differences between Doctoral institutions and Baccalaureate and Master's institutions, but no significant differences between Baccalaureate and Master's institutions, the researcher decided to test the championed alternative path model using a sample combining Baccalaureate and Master's institutions (2012). The dataset was screened and cleaned as with the other datasets, resulting in 367 cases. Mardia's Multivariate Normality coefficient was -59.24, meaning the Satorra-

Bentler adjustment with maximum-likelihood estimation would still be important to correct standard errors and the chi-square test.

Probably because of the larger sample size (*N*=367), the model's fit indexes showed improvement (CFI=.99; SRMR=.03; AIC=44.97), although the S-B x^2 was still significant, indicating a lack of absolute fit (Table 24).

Table 24. Model fit for Alternative Path Model (2012 Baccalaureate / Master's Dataset).

Model	S-B x^2	*df*	*p*-value	CFI	SRMR	AIC
APM2a-MB	19.30	2	<.01	0.99	0.03	44.97

Looking at the structural equations shown in Figure 26, 57% of the variance in Full-Text Articles was explained by the model. For every *sd* increase in Ongoing Expenditures, Full-Text Articles increased by .27 *sd*. The coefficients for the effect of Participants in Group Presentations on Full-Text Articles are shown for comparison purposes, but were not significant (*t*=1.60, *p*<.05).

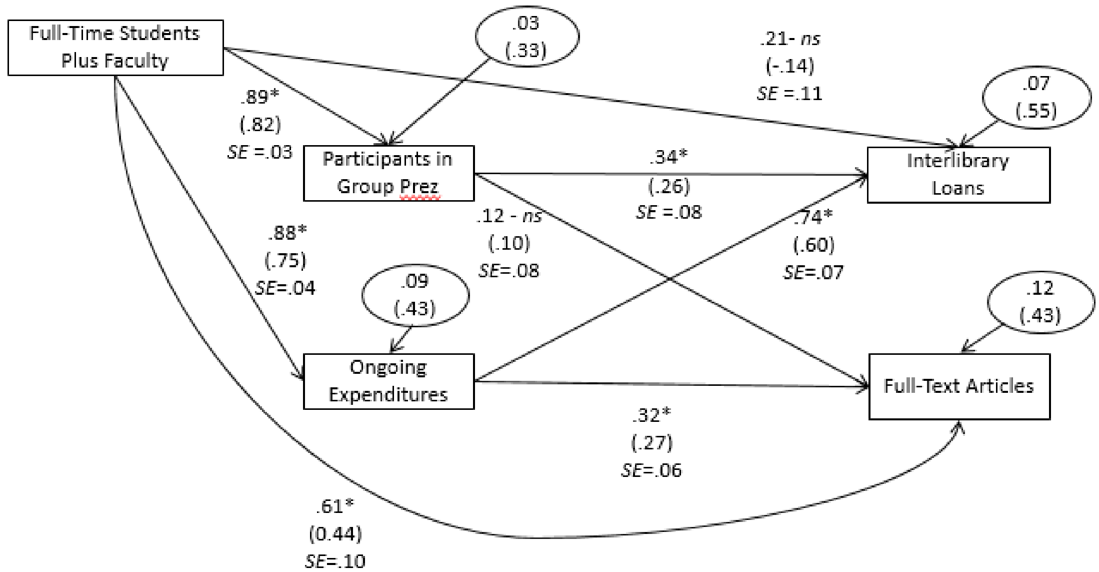
With respect to Interlibrary Loans, 45% of the variance was explained by this model. For every *sd* increase in Ongoing Expenditures, Interlibrary Loans increased by .60 *sd*. The coefficient for the effect of Participants in Group Presentations on Interlibrary Loans was significant for Baccalaureate and Master's; for every *sd* increase in Participants, Interlibrary Loans increased by .26 *sd.*

Fifty-seven percent of the variance in Ongoing Expenditures and 67% of the variance in Participants in Group Presentations in the Baccalaureate and Master's dataset were explained by this model.

The covariate, Full-Time Students plus Faculty, continued to influence Participants in Group Presentations and Ongoing Expenditures much more than Interlibrary Loans or Full-Text Articles. For every *sd* increase in Full-time Students and Faculty, Participants in Group Presentations increased by .82 *sd*; Ongoing Expenditures increased by .75 *sd.* The coefficients for the effect of Full-Time Students plus Faculty on Full-Text Articles were significant with this sample; for each *sd* increase in Full-Time Students and Faculty, Full-Text Articles increased by .44 *sd.* The coefficient for the effect of the covariate on ILs was not significant (t=-1.87, p<.05).

Similar to the Doctoral schools, there was a standardized residual between LOG_FT and LOG_ILL, but more interestingly, there was a large standardized residual (6.40) between Ongoing Expenditures and Participants in Group Presentations, indicating that for Baccalaureate and Master's schools, these two variables have a relationship unexpressed by the model.

Figure 26. Path model 2a for Baccalaureate and Master's 2012 dataset with unstandardized coefficients, standardized coefficients (in parentheses), and standard errors.



Note. S-B x^2 (2)=19.30; CFI=0.99; SRMR=0.03; AIC=44.97. *=significant unstandardized coefficient (p<.05); *ns*=non-significant unstandardized coefficient.

Results—MANCOVA

Groups of libraries were compared using four of the Carnegie Classifications: Basic, Size & Setting (Residential Status), Undergraduate Instruction Program, and Graduate Instruction Program. Carnegie Classification Undergraduate Instruction Program was further divided into its two component parts, Balance between Arts & Sciences vs. Professional Programs ("Program Balance"), and Graduate Program Coexistence ("Graduate Coexistence"). Thus, five sets of two MANCOVAs each were performed. A summary of the levels of each of the five groups is shown in Table 25. Printing the page with the table may assist the reader in navigating MANCOVA results.

Table 25. Carnegie Classification groups and levels for MANCOVAs.

Basic	Size & Setting (Residential Status)	Undergraduate Instruction Program Balance	Undergraduate Instruction Program Graduate Coexistence	Graduate Instruction Program
• Baccalaureate • Master's • Doctoral	• Highly Residential • Primarily Residential • Non-Residential	• Arts & Sciences Focus • Arts & Sciences plus Professions • Balanced Arts & Sciences / Professions • Professions plus Arts & Sciences • Professions Focus	• High graduate coexistence • Some graduate coexistence • No graduate coexistence	• Comprehensive doctoral (no medical/veterinary) • Comprehensive doctoral with medical/veterinary • Master's comprehensive • Master's with arts & sciences or professional (business dominant) • Doctoral, humanities/social sciences or professional dominant • Master's comprehensive • Master's with arts & sciences or professional (business dominant) • Master's with arts & sciences or professional (other) • Single doctoral (education) • Single doctoral (other field) • Single Master's • STEM dominant

Carnegie Classification Basic

For this study, the many values for Basic Carnegie Classification (Carnegie Foundation, 2014) were re-coded into Baccalaureate, Master's, and Doctoral institutions. Associates, Special-Focus, and Tribal Colleges were excluded from this analysis. Thus, independent variables were the categories Baccalaureate, Master's, and Doctoral institutions. For the MANCOVA using three DVs, the sample of 447 was reduced to 410 after eliminating schools with other values for this classification (e.g., "Other Specialized Institutions"). For the MANCOVA using the twelve variables, the cases were reduced to 329 because of missing values for the Social Media variable. Box's *M* test was found to be insignificant for the first MANCOVA involving the three DVs. However, it was significant for the second MANCOVA, with the twelve variables, which is a sign the covariance matrices of the DVs were not equal across groups. However, the variances across DVs fell within the 10:1 ratio recommended by Tabachnick and Fidell (2007).

For the MANCOVA testing the three dependent variables Circulation, Full-Text Articles, and Gate Count, the covariate's effect on the combined DVs was significant and had a large effect size (Pillai's Trace $F(3, 404)=200.80$, $p<.01$, $\square^2=.60$) (Table 26). The combined DV's variance across Baccalaureate, Master's, and Doctoral institutions was statistically significant, but with a small effect size (Pillai's Trace $F(6, 810)=5.93$, $p<.01$, $\square^2=.04$). Separate univariate tests showed significant effects of group membership on Circulation $F(2, 406)=6.58$, $p < .01$, $\square^2=.03$, Full-Text Articles $F(2, 406)=5.70$ $p < .01$, $\square^2=.03$, and Gate Count $F(2, 406)=6.45$, $p < .01$, $\square^2=.03$. Thus, the variance for the individual DVs as predicted by Basic Carnegie Classification was about 3% for each DV.

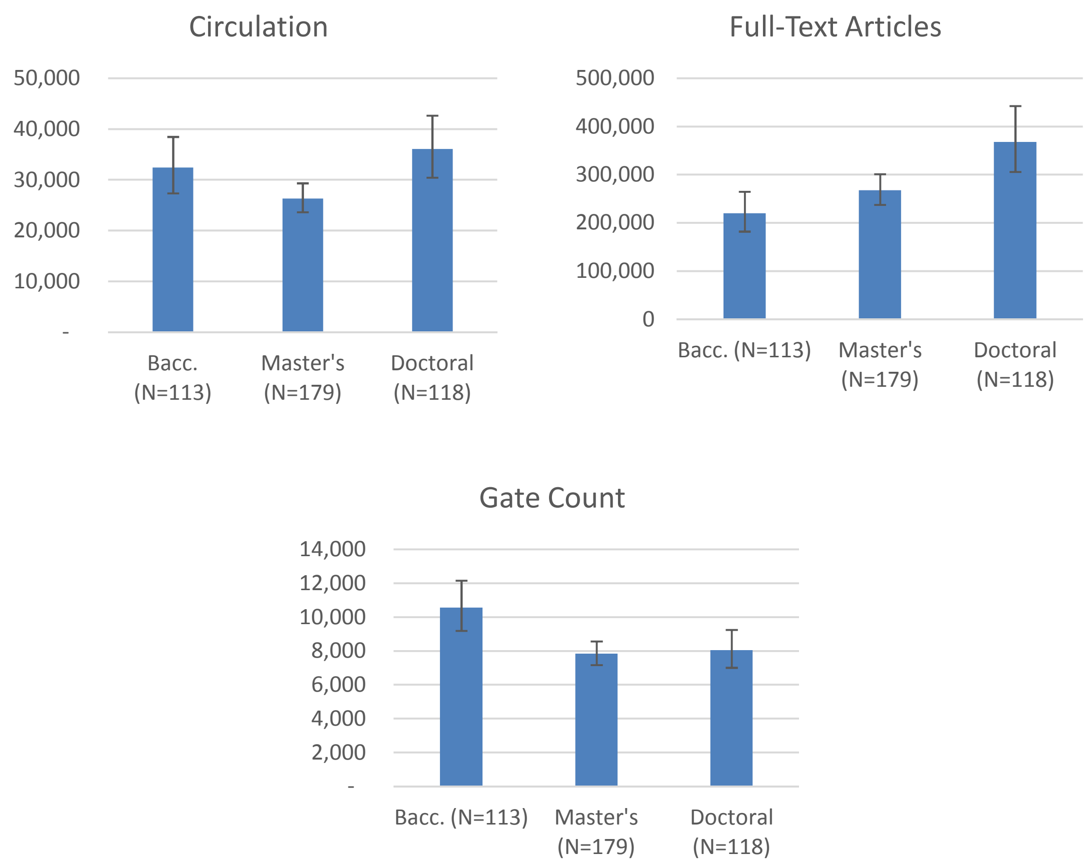
Table 26. Multivariate and univariate tests for the effect of Carnegie Classification – Basic (Baccalaureate, Master's, and Doctoral) on Circulation, Full-Text Articles, and Gate Count.

IV	DV	*V (Pillai's Trace)*	df	*F*	*p*	Partial □^{2}
		Multivariate Tests				
Covariate (FT Stu+Fac)	Combined DVs	0.60	3/404	200.8	<.01	0.60
Combined IVs	Combined DVs	0.08	6/810	5.925	<.01	0.04
		Univariate Tests				
Covariate (FT Stu+Fac)	Circulation		1/406	224.18	<.01	0.36
	Full-Text Articles		1/406	226.42	<.01	0.36
	Gate Count		1/406	417.94	<.01	0.51
Combined IVs	Circulation		2/406	6.58	<.01	0.03
	Full-Text Articles		2/406	5.69	<.01	0.03
	Gate Count		2/406	6.45	<.01	0.03

Contrasts were performed using a Bonferroni adjustment to correct for Type I error. For Full-Text Articles, Doctoral schools had statistically significantly higher means than Master's and Baccalaureate institutions. For Circulation, Doctoral schools had significantly higher means than Master's, but Baccalaureate and Master's institutions did not differ significantly from one another. It is important to remember that the samples for this study excluded small and very small Baccalaureate institutions because of missing data; more difference may have emerged if these schools had been included.

For Gate Count, Baccalaureate schools had the highest mean, which was statistically higher than Master's institutions. Master's and Doctoral schools did not show a statistical mean difference with respect to Gate Count. Graphs of means for each dependent variable, adjusted for the covariate, were generated by taking their inverse log, and error bars were calculated by taking the inverse log of the 95% confidence intervals. (See Figure 27).

Figure 27. Group mean differences across Carnegie Classification – Basic on Circulation, Full-Text Articles, and Gate Count



Note. Error bars represent 95% confidence intervals.

A logical question at this point would be: what is the actual difference between these groups in terms of books checked out, articles downloaded, or people walking into the building? The answer seems easy to provide using arithmetic means calculated from the original data. For example, in the 2012 dataset, Doctoral schools averaged 109,150 circulations, Master's schools, 40,112, and Baccalaureate, 21,847. However, these numbers do not control for the number of students and faculty. These means are also skewed toward extreme values because the data is non-normal.

The geometric mean values provided by reverse-transforming the data from the MANCOVA group means, which controlled for the number of students and faculty, provide a better way to compare the groups. However, the magnitude of the numbers may seem confusing to readers familiar with library data. Doctoral schools' geometric mean, controlling for the covariate, was 36,058 circulations; Master's was 26,302, and Baccalaureate, 32,433. Thus, Doctoral schools have 9,722 more circulations, on average, than Master's schools, but only 3,625 more than Baccalaureate (although this latter figure is not statistically significant). For Full-Text Articles, Doctoral schools have 100,213 more requests than Master's schools and 148,343 more requests than Baccalaureate.

Carnegie Classification Basic – twelve library variables

A separate MANCOVA predicted the twelve DVs Participants in Group Presentations, Reference Transactions, Interlibrary Loans, Reserves Circulations, Ongoing Expenditures, One-Time Expenditures, Librarian / Professional FTE, Staff FTE, Average Librarian / Professional Salary, Average Staff Salary, Library Expenditures as a Proportion of Institutional Expenditures, and Social Media. The multivariate test of the effect of the covariate was significant, with an even larger effect size (Pillai's Trace $F(12,316)=96.86$, $p<.01$, $\square^2=.79$). The linear combination of these twelve DVs also varied significantly across the Basic Classification, with a smaller, but notable effect size (Pillai's Trace $F(24,634)=6.609$, $p<.01$, partial $\square^2=.20$). Separate univariate tests showed significant effects of group membership on Interlibrary Loans $F(2,327)= 8.36$, <.01, partial $\square^2$=0.05, Librarian / Professional FTE $F(2,327)= 26.90$, <.01, partial $\square^2$=0.14, Staff FTE (2,327)= 12.01, <.01, partial $\square^2$=0.07, and Ongoing Expenditures $F(2,327)=$ 48.65, <.01, partial $\square^2$=0.23 and One-Time Expenditures $F(2,327)= 16.37$, <.01, partial $\square^2$=0.09 (Table 27). Average Support Staff Salary was also significant $F(2,327)= 4.55$, <.01, partial $\square^2$=0.03, but had a low power estimate (.63). Non-significant effects included Participants in Group Presentations, Reference, Reserves Circulation, Average Librarian Salary, Library Expenditures as a Proportion of Institutional Expenditures, and Social Media. Power estimates for some of the non-significant variables in this model (.05 level) suggested sample sizes may be barely sufficient or not sufficient for Reference (.69), Average Librarian / Professional Salary (.23), and Social Media (.11). The low-powered results were considered inconclusive.

Contrasts were performed on the groups demonstrating statistical difference and adequate power using a Bonferroni adjustment to correct for Type I error. Doctoral schools had statistically higher means than Master’s or Baccalaureate institutions for Interlibrary Loans, Professional Staff, Support Staff, and Ongoing and One-Time Expenditures ($p<.05$), but there was no statistical difference between Baccalaureate and Master’s institutions—again, remembering that the Baccalaureate schools in this study do not include the smallest schools (Figure 28).

Table 27. Multivariate and univariate tests for the effect of Carnegie Classification – Basic on twelve library variables.

IV	DV	*V (Pillai's Trace)*	*df*	*F*	*p*	Partial □^{2}
		Multivariate Tests				
Covariate (FT Stu+Fac)	Combined DVs	0.79	12/316	96.86	<.01	0.79
Combined IVs	Combined DVs	0.4	24/634	6.61	<.01	0.20
		Univariate Tests				
Covariate (FT Stu+Fac)	LOG_PartGrpPrez		1/327	410.89	<.01	0.56
	LOG_Ref		1/327	190.16	<.01	0.37
	LOG_ILL		1/327	83.87	<.01	0.20
	LOG_ResCirc		1/327	104.22	<.01	0.24
	LOG_ProfFTE		1/327	387.87	<.01	0.54
	LOG_StaffFTE		1/327	336.38	<.01	0.51
	LOG_AvgProf		1/327	35.43	<.01	0.10
	LOG_AvgStaf		1/327	6.76	<.01	0.02
	LOG_Ongoing		1/327	266.37	<.01	0.45
	LOG_Onetime		1/327	108.82	<.01	0.25
	LOG_PCT2		1/327	9.98	<.01	0.03
	LOG_Purpose		1/327	1.69	0.19	0.01
Combined IVs	LOG_PartGrpPrez		2/327	0.25	0.78	0.00
	LOG_Ref		2/327	2.16	0.12	0.01
	LOG_ILL		2/327	8.36	0.00	0.05
	LOG_ResCirc		2/327	0.57	0.57	0.00
	LOG_ProfFTE		2/327	26.90	0.00	0.14
	LOG_StaffFTE		2/327	12.01	0.00	0.07
	LOG_AvgProf		2/327	1.36	0.26	0.01
	LOG_AvgStaf		2/327	4.55	0.01	0.03
	LOG_Ongoing		2/327	48.65	0.00	0.23
	LOG_Onetime		2/327	16.37	0.00	0.09
	LOG_PCT2		2/327	0.42	0.66	0.00
	LOG_Purpose		2/327	0.67	0.51	0.00

In terms of geometric mean differences, Doctoral schools had 2,369 more Interlibrary Loans, 7.2 more Librarian / Professional Staff, 5.3 more Support Staff, $868,363 more Ongoing Expenditures, and $130,298 more One-Time Expenditures than Baccalaureate schools.

Figure 28. Group mean differences across Carnegie Classification – Basic: Interlibrary Loans, Librarian / Professional FTE, Staff FTE, Ongoing Expenditures, and One-Time Expenditures.

Note. Error bars represent 95% confidence intervals.

Summarizing across both MANCOVAs, examining mean differences between the groups Baccalaureate, Master's, and Doctoral showed meaningful univariate effects of the groups on Circulation, Full-Text Articles, and Gate Count. While Doctoral schools had the highest means on Circulation and Full-Text Articles, Baccalaureate institutions had the highest mean on Gate Count.

There were also meaningful differences among Baccalaureate, Master's, and Doctoral institutions with respect to Interlibrary Loans, Staff FTE, Ongoing Expenditures, and One-Time Expenditures. Doctoral schools had the highest group means for these variables, but there was no statistical difference between Baccalaureate and Master's institutions.

Carnegie Classification Size & Setting (Residential Status)

Carnegie Classification Size & Setting incorporates both institution size and residential character (Carnegie Foundation, 2014) and includes consideration of part-time students. Therefore, an additional covariate was tested for this Carnegie Class, Part-Time Students and Full-Time Students Plus Faculty. Large, medium, and small schools were combined in each of the three categories Highly Residential, Primarily Residential, and Non-Residential to form the three groups for this pair of MANCOVAs, dubbed "Residential Status."

Carnegie defines Highly Residential as more than 80% full-time students with more than 50% living in student housing, and Primarily Residential as more than 50% full-time students with more than 25% living in student housing. Non-Residential schools have fewer than 50% of students full-time with fewer than 25% living in student housing. Carnegie adds:

> It is important to note the variety of situations of students who do not live in college or university housing. Some are true "commuting" students, while others may live with other students in rental housing on the periphery of campus, and still others are distance education students who rarely or never set foot on a campus.

For the MANCOVA using Circulation, Full-Text Articles, and Gate Count as DVs, the sample of 447 was reduced to 424 after eliminating schools with other values for this classification (e.g., "Not applicable, special focus institution"), and to 415 for the alternative covariate. For the MANCOVA using the twelve variables, the cases were reduced to 340 because of missing values for the Social Media variable, and to 333 for the alternative covariate. Box's *M* test was found to be significant for all four MANCOVAs.

For the MANCOVA testing the three dependent variables Circulation, Full-Text Articles, and Gate Count, the original covariate's effect on the combined DVs was significant and had a large effect size (Pillai's Trace $F(3, 418)= 465.66$, $p<.01$, □^{2}=.77). The alternative covariate, including part-time students, had similar results (Pillai's Trace $F(3, 409)= 396.51$, $p<.01$, □^{2}=.74). The combined DVs varied across residential groups, both when the original covariate was used (Pillai's Trace $F(6, 838)=8.51$, $p<.01$, □^{2}=.06), and when the alternative covariate was used (Pillai's Trace $F(6, 820)=11.48$, $p<.01$, □^{2}=.08).

Separate univariate tests showed the covariate's effects were significant for each DV, with mostly large effect sizes (Table 28). The univariate tests using the original covariate showed significant effects of group membership on Circulation *F*(2, 420)=17.40, *p*<.01, $\square^2$=.08, and Gate Count *F*(2,420)= 17.04, *p*<.01, $\square^2$=.08, but a non-significant effect of group membership on Full-Text Articles, *F*(2, 420)=8.03, *p*=.41.

Univariate tests using the alternative covariate showed significant effects of group membership on all three, although the effect size on articles was small: Circulation *F*(2, 411)=23.53, *p*=<.01, $\square^2$=.10, Full-Text Articles, *F*(2, 411)=7.02, *p*=<.01, $\square^2$=.03 and Gate Count *F*(2, 411)=2.18, *p*=<.01, $\square^2$=.11 (Table 29). Similar to the multivariate tests, effect sizes were slightly higher when the alternative covariate was used.

Table 28. Multivariate and univariate test results for Residential Status: Circulation, Full-Text Articles, and Gate Count, controlling for the original covariate (Full-Time Students Plus Faculty).

IV	DV	*V* *(Pillai's Trace)*	*df*	*F*	*p*	Partial $\square^2$
		Multivariate Tests				
Covariate (FT Stu + Fac)	Combined DVs	0.74	3/418	400.11	<.01	0.74
Combined IVs	Combined DVs	0.05	6/838	3.63	<.01	0.03
		Univariate Tests				
Covariate (FT Stu + Fac)	Circulation		1/420	565.81	<.01	0.57
	Full-Text Articles		1/420	614.93	<.01	0.59
	Gate Count		1/420	588.35	<.01	0.58
Combined IVs	Circulation		2/420	1.78	0.17	0.01
	Full-Text Articles		2/420	8.03	<.01	0.04
	Gate Count		2/420	0.65	0.53	0.00

Table 29. Multivariate and univariate test results for Residential Status: Circulation, Full-Text Articles, Gate Count, controlling for the alternative covariate (Part-Time and Full-Time Students Plus Faculty).

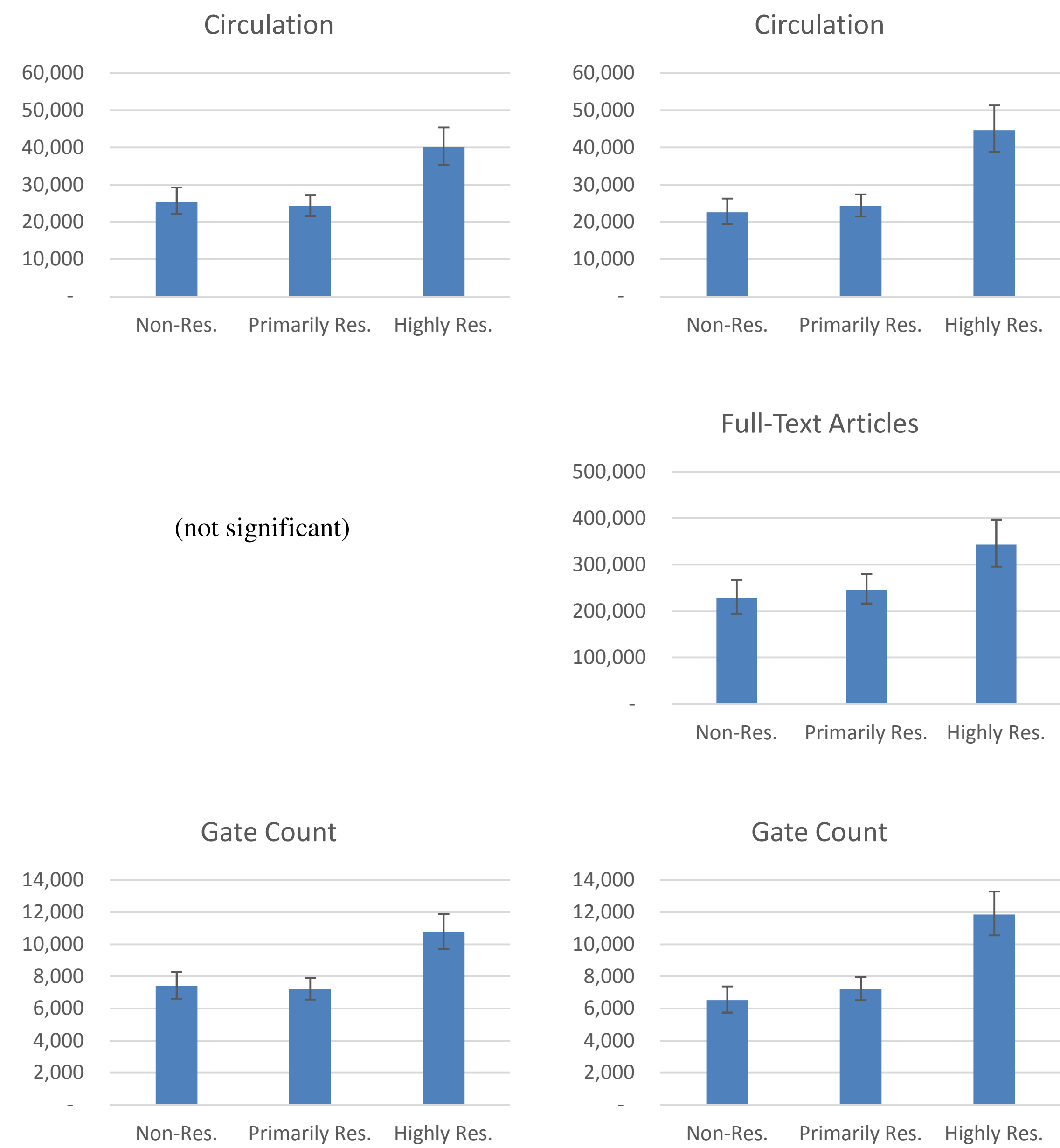
IV	DV	*V* *(Pillai's*	*df*	*F*	*p*	Partial $\square^2$

		Trace)				
		Multivariate Tests				
Covariate (PT+FT Stu+Fac)	Combined DVs	0.77	3/418	465.66	<.01	0.77
Combined IVs	Combined DVs	0.12	6/838	8.506	<.01	0.06
		Univariate Tests				
Covariate (PT+FT Stu+Fac)	Circulation		1/420	564.50	<.01	0.57
	Full-Text Articles		1/420	576.56	<.01	0.58
	Gate Count		1/420	817.01	<.01	0.66
Combined IVs	Circulation		2/420	17.40	<.01	0.08
	Full-Text Articles		2/420	0.89	0.41	0.00
	Gate Count		2/420	17.04	<.01	0.08

Controlling for the original covariate, Highly Residential institutions had significantly higher Circulation and Gate Count than either Primarily or Non-Residential institutions (Figure 29). In terms of geometric mean differences, Highly Residential schools had 15,821 more Circulations than Primarily Residential Schools; 33,680 more Full-Text Article requests; and 3,529 additional visitors, all controlling for Full-Time Students and Faculty. The other mean differences were not statistically significant. Controlling for the alternative covariate, Highly Residential institutions had significantly higher Circulation, Full-Text Articles, and Gate Count than either Primarily or Non-residential institutions, and the geometric means showed larger differences than when using the original covariate. After controlling for Full-Time and Part-Time Students and Faculty, Highly Residential schools had 20,402 more Circulations, 96,731 more Full-Text Articles, and 4,647 higher Gate Count than Primarily Residential Schools. The other mean differences were not statistically significant.

Figure 29. Group mean differences for Circulation, Full-Text Articles, and Gate Count, controlling for two different covariates.

Original Covariate	Alternative Covariate



Note. Error bars represent 95% confidence intervals.

Carnegie Classification Size & Setting (Residential Status) – twelve library variables

For the MANCOVA testing the twelve variables across Highly, Primarily, And Non-Residential schools, the original covariate was significant (Pillai’s Trace $F(12,325)=226.51$, $p<.01$, $\square^2=.89$). Also, the linear combination of the twelve varied across residential groups with a large effect size (Pillai’s Trace $F(24, 652)=5.25$, $p<.01$, $\square^2=.16$). The alternative covariate showed similar results, (Pillai’s Trace $F(12,318)=181.52$, $p<.01$, $\square^2=.87$), as did the linear combination of the twelve dependent variables (Pillai’s Trace $F(24,638)=6.54$, $p<.01$, $\square^2=.20$), with a slightly higher effect size: 20% of the variation in the combined DVs came from group membership.

Separate univariate tests using the original covariate showed significant effects of group membership on Reference $F(2,336)=7.54$, $p < .01$, $\square^2=.04$, Interlibrary Loans $F(2,336)= 15.85$, $p < .01$, $\square^2=.09$, Reserves Circulations $F(2,336)= 12.44$, $p < .01$, $\square^2=.07$, Librarian / Professional FTE $F(2,336)= 10.12$, $p < .01$, $\square^2=.06$, Ongoing Expenditures $F(2,336)= 16.75$, $p < .01$, $\square^2=.09$, and One-Time Expenditures $F(2,336)= 14.48$, $p < .01$, $\square^2=.08$ (Table 30).

When using the alternative covariate, significant univariate tests revealed statistical differences on the same variables, plus Participants in Group Presentations $F(2,336)= 10.07$, $p < .01$, $\square^2=.06$. Presumably because there were only three groups, there were no issues with power of univariate tests in these models (Table 31).

Table 30. Multivariate and univariate test results for Residential Status: twelve library variables, controlling for the original covariate (Full-Time Students Plus Faculty).

IV	DV	*V (Pillai's Trace)*	*df*	*F*	*p*	Partial $\square^2$
		Multivariate Tests				

Covariate (FT Stu+Fac)	Combined DVs	0.89	12/325	226.51	<.01	0.89
Combined IVs	Combined DVs	0.32	24/652	5.25	<.01	0.16
			Univariate Tests			
Covariate (FT Stu+Fac)	LOG_PartGrpPrez		1/336	779.55	<.01	0.70
	LOG_Ref		1/336	346.17	<.01	0.51
	LOG_ILL		1/336	296.46	<.01	0.47
	LOG_ResCirc		1/336	205.12	<.01	0.38
	LOG_ProfFTE		1/336	1010.06	<.01	0.75
	LOG_StaffFTE		1/336	704.54	<.01	0.68
	LOG_AvgProf		1/336	47.22	<.01	0.12
	LOG_AvgStaf		1/336	31.52	<.01	0.09
	LOG_Ongoing		1/336	743.66	<.01	0.69
	LOG_Onetime		1/336	370.87	<.01	0.52
	LOG_PCT2		1/336	10.95	<.01	0.03
	LOG_Purpose		1/336	11.47	<.01	0.03
Combined IVs	LOG_PartGrpPrez		2/336	1.82	0.16	0.01
	LOG_Ref		2/336	7.54	<.01	0.04
	LOG_ILL		2/336	15.85	<.01	0.09
	LOG_ResCirc		2/336	12.44	<.01	0.07
	LOG_ProfFTE		2/336	10.12	<.01	0.06
	LOG_StaffFTE		2/336	2.80	0.06	0.02
	LOG_AvgProf		2/336	1.01	0.37	0.01
	LOG_AvgStaf		2/336	0.50	0.61	0.00
	LOG_Ongoing		2/336	16.75	<.01	0.09
	LOG_Onetime		2/336	14.48	<.01	0.08
	LOG_PCT2		2/336	0.18	0.83	0.00
	LOG_Purpose		2/336	1.41	0.25	0.01

Table 31. Multivariate and univariate test results for Residential Status: twelve library variables, controlling for the alternative covariate (Part-Time And Full-Time Students Plus Faculty).

IV	DV	*V (Pillai's Trace)*	*df*	*F*	*p*	Partial η^2
			Multivariate Tests			
Covariate (PT+FT Stu+Fac)	Combined DVs	0.87	12/318	181.52	<.01	0.87

Combined IVs	Combined DVs	0.13	24/638	6.54	<.01	0.20
	Univariate Tests					
Covariate (PT+FT Stu+Fac)	LOG_PartGrpPrez		1/329	713.52	<.01	0.68
	LOG_Ref		1/329	332.79	<.01	0.50
	LOG_ILL		1/329	267.96	<.01	0.45
	LOG_ResCirc		1/329	193.76	<.01	0.37
	LOG_ProfFTE		1/329	983.49	<.01	0.75
	LOG_StaffFTE		1/329	671.46	<.01	0.67
	LOG_AvgProf		1/329	47.37	<.01	0.13
	LOG_AvgStaf		1/329	31.88	<.01	0.09
	LOG_Ongoing		1/329	680.52	<.01	0.67
	LOG_Onetime		1/329	348.12	<.01	0.51
	LOG_PCT2		1/329	7.98	<.01	0.02
	LOG_Purpose		1/329	11.18	<.01	0.03
Combined IVs	LOG_PartGrpPrez		2/329	10.07	<.01	0.06
	LOG_Ref		2/329	1.58	0.21	0.01
	LOG_ILL		2/329	21.76	<.01	0.12
	LOG_ResCirc		2/329	13.54	<.01	0.08
	LOG_ProfFTE		2/329	26.80	<.01	0.14
	LOG_StaffFTE		2/329	11.20	<.01	0.06
	LOG_AvgProf		2/329	1.45	0.24	0.01
	LOG_AvgStaf		2/329	1.59	0.20	0.01
	LOG_Ongoing		2/329	33.45	<.01	0.17
	LOG_Onetime		2/329	22.29	<.01	0.12
	LOG_PCT2		2/329	0.10	0.91	0.00
	LOG_Purpose		2/329	1.65	0.19	0.01

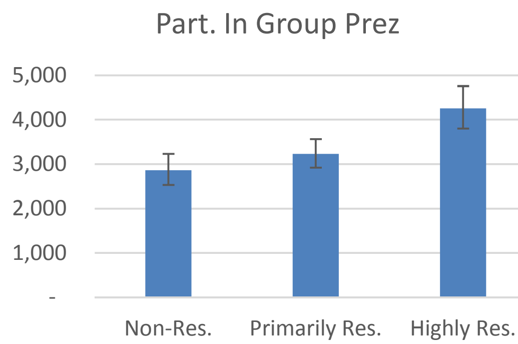
For the original covariate, Non-Residential schools had the highest means for Reference, significantly higher than Primarily Residential schools, for a geometric mean advantage of 2,305 Reference Transactions. Highly Residential schools had the highest means for Interlibrary Loans and Librarian / Professional FTE, significantly higher than both Primarily and Non-Residential schools. Highly Residential schools had 2,815 more Interlibrary Loans and 3.5 more Librarian / Professional FTE than Primarily Residential schools. Primarily Residential Schools had significantly lower means than either Highly or Non-Residential Schools for Reserves Circulations—by about 4,000 Circulations. For both Ongoing and One-Time Expenditures, Highly Residential Schools had significantly higher means than Primarily Residential and Non-Residential Schools. Highly Residential Schools had $388,190 more Ongoing Expenditures than Primarily Residential Schools, and $131,341 more One-Time Expenditures. Although there had been a significant univariate effect on the linear combination of these variables for Staff FTE, there were no significant mean differences.

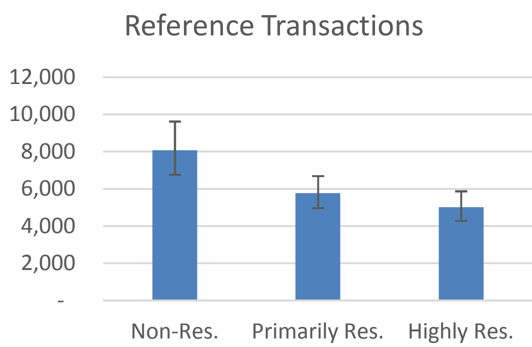
For the alternative covariate (including part-time students), Highly Residential schools had significantly higher means than the other two groups for Participants in Group Presentations, Interlibrary Loans, Librarian / Professional FTE, Staff FTE, and Ongoing and One-Time Expenditures (Figures 30 and 31). Comparing Highly Residential schools with Primarily Residential, the advantages were 1,027 Participants in Group Presentations, 3,645 Interlibrary Loans, 6 Librarian / Professional FTE, $617,917 in Ongoing Expenditures, and $179,608 in One-Time Expenditures. For Reserves Circulations, Highly Residential Schools and Non-Residential Schools had significantly higher means than Primarily Residential Schools, 6,000 and 3,135 more Reserves Circulations, respectively. For Ongoing Expenditures, Primarily Residential Schools also had significantly higher means than Non-residential Schools, but the advantage was smaller, just $167,698.

Figure 30. Group mean differences for Participants in Group Presentations, Reference Transactions, and Librarian / Professional FTE, controlling for two different covariates.

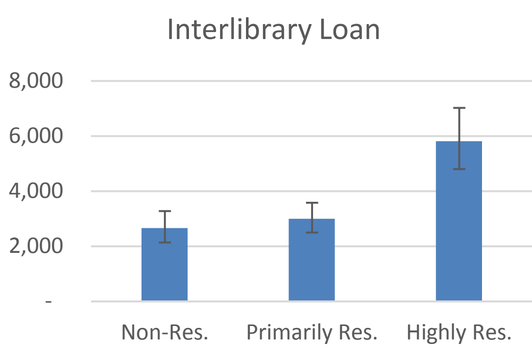
Original Covariate	Alternative Covariate

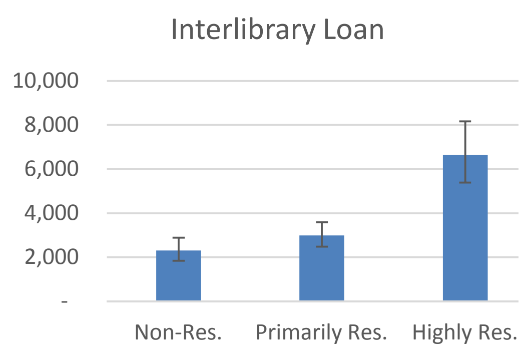
(not significant)





(not significant)





Note: Error bars represent 95% confidence intervals.

Figure 31. Group mean differences for Reserves Circulations, Librarian / Professional FTE, Ongoing Expenditures, and One-Time Expenditures, controlling for two different covariates.

Original Covariate	Alternate Covariate

Note. Error bars represent 95% confidence intervals.

To summarize across the four MANCOVAs in this section, the multivariate effect of Residential Status on Circulation, Full-Text Articles, and Gate Count was small after controlling for either covariate. However, there were still significant group mean differences. Highly Residential institutions had significantly higher Circulation and Gate Count than either Primarily or Non-Residential institutions after controlling for either covariate. Highly Residential institutions also had higher Full-Text Articles after controlling for the covariate including part-time students.

Residential Status also affected group mean differences on Reference, Interlibrary Loans, Reserves Circulations, Librarian / Professional FTE, Ongoing Expenditures, and One-Time Expenditures. When the alternative covariate including part-time students was used, groups also differed on Participants in Group Presentations. Highly Residential schools had the highest means on all the variables mentioned except for Reference, for which Non-Residential schools had the highest group mean.

Comparing the effects of the two covariates, it seems the proportional effect was similar, although the magnitudes of the group means adjusted for the covariate were greater for the alternative covariate (with part-time students). Although the group mean differences for Reference and Participants were not directly compared between the two covariates because each was insignificant for one covariate, the ranked order of means was the same for both covariates.

Carnegie Classification Undergraduate Instruction Program

The Carnegie Classification for Undergraduate Instruction Program “focuses attention on undergraduate education, regardless of the presence or extent of graduate education” (Carnegie Foundation, 2014). The three criteria are: “the level of undergraduate degrees awarded (Associate’s or Baccalaureate), the proportion of Baccalaureate degree majors in the arts and sciences and in professional fields, and the extent to which an institution awards graduate degrees in the same fields in which it awards undergraduate degrees" (Carnegie Foundation, 2014). Carnegie notes that none of the classifications denote a liberal arts education, and that they do not view the categories as relating to value or quality.

There were sixteen categories; these were split into two sets for this study: 1) arts & sciences vs. professions focus ("Program Balance") and 2) degree of graduate coexistence ("Graduate Coexistence"). Associates-dominant institutions were removed. The resulting groups for each set are shown in Table 32.

Table 32. Groups used for Carnegie Classification – Undergraduate Instruction Program.

Category	N
Set 1 – Program Balance	
Arts & Sciences Focus	31
Arts & Sciences plus Professions	50
Balanced Arts & Sciences / Professions	151
Professions plus Arts & Sciences	155
Professions Focus	28
Set 2 – Graduate Coexistence	
High graduate coexistence	98
Some graduate coexistence	251
No graduate coexistence	66

Set 1 – Program Balance

The sample of 447 was reduced to 424 after eliminating schools with other values for this classification (e.g., "Associates"). For the MANCOVA using the twelve variables, the cases were reduced to 340 because of missing values for the Social Media variable. Box's *M* test was found to be insignificant for the MANCOVA on Circulation, Full-Text Articles, and Gate Count, but was significant for the more complex MANCOVA, which is a sign the covariance matrices of the DVs are not equal across groups.

For the MANCOVA testing the three dependent variables Circulation, Full-Text Articles, and Gate Count, the covariate showed a significant effect on the combined DVs (Pillai's Trace F(3, 415)=499.22, *p*<.01, □^{2}=.78), and the combined IVs also varied

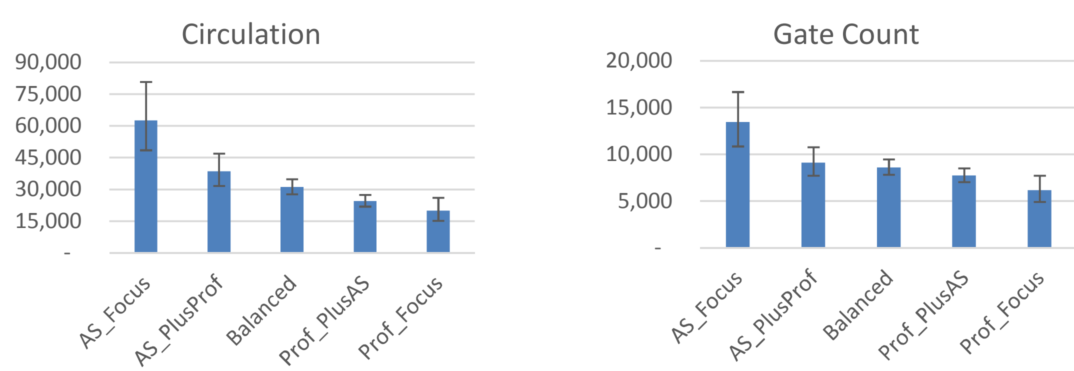
Table 33. Multivariate and univariate tests for the effect of Program Balance on Circulation, Full-Text Articles, and Gate Count.

IV	DV	*V (Pillai's Trace)*	df	*F*	*p*	Partial □*2*
		Multivariate Tests				
Covariate (FT Stu+Fac)	Combined DVs	0.78	3/415	499.22	<.01	0.78
Combined IVs	Combined DVs	0.19	15/1251	5.72	<.01	0.06
		Univariate Tests				
Covariate (FT Stu+Fac)	Circulation		1/417	588.57	<.01	0.59
	Full-Text Articles		1/417	662.03	<.01	0.61
	Gate Count		1/417	777.08	<.01	0.65
Combined IVs	Circulation		5/417	14.34	<.01	0.15
	Full-Text Articles		5/417	3.42	<.01	0.04
	Gate Count		5/417	6.43	<.01	0.07

across groups (Pillai's Trace *F*(15, 1251)=5.72, *p*<.01, □^{2}=.06) (Table 33). Separate univariate tests showed significant effects of group membership on Circulation *F*(5, 417)=14.34, $p < .01$, $\square^2$=.15, Full-Text Articles F(5, 417)= 3.42, $p < .01$, $\square^2$=.04, and Gate Count F(5, 417)= 6.43, $p < .01$, $\square^2$=.07.

Arts-and-Science-Focused institutions experienced significantly more Circulation than each of the other groups, and significantly more Gate Counts than Professional-focused institutions (Figure 32). The advantage of Arts-and-Science-Focused schools over the next group, Arts-and-Sciences-Plus-Professional, was 24,025 Circulations, while the Arts-and-Science-Focused advantage over Professional-focused institutions in terms of Gate Count was 7,307. Arts-and-Sciences-plus-Professional-Programs institutions also experienced significantly more Circulations than the other two “Professional” Programs categories, and Balanced Programs experienced significantly more Circulations than Professional-Focused institutions. No groups’ mean differences varied significantly in terms of Full-Text Articles, however, and there were no significant differences between groups for Gate Count other than between the Arts-and-Science-Focused and Professional-Focused institutions.

Figure 32. Group mean differences among Program Balance Groups for Circulation, Full-Text Articles, and Gate Count, controlling for Full-Time Students Plus Faculty



Note. Error bars represent 95% confidence intervals.

Carnegie Classification Undergraduate Instruction Program, Program Balance – twelve library variables

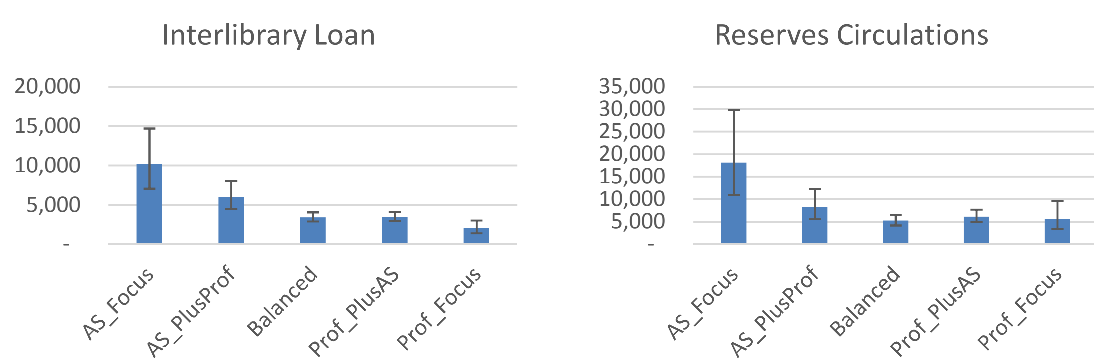
For the MANCOVA testing the twelve library variables, the covariate's effect on the combined DVs was significant (Pillai's Trace $F(12,322)=240.71$, $p<.01$, □^{2}=0.90). The linear combination of the twelve library variable also varied across the five Program Balance groups (Pillai's Trace $F(60,1630)=3.56$, $p<.01$, □^{2}=.12). Separate univariate tests showed significant effects of group membership on all variables except Participants in Group Presentations and Average Staff Salary (Table 34). For some variables, the sample size may not have provided adequate statistical power, including Reference (.69), Average Professional Salary (.23), Average Staff Salary (.64), and Social Media – Purpose (.11).

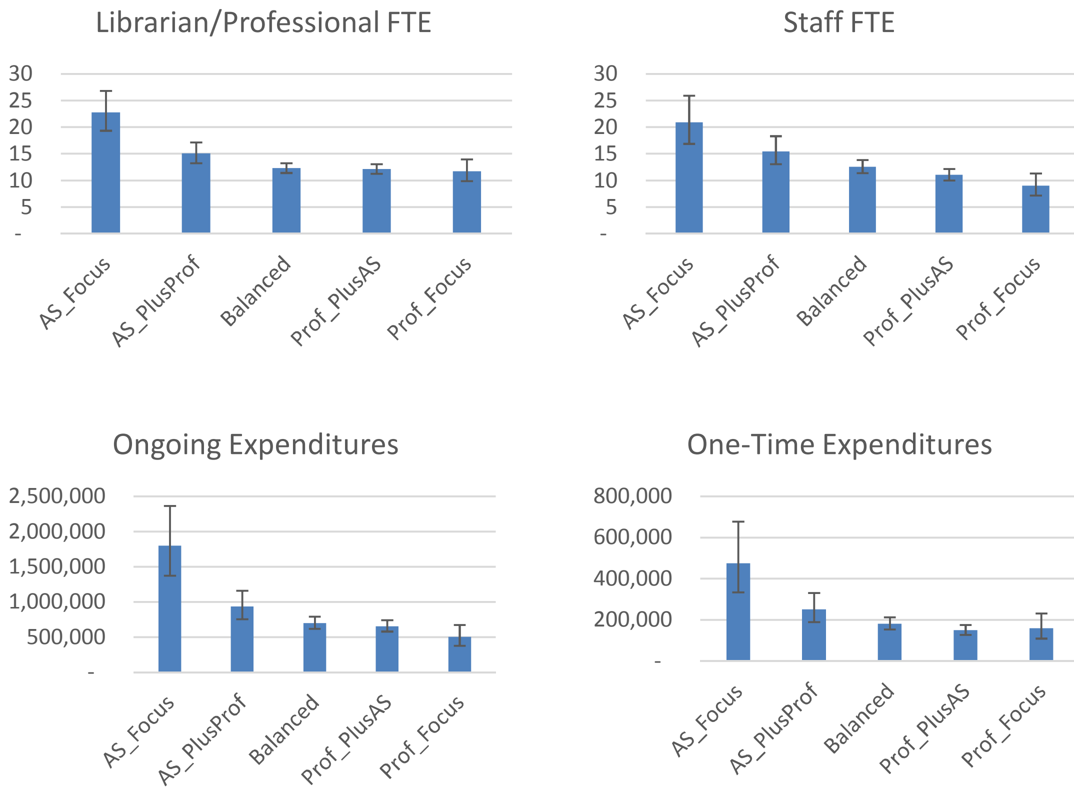
Table 34. Multivariate and univariate tests for the effect of Program Balance on twelve library variables

IV	DV	*V (Pillai's Trace)*	*df*	*F*	*p*	Partial □^{2}
		Multivariate Tests				
Covariate (FT Stu+Fac)	Combined DVs	0.9	12/322	240.71	<.01	0.90
Combined IVs	Combined DVs	0.58	60/1630	3.56	<.01	0.12
		Univariate Tests				
Covariate (FT Stu+Fac)	LOG_PartGrpPrez		1/333	831.89	<.01	0.71
	LOG_Ref		1/333	475.82	<.01	0.59
	LOG_ILL		1/333	310.23	<.01	0.48
	LOG_ResCirc		1/333	231.19	<.01	0.41
	LOG_ProfFTE		1/333	1243.82	<.01	0.79
	LOG_StaffFTE		1/333	889.71	<.01	0.73

	LOG_AvgProf	1/333	62.33	<.01	0.16
	LOG_AvgStaf	1/333	32.60	<.01	0.09
	LOG_Ongoing	1/333	861.42	<.01	0.72
	LOG_Onetime	1/333	388.01	<.01	0.54
	LOG_PCT2	1/333	8.15	<.01	0.02
	LOG_Purpose	1/333	12.42	<.01	0.04
Combined IVs	LOG_PartGrpPrez	5/333	1.34	0.25	0.02
	LOG_Ref	5/333	2.35	0.04	0.03
	LOG_ILL	5/333	17.98	<.01	0.21
	LOG_ResCirc	5/333	4.53	<.01	0.06
	LOG_ProfFTE	5/333	12.80	<.01	0.16
	LOG_StaffFTE	5/333	10.05	<.01	0.13
	LOG_AvgProf	5/333	4.61	<.01	0.06
	LOG_AvgStaf	5/333	0.45	0.82	0.01
	LOG_Ongoing	5/333	18.36	<.01	0.22
	LOG_Onetime	5/333	9.07	<.01	0.12
	LOG_PCT2	5/333	7.15	<.01	0.10
	LOG_Purpose	5/333	3.64	<.01	0.05

Figure 33. Group mean differences among Program Balance groups for dependent variables with significant mean differences, controlling for Full-Time Students Plus Faculty.





Note. Error bars represent 95% confidence intervals.

Arts-and-Science-Focused institutions had significantly higher means than the lowest three groups for all of the six variables with significant univariate test results and adequate power (Figure 33). Arts-and-Science-Focused institutions had 6,766 more Interlibrary Loans, 11 more Librarian / Professional FTE, 8 more Staff FTE, $1,100,639 more Ongoing Resource Expenditures, and $294,618 more One-Time Resource Expenditures, in terms of geometric mean differences. The other groups did not demonstrate significant differences, with a few exceptions. With respect to Interlibrary Loans, Arts-and-Sciences-Plus-Professional had significantly higher means than the lower three groups. With respect to Ongoing Expenditures, Arts-and-Sciences-Plus-

Professional had significantly higher means than the Professional-Focused groups. Finally, with respect to One-Time Expenditures, Arts-and-Sciences-Plus-Professional had significantly higher means than the Professional-Plus-Arts-and-Sciences group.

To summarize, Arts-and-Sciences-Focused institutions had the highest means on all the variables with significant group mean differences, and Professional-Focused had the lowest, although not all differences between groups were statistically significant. For example, no groups differed significantly with respect to Full-Text Articles, and only the two most extreme groups differed significantly with respect to Gate Count. Similarly, while Arts-and-Sciences-Focused institutions had a significantly higher mean than the next-highest group on One-Time Expenditures, the other groups did not differ significantly from one another.

Set 2 – Graduate Coexistence

In the second set of MANCOVAs involving Undergraduate Instruction Program, the focus was the coexistence of graduate programs with undergraduate programs. Box's *M* test was found to be significant for both MANCOVAs.

For the MANCOVA testing the three dependent variables Circulation, Full-Text Articles, and Gate Count, the covariate had a significant effect on the combined DV (Pillai's Trace $F(3,417)=289.30$, $p<.01$, partial □^{2}=0.68). The combined DVs also varied significantly across group membership (Pillai's Trace $F(9, 1257)=6.06$, $p<.01$, partial □^{2}=0.04). Separate univariate tests showed significant effects of group membership on

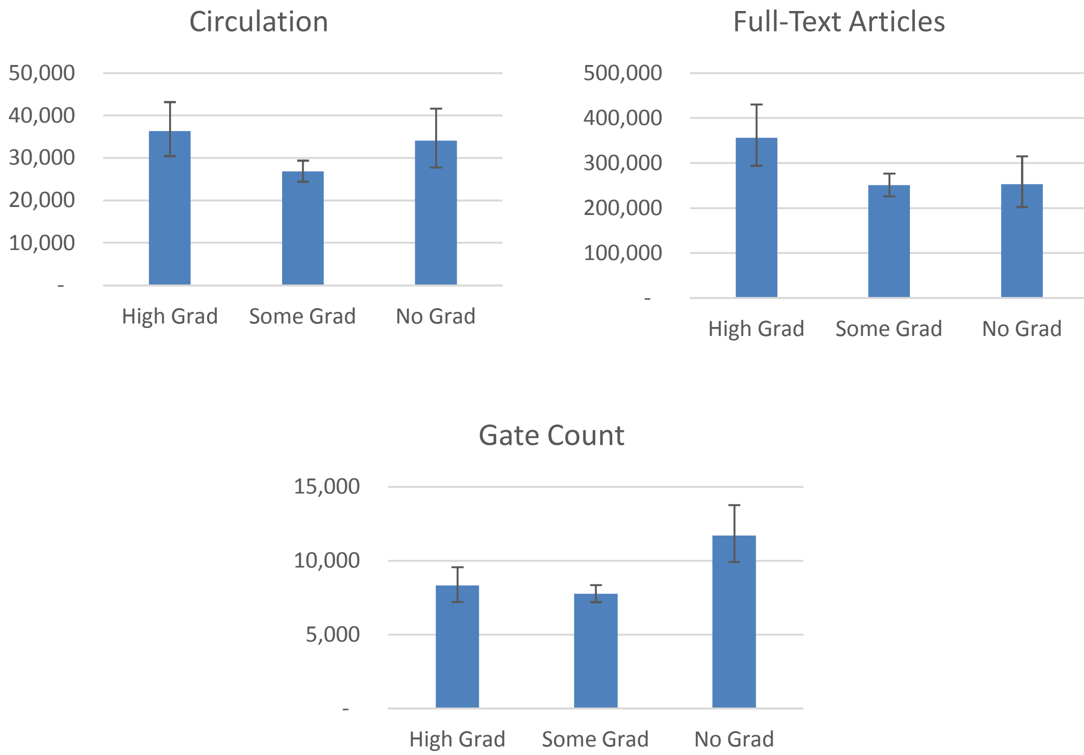
Circulation *F*(3, 419)=7.604, *p* < .01, Full-Text Articles *F*(3, 419)= 7.165, *p* < .01 and Gate Count *F*(3, 419)=7.558, *p* < .05, all with a partial □^{2}=.05 (Table 35).

Table 35. Multivariate and univariate tests for the effect of Graduate Coexistence on Circulation, Full-Text Articles, and Gate Count

IV	DV	*V (Pillai's Trace)*	*df*	*F*	*p*	Partial □^{2}
		Multivariate Tests				
Covariate (FT Stu+Fac)	Combined DVs	0.68	3/417	289.297	<.01	0.68
Combined IVs	Combined DVs	0.13	9/1257	6.055	<.01	0.04
		Univariate Tests				
Covariate (FT Stu+Fac)	Circulation		1/419	295.80	<.01	0.41
	Full-Text Articles		1/419	364.35	<.01	0.47
	Gate Count		1/419	545.19	<.01	0.57
Combined IVs	Circulation		3/419	7.60	<.01	0.05
	Full-Text Articles		3/419	7.17	<.01	0.05
	Gate Count		3/419	7.56	<.01	0.05

Schools with high Graduate Coexistence had significantly higher means than schools with some Graduate Coexistence for Circulation and Full-Text Articles—advantages of 9,516 Circulations and 105,840 Full-Text Articles, respectively (Figure 34). However, No Graduate Coexistence schools ranked between these two categories. For Gate Count, No Graduate Coexistence schools had a significantly higher mean (3,377 visitors higher) than High Graduate Coexistence schools. Other differences between group means were not statistically significant.

Figure 34. Group mean differences among Graduate Coexistence groups for Circulation, Full-Text Articles, and Gate Count, controlling for Full-Time Students Plus Faculty.



Note. Error bars represent 95% confidence intervals.

Carnegie Classification Undergraduate Instruction Program, Graduate Coexistence – twelve library variables

The covariate also had a significant effect on the twelve DVs (Pillai's Trace *F*(12,324)= 134.51, *p*<.01, η^2=0.83). The linear combination of the twelve library variable also varied significantly across the eleven Graduate Instruction Program groups (Pillai's Trace *F*(36, 978=5.710, *p*<.01, η^2=0.17). Separate univariate tests showed significant effects of group membership on all variables except Participants in Group Presentation, Average Professional Salary and Average Staff Salary (Table 36). The power analysis suggested sample size may not have been adequate for Reference (.69), Average Professional Salary (.23), Average Staff Salary (.64), or Social Media – Purpose (.11).

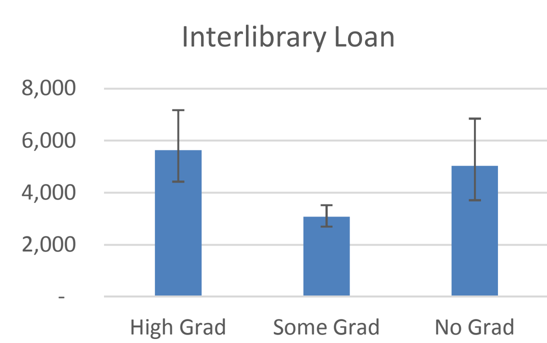
For Interlibrary Loan and One-Time Expenditures, schools with High Graduate Coexistence had significantly higher means than those with Some Graduate Coexistence (*p*<.05), as did schools with No Graduate Coexistence (*p*<.05) (Figure 35). Interlibrary Loans at High Graduate Coexistence schools were 2,560 higher, and One-Time Resources were $98,760 higher than at Some Graduate Coexistence schools. For Librarian / Professional FTE and Staff FTE, Schools with High Graduate Coexistence had significantly higher means than those with Some Graduate Coexistence (*p*<.01), about 6 Librarian / Professional FTE and 5 Staff FTE in terms of geometric mean difference, controlling for the covariate.. For Ongoing Expenditures, Schools with High Graduate Coexistence also had significantly higher means than those with Some Graduate Coexistence (*p*<.01), an advantage of $595,528, but the other group means were not statistically different.

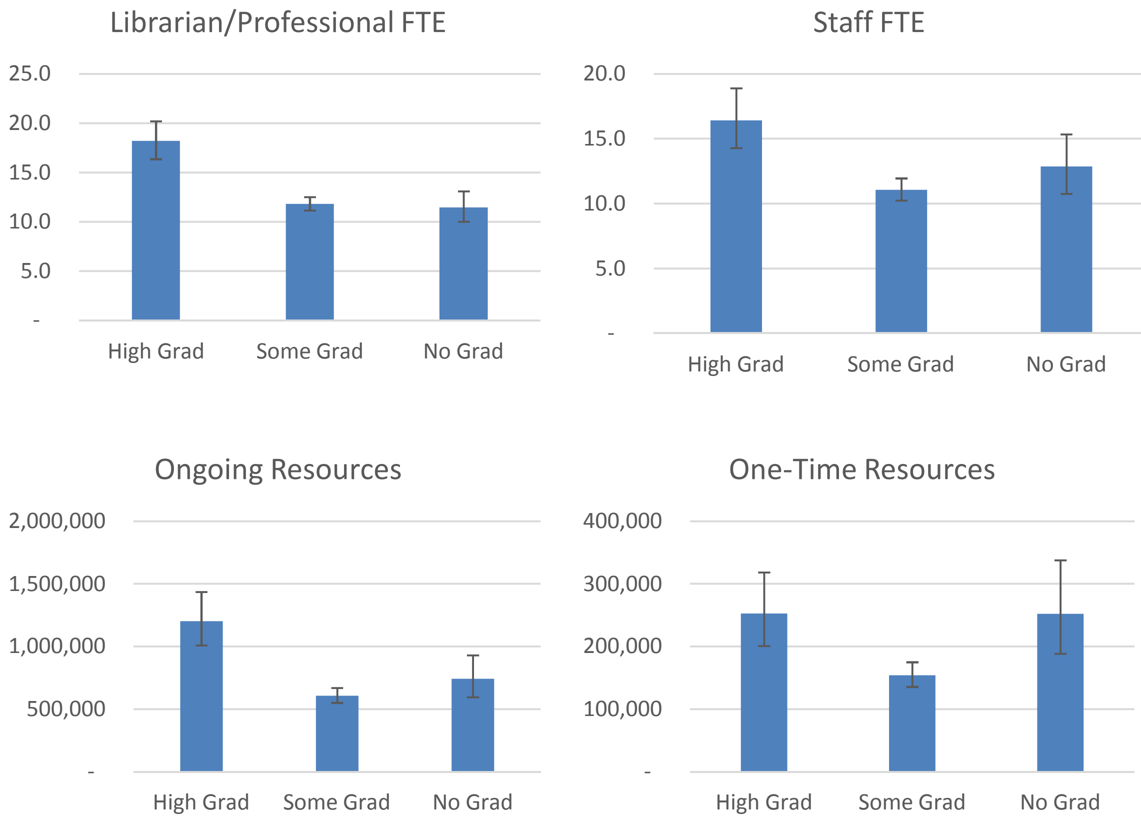
Table 36. Group mean differences among Graduate Coexistence groups for twelve library variables, controlling for Full-Time Students Plus Faculty.

IV	DV	*V (Pillai's Trace)*	*df*	*F*	*p*	Partial η^2
		Multivariate Tests				
Covariate (FT Stu+Fac)	Combined DVs	0.83	12/324	134.51	<.01	0.83
Combined IVs	Combined DVs	0.51	36/978	5.52	<.01	0.17
		Univariate Tests				
Covariate (Total Inst.	LOG_PartGrpPrez		1/335	561.05	<.01	0.63

Expend.)	LOG_Ref	1/335	255.55	<.01	0.43
	LOG_ILL	1/335	146.14	<.01	0.30
	LOG_ResCirc	1/335	110.86	<.01	0.25
	LOG_ProfFTE	1/335	550.10	<.01	0.62
	LOG_StaffFTE	1/335	453.06	<.01	0.57
	LOG_AvgProf	1/335	35.50	<.01	0.10
	LOG_AvgStaf	1/335	19.06	<.01	0.05
	LOG_Ongoing	1/335	394.58	<.01	0.54
	LOG_Onetime	1/335	194.98	<.01	0.37
	LOG_PCT2	1/335	2.81	0.09	0.01
	LOG_Purpose	1/335	1.75	0.19	0.01
Combined IVs	LOG_PartGrpPrez	3/335	0.03	0.99	0.00
	LOG_Ref	3/335	5.20	<.01	0.04
	LOG_ILL	3/335	20.99	<.01	0.16
	LOG_ResCirc	3/335	3.46	0.02	0.03
	LOG_ProfFTE	3/335	17.90	0.00	0.14
	LOG_StaffFTE	3/335	10.32	<.01	0.08
	LOG_AvgProf	3/335	0.50	0.68	0.00
	LOG_AvgStaf	3/335	1.85	0.14	0.02
	LOG_Ongoing	3/335	25.84	<.01	0.19
	LOG_Onetime	3/335	9.74	<.01	0.08
	LOG_PCT2	3/335	3.65	0.01	0.03
	LOG_Purpose	3/335	4.69	<.01	0.04

Figure 35. Group mean differences among Graduate Coexistence groups for dependent variables with significant mean differences, controlling for Full-Time Students Plus Faculty.





Note. Error bars represent 95% confidence intervals.

To summarize, Graduate Coexistence with undergraduate programs had small, but significant effects on Circulation, Full-Text Articles, and Gate Count. High Graduate Coexistence schools had the highest mean on Circulation and Full-Text Articles, and No Graduate Coexistence schools had the highest mean on Gate Count.

Graduate Coexistence had significant effects on the twelve library variables except Participants in Group Presentations, but the effect sizes varied greatly. Graduate Coexistence had large effects on Interlibrary Loan, Librarian / Professional FTE, and Ongoing Expenditures, but more moderate effects on Staff FTE and One-Time

Expenditures. Additionally, the groups did not always result in a logical order: for example, Interlibrary Loan and One-Time Expenditures were highest for High Graduate Coexistence Schools, but the next-highest group was No Graduate Coexistence. On the other hand, for Librarian / Professional FTE, High Graduate Coexistence was followed by Some, then No Graduate Coexistence.

Carnegie Classification Graduate Instruction Program

The Carnegie Classification for Graduate Instruction Program defined eighteen categories (2014). These were collapsed into eleven categories (Table 37). The term "Master's" was used in this study instead of "PostBaccalaureate." Second-level bullets list categories that were collapsed into the parent category.

The sample of 447 was reduced to 424 after eliminating schools with other values for this classification (e.g., "Not Applicable"). For the MANCOVA using the twelve variables, the cases were reduced to 340 because of missing values for the Social Media – Purpose variable. The smallest cell was 16 cases. Box's *M* test was found to be significant for both MANCOVAs.

Table 37. Eleven categories used to differentiate Carnegie Classification – Graduate Instruction Program.

Classifications	***N***
Comprehensive doctoral (no medical/veterinary)	35
Comprehensive doctoral with medical/veterinary	33
Doctoral, humanities/social sciences or professional dominant	46
Doctoral, humanities/social sciences dominant (2)	
Doctoral, professional dominant (44)	

Master's comprehensive	43
Master's with arts & sciences or professional (business dominant)	24
Master's professional (business dominant) (11)	
Master's with arts & sciences (business dominant) (13)	24
Master's with arts & sciences or professional (education dominant)	57
Master's professional (education dominant) (23)	
Master's with arts & sciences (education dominant) (34)	
Master's with arts & sciences or professional (other)	34
Master's professional (other dominant fields) (16)	
Master's with arts & sciences (other dominant fields) (15)	
Master's, arts & sciences dominant (3)	
Single doctoral (education)	25
Single doctoral (other field)	22
Single Master's	25
Single Master's (business) (3)	
Single Master's (education) (12)	
Single Master's (other field) (10)	
STEM dominant	25

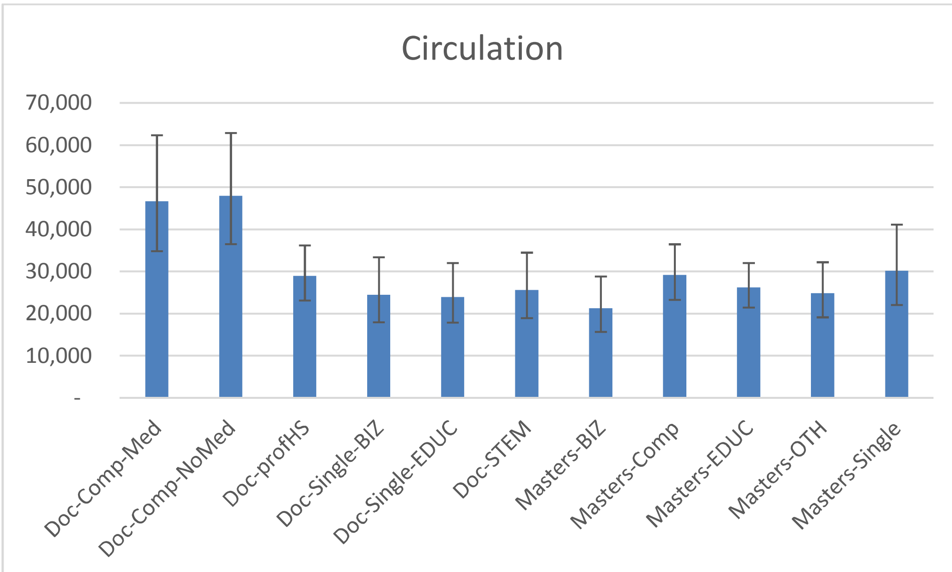
For the MANCOVA testing the three dependent variables Circulation, Full-Text Articles, and Gate Count (Table 38), the covariate significantly affected the combined DV (Pillai's Trace $F(3, 409)=203.58$, $p<.01$, □^{2}=0.60). The combined DVs also varied across the combined IVs (Pillai's Trace $F(33, 1233)=2.34$, $p<.01$, □^{2}=0.06). Separate univariate tests showed significant effects of group membership on Circulation $F(11, 411)=2.810$, $p < .01$, □^{2}=0.07, Full-Text Articles $F(11, 411)= 2.085$ $p < .01$, □^{2}=0.05 and Gate Count $F(11, 411)= 2.169$ $p < .05$, □^{2}=0.05.

Table 38. Multivariate and univariate tests for the effect of Graduate Instruction Program on Circulation, Full-Text Articles, and Gate Count.

IV	DV	*V (Pillai's Trace)*	*df*	*F*	*p*	Partial □^{2}
			Multivariate Tests			
Covariate (FT Stu+Fac)	Combined DVs	0.6	3/409	203.58	<.01	0.60
Combined IVs	Combined DVs	0.18	33/1233	2.336	<.01	0.06
			Univariate Tests			
Covariate (Total Inst. Expend.)	Circulation		1/411	180.84	<.01	0.31
	Full-Text Articles		1/411	259.55	<.01	0.39
	Gate Count		1/411	410.18	<.01	0.50
Combined IVs	Circulation		11/411	2.81	<.01	0.07
	Full-Text Articles		11/411	2.08	0.02	0.05
	Gate Count		11/411	2.17	0.02	0.05

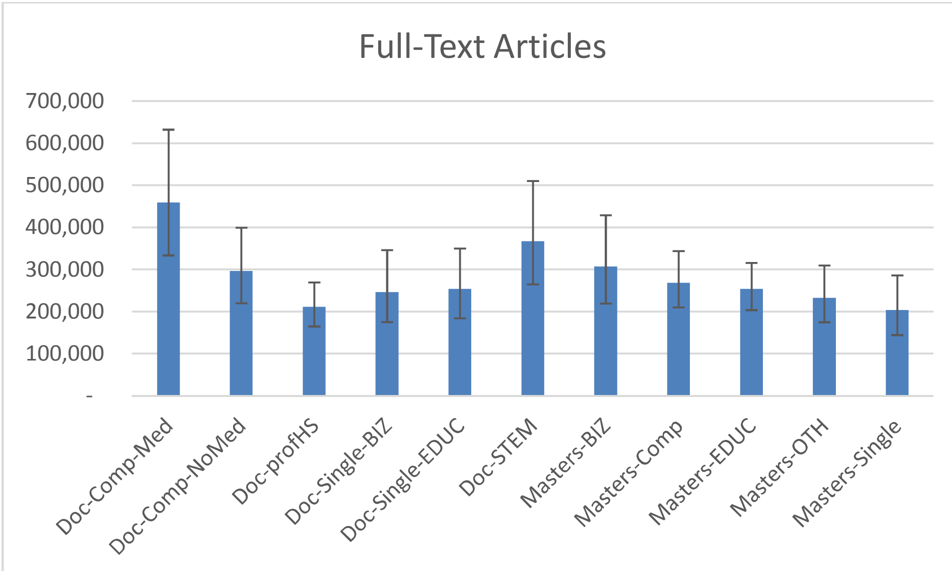
Although the univariate tests showed an overall difference among groups, in only a few cases did groups have statistically different means. For Circulation, Doctoral Comprehensive Schools with a Medical school and Doctoral Comprehensive with no Medical School had higher means than Master's Schools, Business Dominant (p<.05), which was the group with the lowest mean (Figure 36). Doctoral Comprehensive Schools without a Medical school had 26,692 more Circulations than Master's Schools, Business Dominant, when comparing geometric means after controlling for the covariate. For Full-Text Articles, Doctoral Comprehensive Schools with a Medical school had a significantly higher mean than Doctoral, Humanities and Science or Professional Dominant (p<.01), for a difference of 248,335 Full-Text Articles (Figure 37). There were no significant group mean differences between groups on Gate Count.

Figure 36. Group mean differences among Graduate Instruction Program groups for Circulation controlling for Full-Time Students Plus Faculty.



Note. Error bars represent 95% confidence intervals.

Figure 37. Group mean differences among Graduate Instruction Program groups for Circulation and Full-Text Articles controlling for Full-Time Students Plus Faculty.



Note. Error bars represent 95% confidence intervals.

Carnegie Classification Graduate Instruction Program – twelve library variables

For the MANCOVA testing the twelve library variables, all four of the multivariate tests were also significant (Table 39), meaning the linear combination of the twelve library variable varied across the eleven Graduate Instruction Program groups ($F(132, 3586)=2.15$, $p<.01$, $\square^2=0.07$). Separate univariate tests showed significant effects of group membership on Interlibrary Loans, Librarian / Professional FTE, Staff FTE, Ongoing and One-Time Expenditures, and Library Percent of Institutional Expenditures. Non-significant effects included Participants in Group Presentations, Reference, Reserves Circulation, Average Librarian Salary, Average Staff Salary, and Social Media. Power estimates for this model with less than .75 included Reference (.63), Average Librarian Salary (.21), Average Staff Salary (.21), and Social Media (.10). Results relating to these are therefore deemed inconclusive.

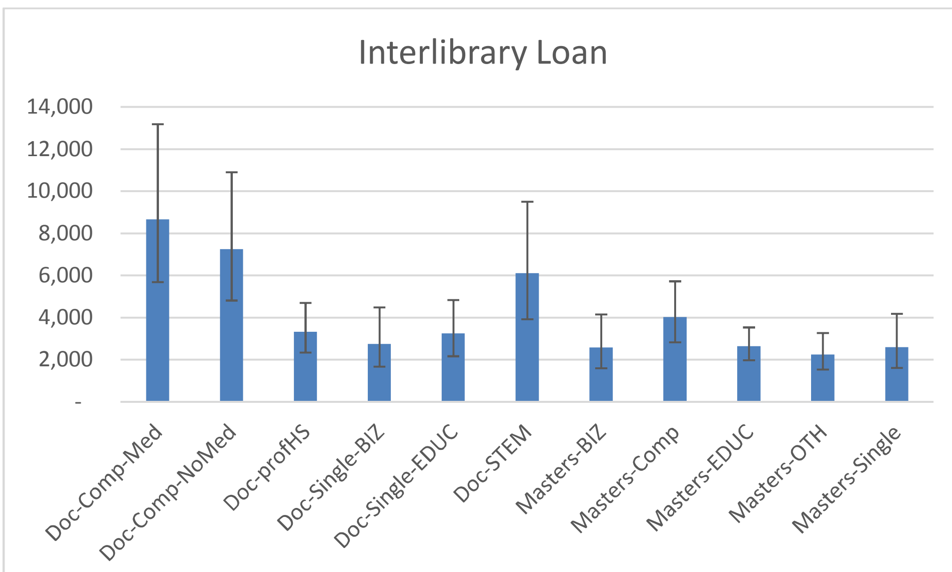
Table 39. Multivariate and univariate tests for the effect of Graduate Instruction Program on twelve library variables.

IV	DV	*V* *(Pillai's Trace)*	*df*	*F*	*p*	Partial η^2
		Multivariate Tests				
Covariate (FT Stu+Fac)	Combined DVs	0.79	12/316	96.59	<.01	0.79
Combined IVs	Combined DVs	0.81	132/3586	2.15	<.01	0.07
		Univariate Tests				
Covariate (FT Stu+Fac)	LOG_PartGrpPrez		1/327	399.48	<.01	0.55
	LOG_Ref		1/327	171.36	<.01	0.34
	LOG_ILL		1/327	58.21	<.01	0.15
	LOG_ResCirc		1/327	94.47	<.01	0.22
	LOG_ProfFTE		1/327	334.83	<.01	0.51
	LOG_StaffFTE		1/327	255.14	<.01	0.44
	LOG_AvgProf		1/327	39.03	<.01	0.11
	LOG_AvgStaf		1/327	14.87	<.01	0.04
	LOG_Ongoing		1/327	177.13	<.01	0.35
	LOG_Onetime		1/327	107.14	<.01	0.25
	LOG_PCT2		1/327	11.42	<.01	0.03
	LOG_Purpose		1/327	4.80	0.03	0.01
Combined IVs	LOG_PartGrpPrez		11/327	0.85	0.59	0.03
	LOG_Ref		11/327	1.10	0.36	0.04
	LOG_ILL		11/327	3.41	0.00	0.10
	LOG_ResCirc		11/327	0.77	0.67	0.03
	LOG_ProfFTE		11/327	8.76	<.01	0.23
	LOG_StaffFTE		11/327	5.20	<.01	0.15
	LOG_AvgProf		11/327	1.49	0.13	0.05
	LOG_AvgStaf		11/327	0.74	0.70	0.02
	LOG_Ongoing		11/327	12.70	0.00	0.30
	LOG_Onetime		11/327	4.27	0.00	0.13
	LOG_PCT2		11/327	2.31	0.01	0.07
	LOG_Purpose		11/327	0.76	0.68	0.03

With respect to Interlibrary Loans, Doctoral Comprehensive schools with a Medical School were significantly different from all the other groups ($p<.05$) except

Doctoral Comprehensive schools without a Medical School, Schools with a Single Doctoral Program (Education), STEM Schools, and Master's Comprehensive Schools. Doctoral Comprehensive schools with a Medical School had 5,343 more Interlibrary Loans than the next highest, but significantly different category, Doctoral, Humanities and Science or Professional Dominant. Doctoral Comprehensive schools without a Medical School were significantly different from Master's, Education dominant schools (*p*<.05) (Figure 38).

Figure 38. Group mean differences among Graduate Instruction Program groups for Interlibrary Loan, controlling for Full-Time Students Plus Faculty.

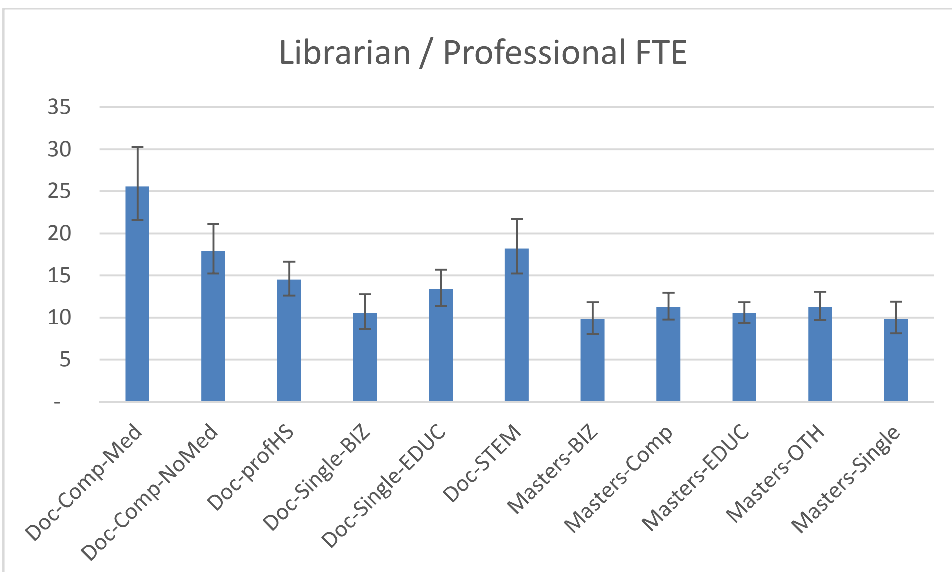


Note. Error bars represent 95% confidence intervals.

With respect to Librarian / Professional FTE, Doctoral Comprehensive schools with a Medical School were statistically different from all other groups (*p*<.05) except Doctoral Comprehensive schools without a Medical School and STEM Schools (Figure 39), for a difference of 11 FTE from the next highest category, Doctoral, Humanities and

Science or Professional Dominant. Doctoral Comprehensive schools without a Medical School were also statistically different from the other groups (*p*<.05) except Doctoral Comprehensive schools with a Medical School, Doctoral Schools with Humanities, Sciences, & Professional programs, Doctoral Schools with a Single Doctoral Program (Education) and STEM Schools. STEM Schools were significantly different from all the Master's categories (*p*<.01), with 7 or 8 additional Librarian / Professional FTE on average.

Figure 39. Group mean differences among Graduate Instruction Program groups for Librarian / Professional FTE, controlling for Full-Time Students Plus Faculty.

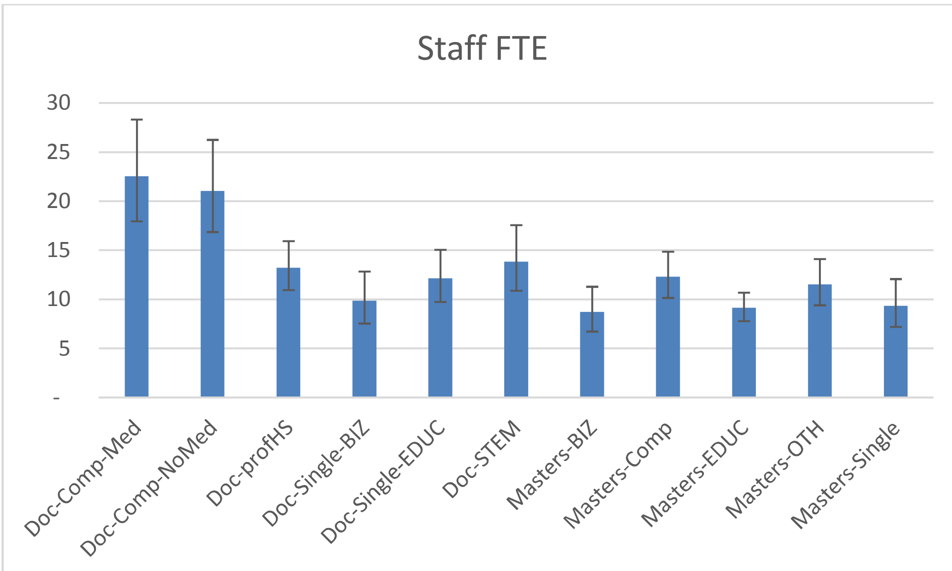


Note. Error bars represent 95% confidence intervals.

With respect to Staff FTE, Doctoral Comprehensive schools with a Medical School were statistically different from all other groups (*p*<.05) except Doctoral Comprehensive schools without a Medical School and STEM Schools (Figure 40), with 9 more staff than the next highest statistically significant group, Doctoral, Humanities and

Science or Professional Dominant. Doctoral Comprehensive schools without a Medical School were also statistically different from the other groups (*p*<.05) except Doctoral Comprehensive schools with a Medical School and STEM Schools.

Figure 40. Group mean differences among Graduate Instruction Program groups for Staff FTE, controlling for Full-Time Students Plus Faculty.

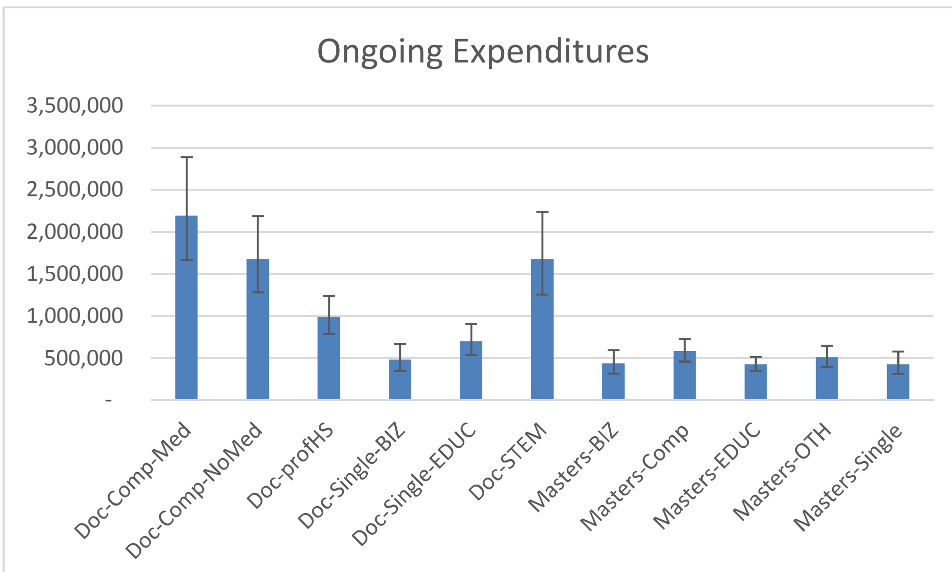


Note. Error bars represent 95% confidence intervals.

With respect to Ongoing Expenditures, Doctoral Comprehensive schools with a Medical School were statistically different from all other groups (*p*<.01) except Doctoral Comprehensive schools without a Medical School and STEM Schools (Figure 41). The difference between Doctoral Comprehensives with a Medical School and the next highest statistically different category, Doctoral, Humanities and Science or Professional Dominant, was impressive: $1,206,525. Doctoral Comprehensive schools without a Medical School were also statistically different from the other groups (*p*<.01) except Doctoral Comprehensive schools with a Medical School, Doctoral Schools with

Humanities, Sciences, & Professional programs, and STEM Schools. Doctoral Schools with Humanities, Social Sciences, or Professional Programs were statistically different from the Master's programs ($p<.05$) except for Master's Comprehensives. STEM Schools were also significantly different from all the Master's categories ($p<.01$). In this category, there were basically two groups of schools: The two Doctoral Comprehensive groups and STEM schools in one group, and everyone else in another group.

Figure 41. Group mean differences among Graduate Instruction Program groups for Ongoing Expenditures, controlling for Full-Time Students Plus Faculty.

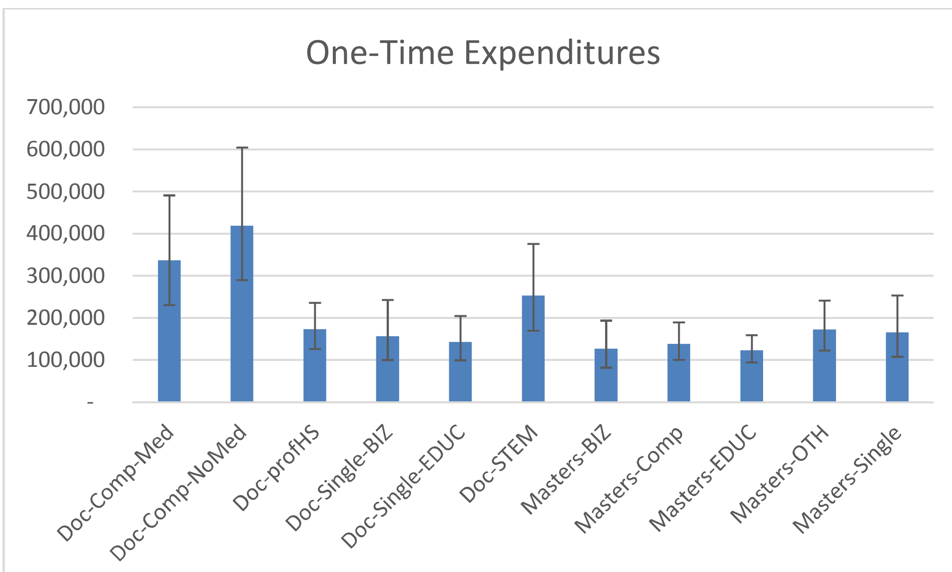


Note. Error bars represent 95% confidence intervals.

For One-Time Expenditures, Doctoral Comprehensive schools with a Medical School were statistically different only from Master's Comprehensive and Master's Education-Dominant ($p<.05$) (Figure 42). Doctoral Comprehensive schools without a Medical School were statistically different from Doctoral Schools, Professional / Humanities emphasis, Doctoral Schools with Humanities, Social Sciences, or

Professional Programs, Doctoral Schools with a Single Program (Education), Master's Comprehensive, Master's, Business-dominant, and Master's, Education-dominant. Looking at the geometric mean differences between the groups with the highest and lowest means (Doctoral Comprehensive without a Medical School and Master's, Education-Dominant) shows that while the magnitude of difference between One-Time and Ongoing Expenditures is great, the proportions are about the same. The difference in these groups' One-Time Expenditures is $295,767, or a 70% difference, while the difference in their Ongoing Expenditures is $1,251,300, a 75% difference.

Figure 42. Group mean differences among Graduate Instruction Program groups for One-Time Expenditures, controlling for Full-Time Students Plus Faculty.

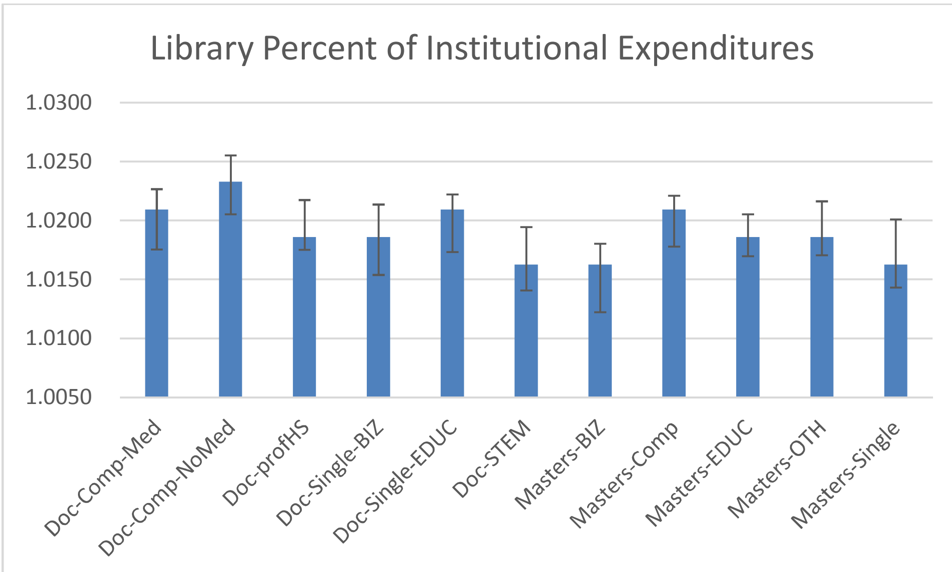


Note. Error bars represent 95% confidence intervals.

Only two pairs of groups showed statistical differences on Percent of Institutional Expenses: Doctoral Comprehensive without a Medical School and STEM Schools, and Doctoral Comprehensive without a Medical School and Master's Schools, Business-

Dominant (Figure 43). The differences in geometric means between the higher and lower groups were both approximately 0.01%.

Figure 43. Group mean differences Graduate Instruction Program groups for Library Expenditures as a Proportion of Institutional Expenditures, controlling for Full-Time Students Plus Faculty.



Note. Error bars represent 95% confidence intervals.

In summary, for most variables, Graduate Instruction Program was significantly different only for a few levels of each group. That is, the group with the highest mean might be significantly different from the group with the lowest mean, but otherwise the groups may not have been that much statistically different from one another. There were some differences among Graduate Instruction Program groups with respect to Circulation and Full-Text Articles, but none with respect to Gate Count. There were also significant differences among groups for Interlibrary Loan, Librarian / Professional FTE and Staff

FTE, Ongoing and One-Time Expenditures, and the library's percentage of the institutional budget.

In conclusion, the MANCOVA analyses support rejecting Covariate Hypothesis 2, "After controlling for Full-Time Students Plus Faculty, there will be no meaningful group mean differences between institutions' Carnegie Classifications." There were a variety of meaningful group mean differences across Carnegie Classifications. The MANCOVA analyses also support rejecting both MANCOVA hypotheses, which proposed no mean differences on a multivariate combination of Circulation, Full-Text Articles, and Gate Count between groups, and no mean differences on a multivariate combination of twelve library service and expenditure variables. The Carnegie Classifications do have meaningful effects on both the multivariate combinations of variables and select univariate comparisons.

An analysis of results across all the MANCOVAs will be provided in the Discussion.

Results—Regression

A series of sequential regressions predicted External Research Dollars from Circulation, Full-Text Article, and Gate Count. The first step was entering the covariate Full-Time Students Plus Faculty in the model. Step 2 was entering the primary variables of interest, Circulation, Full-Text Article, and Gate Count, into the model. Step 3 was where various Carnegie Classifications were entered, using dummy-coding to represent each group. Finally, Step 4 entered interaction variables created by multiplying Circulation, Full-Text Articles, and Gate Count with the dummy-coded Carnegie

Classification variables. All continuous independent variables were centered before entering them into the models.

Carnegie Classification Basic

The first series of regressions involved Carnegie Classification – Basic (Table 40). For the 2010 merged dataset, the first step showed Full-time Students Plus Faculty accounted for a significant amount of External Research Dollars, R^2=.314, F(1, 134)=61.274, p<.01, indicating that larger schools net more External Research Dollars. Thirty-one percent of the variance in External Research Dollars was predicted when just Full-time Students Plus Faculty was entered. In the second step, variables were added for the three library use variables Circulation, Full-Text Articles, and Gate Count. This step did not significantly improve the model, R^2 Change= .018, F(3,131)=1.15, p=.33. In the third step, the dummy-coded variables representing Carnegie Classification – Basic were entered, and the change was significant R^2 Change= .126, F(2,129)=14.89, p<.01. In the final step, the interactions (constructed by multiplying each dummy variable with each of the other independent variables) were entered; these did not produce a significant change, R^2 Change= .028, F(6,123)=1.21, p=.31.

Table 40. Sequential regression results for Carnegie Classification-Basic (2010 dataset)

Step	R^2	Adjusted R^2	R^2 Change	*df*	*F*	Sig.
Step 1	0.31	0.31	0.31	1/134	61.27	<.01
Step 2	0.33	0.61	0.02	3/131	1.15	0.33
Step 3	0.46	0.55	0.13	2/129	14.89	<.01
Step 4	0.49	0.55	0.03	6/123	1.21	0.31

Table 41 shows the coefficients, with "C_" added to variable labels to signify that they were centered before entering them into the equation, and "DC_" indicating a dummy-coded variable. Looking at Step 3, the covariate had a significant effect on External Research Dollars, $t(139)=2.66$, $p<.01$, $sr^2=.03$. The difference between Doctoral Schools and Baccalaureate schools also made a significant contribution, $t(139)=3.58$, $p<.01$, $sr^2=.05$. Doctoral institutions showed a .39 *sd* advantage over Baccalaureate in terms of External Research Dollars, and contributed 5% of unique variance to the model. Master's institutions did not significantly differ from Baccalaureate. Looking at the original group means (prior to log transformation) shows these results in more dramatic terms: Doctoral institutions in this sample had an average of $40,185 in External Research Dollars, Master's averaged $6,776, and Baccalaureate averaged $5,233.Finally, the primary variables of interest (Circulation, Full-Text Articles, and Gate Count), were not significant predictors in the model.

For the 2012 merged dataset, results again indicated that larger schools net more External Research Dollars, $R^2=.24$, $F(1, 195)=61.912$, $p<.01$ (Table 42). Similarly to 2012, 31% of the variance in External Research Dollars was predicted by the covariate. In the second step, variables were added for the three library use variables Circulation, Full-Text Articles, and Gate Count. Unlike 2010, these variables did contribute significantly to the model at this step, adding 12% to the prediction, R^2 Change=.12, $F(3, 192)=11.499$, $p<.01$. Next, the Carnegie Classification dummy-coded variables were added as Step 3, which increased the predictive ability of the model by 24%, R^2 Change= .24, $F(2, 190)=57.33$, $p<.01$. The addition of interactions between the library variables and Carnegie Classifications further increased prediction, although by just 4%, R^2

Change= .04, *F*(6, 184)=3.078, *p*<.01. Also, none of the individual interaction parameters were statistically significant.

Table 41. Sequential regression coefficients for Carnegie Classification-Basic (2010 dataset).

Step and predictor variables	*B*	*SE B*	*t*	Sig.	95% CI (lower)	95% CI (upper)	*β*	sr^2
Step 1								
(Constant)	3.55	0.05	67.65	0.00	3.44	3.65		
LOG FT Stu+Fac	1.32	0.17	7.83	0.00	0.99	1.65	0.56	0.314
Step 2				0.33				
(Constant)	3.54	0.05	67.37	0.00	3.44	3.65		
LOG FT Stu+Fac	1.11	0.25	4.49	0.00	0.62	1.60	0.47	0.103
LOG FT	0.28	0.16	1.71	0.09	-0.04	0.60	0.16	0.015
LOG Circ	-0.17	0.17	-0.96	0.34	-0.51	0.18	-0.09	0.005
LOG Gate	0.09	0.21	0.43	0.67	-0.33	0.51	0.04	0.001
Step 3								
(Constant)	3.38	0.12	28.86	0.00	3.15	3.62		
C_LOG_FTStu+Fac	0.75	0.28	2.66	0.01	0.19	1.31	0.32	0.030
C_LOG_FT	0.23	0.15	1.55	0.12	-0.06	0.52	0.14	0.010
C_LOG_CIRC	-0.24	0.16	-1.49	0.14	-0.56	0.08	-0.13	0.009
C_LOG_GATE	0.20	0.20	1.00	0.32	-0.19	0.59	0.09	0.004
DC_Master's	-0.01	0.15	-0.06	0.95	-0.31	0.29	-0.01	0.000
DC_Doctoral	0.64	0.18	3.58	0.00	0.29	1.00	0.39	0.054
Step 4								
(Constant)	3.38	0.15	23.15	0.00	3.09	3.66		
C_LOG_FTStu+Fac	0.67	0.29	2.32	0.02	0.10	1.24	0.28	0.022
C_LOG_FT	0.36	0.32	1.13	0.26	-0.27	0.98	0.21	0.005
C_LOG_CIRC	-0.09	0.27	-0.33	0.74	-0.63	0.45	-0.05	0.000
C_LOG_GATE	-0.27	0.36	-0.75	0.46	-0.99	0.45	-0.12	0.002
DC_Master's	0.00	0.17	0.01	0.99	-0.34	0.34	0.00	0.000
DC_Doctoral	0.70	0.21	3.38	0.00	0.29	1.10	0.43	0.048
DC_Master's X FT	-0.13	0.37	-0.36	0.72	-0.86	0.59	-0.05	0.001
Doc X FT	-0.04	0.36	-0.11	0.91	-0.75	0.67	-0.02	0.000
DC_Master's X Gate	-0.21	0.43	-0.49	0.63	-1.07	0.64	-0.06	0.001
Doc X Gate	0.43	0.45	0.97	0.33	-0.45	1.31	0.14	0.004
DC_Master's X FT	-0.59	0.45	-1.31	0.19	-1.49	0.30	-0.17	0.007
Doc X FT	1.29	0.55	2.36	0.02	0.21	2.37	0.26	0.023

Table 42. Sequential regression results for Circulation, Full-Text Articles, Gate Count, and Carnegie Classification – Basic on External Research Dollars, controlling for Full-Time Students Plus Faculty (2012 dataset).

Step and predictor variables	R^2	Adjusted R^2	R^2 Change	*df*	*F*	Sig.
Step 1	0.24	0.24	0.24	1/195	61.91	<.01
Step 2	0.36	0.34	0.12	3/192	11.50	<.01
Step 3	0.60	0.59	0.24	2/190	57.33	<.01
Step 4	0.64	0.61	0.04	6/184	3.08	0.01

Looking at the coefficients in the equation for Step 4 (Table 43), Full-Text Articles made a significant contribution to External Research Dollars $t(184)=4.00$, $p<.01$. For each *sd* increase in Full-Text Articles, External Research Dollars increased by .46 *sd*. The squared semi-partial correlation for Full-Text Articles is the amount of variance associated with just that predictor in this model, 3.2%. Circulation also made a significant contribution, $t(184)=-2.26$, $p<.01$. However, it was a negative relationship: For each *sd* increase in Circulation, External Research Dollars decreased by .41 *sd*. The difference between Baccalaureate and Doctoral institutions was also a predictor of External Research Dollars, $t(184)=3.25$, $p<.01$. Doctoral schools experienced a .38 *sd* advantage in External Research Dollars. The interaction coefficients were not statistically significant.

Providing the standardized coefficients allows comparison of the relative contributions of the coefficients to the dependent variable, but unfortunately, standard deviations on a logarithmic scale cannot be reverse-transformed to the original scale (Bland & Altman, 1996a) in order to provide a “dollar amount” that corresponds to increases in full-text articles.

Table 43. Sequential regression coefficients for Circulation, Full-Text Articles, Gate Count, and Carnegie Classification – Basic on External Research Dollars, controlling for Full-Time Students Plus Faculty (2012 dataset).

Step and predictor variables	*B*	*SE B*	*t*	Sig.	95% CI (lower)	95% CI (upper)	*β*	sr^2
Step 1								
(Constant)	4.10	0.05			4.00	4.20		
LOG FT Stu+Fac	1.12	0.14	7.87	<.01	0.00	0.84	0.49	0.24
Step 2								
(Constant)	4.11	0.05			4.02	4.20		
LOG FT Stu+Fac	0.49	0.25	2.01	0.05	0.05	0.01	0.22	0.01
LOG FT	0.79	0.14	5.86	<.01	0.00	0.52	0.52	0.12
LOG Circ	-0.12	0.15	-0.82	0.42	0.42	-0.42	-0.07	0.00
LOG Gate	-0.17	0.21	-0.80	0.42	0.42	-0.58	-0.08	0.00
Step 3								
(Constant)	4.14	0.13			3.88	4.40		
C_LOG_FTStu+Fac	0.54	0.23	2.35	0.02	0.09	0.99	0.24	0.01
C_LOG_FT	0.57	0.11	5.17	<.01	0.35	0.78	0.37	0.06
C_LOG_CIRC	-0.28	0.12	-2.27	0.02	-0.52	-0.04	-0.16	0.01
C_LOG_GATE	-0.13	0.17	-0.79	0.43	-0.46	0.20	-0.06	0.00
DC_Master’s	-0.55	0.14	-3.83	<.01	-0.83	-0.27	-0.33	0.03
DC_Doctoral	0.36	0.16	2.25	0.03	0.04	0.68	0.23	0.01
Step 4								
(Constant)	3.84	0.17			3.51	4.18		
C_LOG_FTStu+Fac	0.42	0.23	1.84	0.07	-0.03	0.86	0.18	0.01
C_LOG_FT	0.70	0.17	4.00	<.01	0.35	1.04	0.46	0.032
C_LOG_CIRC	-0.70	0.31	-2.26	0.02	-1.31	-0.09	-0.41	0.01
C_LOG_GATE	-0.56	0.38	-1.48	0.14	-1.30	0.19	-0.26	0.00
DC_Master’s	-0.25	0.18	-1.38	0.17	-0.61	0.11	-0.15	0.00
DC_Doctoral	0.61	0.19	3.25	<.01	0.24	0.98	0.38	0.02
DC_Master’s X Circ	0.58	0.37	1.57	0.12	-0.15	1.31	0.19	0.00
Doc X Circ	0.54	0.35	1.54	0.13	-0.15	1.23	0.20	0.00
DC_Master’s X FT	-0.27	0.23	-1.17	0.24	-0.73	0.18	-0.10	0.00
Doc X FT	-0.12	0.27	-0.44	0.66	-0.66	0.42	-0.04	0.00
DC_Master’s X Gate	0.58	0.45	1.31	0.19	-0.29	1.46	0.15	0.00
Doc X Gate	0.70	0.43	1.62	0.11	-0.15	1.56	0.19	0.01

In summary, both 2010 and 2012 datasets showed a relationship between being a Doctoral institution (as compared to Baccalaureate) and External Research Dollars above and beyond institution size. However, there were no significant differences between being a Master's institution versus being a Baccalaureate. Additionally, while the 2012 data suggests that Doctoral institutions with higher Full-Text Articles and lower circulation counts have higher External Research Dollars, the 2010 data did not show this relationship. Additional research would be needed to determine whether this difference is due to sample size.

Carnegie Classification Undergraduate Instruction Program (Graduate Coexistence)

Next, a sequential regression examined the entrance of Carnegie Classification—Undergraduate Program Graduate Coexistence (Graduate Coexistence) into the model. Six cases did not have this classification, bringing the sample to 130 for 2010 and 188 for 2012.

For the 2010 data, Step 1 was significant, R^2=.34, F(1,128)=65.95, p<.01; 34% of the variance in External Research Dollars was due to the covariate alone. (Table 44). Step 2, with the library use variables, was not significant, R^2 Change= .02, F(3,125)= 0.71, p=.55. With Step 3, dummy-coded variables for Some Graduate Coexistence and High Graduate Coexistence were entered into the model, using No Graduate Coexistence as the reference group. The addition was significant, with 13% additional variance predicted, R^2 Change= .13, F(2, 123)= 16.05, p<.01. Step 4, with the interaction variables included, was not a statistically significant improvement, R^2 Change= .02, F(6,117)= 0.99, p=.43.

Table 44. Sequential regression results for Circulation, Full-Text Articles, Gate Count, and Carnegie Classification – Graduate Coexistence on External Research Dollars, controlling for Full-Time Students Plus Faculty (2010 dataset).

Step	R^2	Adjusted R^2	R^2 Change	*df*	*F*	Sig.
Step 1	0.34	0.33	0.34	1/128	65.95	<.01
Step 2	0.35	0.33	0.01	3/125	0.71	0.55
Step 3	0.49	0.46	0.13	2/123	16.05	<.01
Step 4	0.51	0.46	0.02	6/117	0.99	0.43

Looking at the coefficients for Step 3 (Table 45), there was a significant effect of High Graduate Coexistence, which had .46 *sd* advantage over No Graduate Coexistence Schools $t(123)=4.04$, $p<.01$, $sr^2=.07$. The variable labels beginning "C_" indicate that the variable was centered before entering it into the model and "DC_" indicates a dummy-coded variable.

For the 2012 dataset, Step 1 was significant, $R^2= .34$, $F(1,186)= 96.90$, $p<.01$. The covariate predicted 34% of the variance on its own. Step 2, adding the library use variables, was also significant, adding 6% additional predicted variance, R^2 Change= .06, $F(3,183)= 6.40$, $p<.01$. Step 3, adding the Graduate Coexistence dummy variables, added 15% additional prediction, R^2 Change= .15, $F(2, 181)= 30.60$, $p<.01$. Step 4 was not significant, R^2 Change= .05, $F(6,175)= .70$, $p=.65$.

Table 45. Sequential regression coefficients for Circulation, Full-Text Articles, Gate Count, and Carnegie Classification – Graduate Coexistence on External Research Dollars, controlling for Full-Time Students Plus Faculty (2010 dataset).

Step and predictor variables	*B*	*SE B*	*t*	Sig.	95% CI (lower)	95% CI (upper)	*β*	sr^2
Step 1								
(Constant)	3.56	0.05	68.52	<.01	3.45	3.66		
LOG FT Stu+Fac	1.37	0.17	8.12	<.01	1.04	1.70	0.58	0.340
Step 2								
(Constant)	3.56	0.05	67.55	<.01	3.45	3.66		
LOG FT Stu+Fac	1.24	0.25	5.03	<.01	0.75	1.73	0.53	0.131
LOG FT	0.20	0.16	1.22	0.22	-0.12	0.53	0.12	0.008
LOG Circ	-0.18	0.18	-0.99	0.32	-0.53	0.18	-0.09	0.005
LOG Gate	0.07	0.21	0.32	0.75	-0.35	0.49	0.03	0.001
Step 3								
(Constant)	3.31	0.16	20.97	<.01	3.00	3.62		
C_LOG_FTStu+Fac	1.00	0.26	3.90	<.01	0.49	1.51	0.43	0.063
C_LOG_FT	0.07	0.15	0.48	0.63	-0.22	0.37	0.04	0.001
C_LOG_CIRC	-0.17	0.16	-1.06	0.29	-0.50	0.15	-0.09	0.005
C_LOG_GATE	0.08	0.19	0.40	0.69	-0.30	0.45	0.03	0.001
DC_Some Grad Coex	0.14	0.17	0.84	0.40	-0.20	0.49	0.09	0.003
DC_High Grad Coex	0.84	0.21	4.04	0.00	0.43	1.26	0.46	0.068
Step 4								
(Constant)	3.37	0.24	13.77	<.01	2.88	3.85		0.046
C_LOG_FTStu+Fac	0.89	0.27	3.31	<.01	0.36	1.41	0.38	0.002
C_LOG_FT	0.42	0.56	0.75	0.45	-0.68	1.52	0.25	0.005
C_LOG_CIRC	-0.64	0.60	-1.06	0.29	-1.83	0.56	-0.32	0.002
C_LOG_GATE	-0.56	0.80	-0.70	0.49	-2.15	1.03	-0.25	0.001
DC_Some Grad Coex	0.10	0.25	0.38	0.70	-0.41	0.60	0.06	0.035
DC_High Grad Coex	0.85	0.29	2.89	<.01	0.27	1.44	0.47	0.001
DC_Some Coex X FT	-0.29	0.58	-0.50	0.62	-1.43	0.85	-0.14	0.007
DC_High Coex X FT	-0.86	0.69	-1.26	0.21	-2.22	0.49	-0.23	0.003
DC_Some Coex X Circ	0.53	0.63	0.83	0.41	-0.73	1.78	0.23	0.002
DC_High Coex X Circ	0.48	0.74	0.65	0.52	-0.98	1.94	0.11	0.002
DC_Some Coex X Gate	0.54	0.83	0.65	0.52	-1.10	2.18	0.20	0.010
DC_High Coex X Gate	1.39	0.91	1.53	0.13	-0.41	3.19	0.32	0.000

Table 46. Sequential regression results for Circulation, Full-Text Articles, Gate Count, and Carnegie Classification – Graduate Coexistence on External Research Dollars, controlling for Full-Time Students Plus Faculty (2012 dataset).

Step	R^2	Adjusted R^2	R^2 Change	*df*	*F*	Sig.
Step 1	0.34	0.34	0.34	1/186	96.90	<.01
Step 2	0.40	0.39	0.06	3/183	6.40	<.01
Step 3	0.56	0.54	0.15	2/181	30.60	<.01
Step 4	0.57	0.54	0.01	6/175	0.70	0.65

Looking at the coefficients for Step 3 (Table 47), Full-Text Articles had a significant contribution to External Research Dollars, $t(181)= 3.18$, $p<.01$, $sr^2=.03$. For every *sd* increase in Full-Text Articles, External Research Dollars increased by .25 *sd*. The dummy variable High Graduate Coexistence was also significant, $t(181)= 3.19$, $p<.01$, $sr^2<.03$. High Graduate Coexistence Schools had .48 *sd* advantage in External Research Dollars over No Graduate Coexistence Schools. The variable labels beginning “C_” indicate that the variable was centered before entering it into the model, and “DC” indicates a dummy coded variable.

In summary, Graduate Coexistence affected External Research Dollars for both 2010 and 2012 datasets, but only between High Graduate Coexistence and No Graduate Coexistence schools. There was no significant difference between Some Graduate Coexistence schools and No Graduate Coexistence Schools. Although an effect of Full-Text Articles on External Research Dollars was observed in the 2012 dataset, it was not observed in 2010.

Table 47. Sequential regression coefficients for Circulation, Full-Text Articles, Gate Count, and Carnegie Classification – Graduate Coexistence on External Research Dollars, controlling for Full-Time Students Plus Faculty (2012 dataset).

Step and predictor variables	*B*	*SE B*	*t*	Sig.	95% CI (lower)	95% CI (upper)	*β*	sr^2
Step 1								
(Constant)	4.04	0.05	86.53	<.01	3.95	4.14		
C_LOG_FTStu+Fac	1.43	0.15	9.84	0.00	1.14	1.72	0.59	0.343
Step 2								
(Constant)	4.06	0.05	89.59	<.01	3.97	4.15		
C_LOG_FTStu+Fac	0.79	0.24	3.26	<.01	0.31	1.26	0.32	0.034
C_LOG_FT	0.62	0.14	4.29	<.01	0.34	0.91	0.39	0.060
C_LOG_CIRC	-0.04	0.15	-0.29	0.77	-0.33	0.25	-0.02	0.000
C_LOG_GATE	-0.04	0.21	-0.17	0.87	-0.45	0.38	-0.02	0.000
Step 3								
(Constant)	3.75	0.22	17.35	<.01	3.32	4.17		
C_LOG_FTStu+Fac	0.51	0.23	2.20	0.03	0.05	0.97	0.21	0.012
C_LOG_FT	0.41	0.13	3.18	<.01	0.15	0.66	0.25	0.025
C_LOG_CIRC	-0.08	0.13	-0.59	0.56	-0.33	0.18	-0.04	0.001
C_LOG_GATE	-0.10	0.18	-0.55	0.58	-0.46	0.26	-0.04	0.001
DC_Some Grad Coex	0.02	0.22	0.09	0.93	-0.41	0.45	0.01	0.000
DC_High Grad Coex	0.76	0.24	3.19	<.01	0.29	1.24	0.48	0.025
Step 4								
(Constant)	3.66	0.46	7.99	<.01	2.75	4.56		
C_LOG_FTStu+Fac	0.46	0.24	1.90	0.06	-0.02	0.94	0.19	0.009
C_LOG_FT	0.48	0.71	0.67	0.50	-0.93	1.88	0.30	0.001
C_LOG_CIRC	-0.73	0.72	-1.02	0.31	-2.15	0.69	-0.41	0.003
C_LOG_GATE	0.03	1.26	0.02	0.98	-2.45	2.51	0.01	0.000
DC_Some Grad Coex	0.10	0.46	0.21	0.83	-0.81	1.01	0.06	0.000
DC_High Grad Coex	0.76	0.47	1.61	0.11	-0.17	1.69	0.48	0.006
DC_Some Coex X FT	0.66	0.74	0.90	0.37	-0.79	2.12	0.26	0.002
DC_High Coex X FT	0.67	0.75	0.90	0.37	-0.81	2.14	0.24	0.002
DC_Some Coex X Circ	-0.18	1.28	-0.14	0.89	-2.70	2.35	-0.05	0.000
DC_High Coex X Circ	-0.09	1.29	-0.07	0.95	-2.63	2.46	-0.02	0.000
DC_Some Coex X Gate	-0.11	0.73	-0.16	0.88	-1.56	1.33	-0.05	0.000
DC_High Coex X Gate	0.22	0.77	0.29	0.78	-1.30	1.74	0.07	0.000

Carnegie Classification Graduate Instruction Program

Next, a sequential regression examined the entrance of Carnegie Classification – Graduate Instruction Program into the model (Table 48). Some cases did not have this classification, bringing the sample to 117 for 2010 and 196 for 2012. At Step 1, with just the covariate entered, R^2 =.28, $F(1,115)$= 44.15, p<.01. With Step 2, the library use variables did not add significantly to the model, R^2 Change=.01, $F(3,112)$=0.49, p<.01. With Step 3, dummy-coded variables for the four Graduate Instruction Programs were entered into the model, using Master's Programs as the reference group. The addition was significant, predicting 13% additional variance in the model, R^2 Change= .13, $F(3, 109)$= 19.56, p<.01. Step 4, with the interaction variables included, was not a statistically significant improvement, R^2 Change= .03, $F(9,100)$= 0.64, p=.77.

Table 48. Sequential regression results for Circulation, Full-Text Articles, Gate Count, and Carnegie Classification – Graduate Instruction Program on External Research Dollars, controlling for Full-Time Students Plus Faculty (2010 dataset).

Step	R^2	Adjusted R^2	R^2 Change	*df*	*F*	Sig.
Step 1	0.28	0.27	0.28	1/115	44.15	<.01
Step 2	0.29	0.26	0.01	3/112	0.49	0.69
Step 3	0.54	0.51	0.25	3/109	19.56	<.01
Step 4	0.56	0.50	0.03	9/100	0.64	0.77

Table 49. Sequential regression coefficients for Circulation, Full-Text Articles, Gate Count, and Carnegie Classification – Graduate Instruction Program on External Research Dollars, controlling for Full-Time Students Plus Faculty (2010 dataset).

Step and predictor variables	*B*	*SE B*	*t*	Sig.	95% CI (lower)	95% CI (upper)	*β*	sr^2
Step 1								
(Constant)	3.59	0.06	62.32	<.01	3.47	3.70		
C_LOG FT Stu Fac	1.28	0.19	6.64	<.01	0.90	1.66	0.53	0.277
Step 2								
(Constant)	3.58	0.06	61.79	<.01	3.47	3.70		
C_LOG FT Stu Fac	1.15	0.29	3.99	<.01	0.58	1.72	0.47	0.101
C_LOG FT	0.17	0.17	1.00	0.32	-0.17	0.52	0.11	0.006
C_LOG Circ	-0.15	0.19	-0.76	0.45	-0.53	0.23	-0.08	0.004
C_LOG Gate	0.10	0.22	0.45	0.65	-0.34	0.54	0.05	0.001
Step 3								
(Constant)	3.24	0.07	45.54	<.01	3.10	3.38		
C_LOG_FTStuFac	0.79	0.24	3.25	<.01	0.31	1.27	0.32	0.045
C_LOG_FT	-0.01	0.15	-0.08	0.93	-0.30	0.28	-0.01	0.000
C_LOG_CIRC	-0.12	0.16	-0.72	0.47	-0.44	0.21	-0.06	0.002
C_LOG_GATE	0.29	0.19	1.52	0.13	-0.09	0.66	0.13	0.010
DC_GIP_Other	0.50	0.11	4.48	<.01	0.28	0.72	0.34	0.085
DC_GIP_STEM	1.14	0.18	6.19	<.01	0.77	1.50	0.43	0.163
DC_GIP_Comp	0.84	0.15	5.48	<.01	0.54	1.15	0.41	0.128
Step 4								
(Constant)	3.26	0.07	43.71	0.00	3.11	3.41		
C_LOG_FTStuFac	0.70	0.26	2.75	0.01	0.20	1.21	0.29	0.033
C_LOG_FT	0.13	0.20	0.64	0.52	-0.26	0.52	0.08	0.002
C_LOG_CIRC	-0.02	0.24	-0.08	0.94	-0.51	0.47	-0.01	0.000
C_LOG_GATE	0.07	0.29	0.25	0.80	-0.49	0.64	0.03	0.000
DC_GIP_Other	0.50	0.12	4.32	0.00	0.27	0.74	0.34	0.082
DC_GIP_STEM	1.26	0.26	4.86	0.00	0.75	1.78	0.48	0.103
DC_GIP_Comp	0.93	0.28	3.31	0.00	0.37	1.48	0.46	0.048
DC_GIP_Other X FT	-0.22	0.29	-0.78	0.44	-0.79	0.35	-0.08	0.003
DC_GIP_Comp X. FT	-1.01	0.62	-1.62	0.11	-2.25	0.22	-0.16	0.012
DC_GIP_Other X Circ	0.08	0.75	0.10	0.92	-1.41	1.56	0.02	0.000
DC_GIP_STEM X Circ	0.02	0.39	0.04	0.97	-0.76	0.79	0.01	0.000
DC_GIP_Comp X Circ	-0.05	0.55	-0.09	0.93	-1.15	1.05	-0.01	0.000
DC_GIP_Other X Gate	-0.70	0.59	-1.19	0.24	-1.87	0.47	-0.16	0.006
DC_GIP_STEM X Gate	0.21	0.41	.512	0.30	-0.61	1.03	0.06	0.001
DC_GIP_Comp X Gate	0.92	0.90	1.024	0.23	-0.86	2.70	0.10	0.005

Looking at the coefficients for Step 3 (Table 49), the differences between all three Graduate Instruction Programs and the reference group, Master's schools, were significant. Doctoral Schools – Other had .34 *sd* more External Research Dollars than Master's schools $t(109)= 4.48$, $p<.01$, $sr^2=.09$; Doctoral Schools – Comprehensive, .41 *sd* more than Master's schools, $t(109)= 5.48$, $p<.01$, $sr^2=.16$, and Doctoral Schools – STEM, .43 *sd*, $t(109)= 6.19$, $p<.01$, $sr^2=.13$.

For 2012, the Step 1 model was significant, $R^2 =.28$, $F(1,180)= 77.14$, $p<.01$ (Table 50). The library use variables increased the prediction of External Research Dollars by 7%, R^2 Change=.07, $F(3,177)= 6.70$, $p<.01$. With the addition of Graduate Instruction Program variables, prediction increased 28%, R^2 Change =.28, $F(3,174)= 45.78$, $p<.01$. The addition of the interaction variables in Step 4 was also significant, increasing prediction by 4%, R^2 Change =.04, $F(9,165)= 2.25$, $p<.05$.

Table 50. Sequential regression results for Circulation, Full-Text Articles, Gate Count, and Carnegie Classification – Graduate Instruction Program on External Research Dollars, controlling for Full-Time Students Plus Faculty (2012 dataset).

Step	R^2	Adjusted R^2	R^2 Change	*df*	*F*	Sig.
Step 1	0.30	0.30	0.30	1/180	77.14	<.01
Step 2	0.37	0.36	0.07	3/177	6.70	<.01
Step 3	0.65	0.63	0.28	3/174	45.78	<.01
Step 4	0.69	0.66	0.04	9/165	2.25	0.02

Looking at the coefficients for Step 4 (Table 51), Full-Text Articles was the only library use variable contributing significantly to the prediction of External Research

Dollars, $t(165)=2.15$, $p<.05$, $sr^2=.01$. For every *sd* increase in Full-Text Articles, External Research Dollars increased by .20 *sd.* The dummy-coded variables for Graduate Instruction Program were also significant: STEM schools had a .53 *sd* advantage over Master's Schools $t(165)=8.43$, $p<.01$, $sr^2=.14$. Other Doctoral had a .22 *sd* advantage over Master's Schools $t(165)= 3.75$, $p<.01$, $sr^2=.03$, and Doctoral-Comprehensive had a .56 *sd* advantage over Master's schools $t(165)= 7.22$, $p<.01$, $sr^2=.10$. There were two significant interactions. The standardized coefficient of the interaction between Doctoral Comprehensive (compared to Master's) and Full-Text Articles was .22 *sd*, $t(165)=2.36$, $p<.05$, $sr^2=.01$, and the standardized coefficient of the interaction of Other Doctoral and Gate Count was -.22 *sd*, $t(165)=-2.15$, $p<.05$, $sr^2=.01$. Because these effects were smaller than the main effects of the Carnegie variables, and the squared semi-partial coefficients were so small, these interactions were not interpreted.

In summary, Graduate Instruction Program had a significant effect on External Research Dollars above and beyond institution size and library use, although the differences between Graduate Instruction Programs and Master's schools varied between 2010 and 2012. While in 2010, Other Doctoral, Comprehensive Doctoral, and STEM Doctoral schools were .34 *sd*, .41 *sd*, and .43 *sd* higher than Master's schools, in 2010, their differences were .22 *sd*, .56 *sd*, and .53 *sd,* respectively. Full-Text Articles had a significant effect above and beyond institution size and Graduate Instruction Program only in 2012.

Table 51. Sequential regression coefficients for Circulation, Full-Text Articles, Gate Count, and Carnegie Classification – Graduate Instruction Program on External Research Dollars, controlling for Full-Time Students Plus Faculty (2012 dataset).

Step and predictor variables	*B*	*SE B*	*t*	Sig.	95% CI (lower)	95% CI (upper)	*β*	sr^2
Step 1								
(Constant)	4.05	0.05	82.88	<.01	3.95	4.15		
C_LOG FT Stu+Fac	1.41	0.16	8.78	<.01	1.09	1.72	0.55	0.300
Step 2								
(Constant)	4.07	0.05	86.68	<.01	3.97	4.16		
C_LOG FT Stu+Fac	0.68	0.28	2.46	0.01	0.13	1.23	0.27	0.021
C_LOG FT	0.65	0.15	4.40	<.01	0.36	0.94	0.40	0.069
C_LOG Circ	-0.02	0.15	-0.13	0.90	-0.32	0.28	-0.01	0.000
C_LOG Gate	-0.02	0.21	-0.10	0.92	-0.44	0.40	-0.01	0.000
Step 3								
(Constant)	3.53	0.07	50.00	0.00	3.39	3.67		
C_LOG_FTStu+Fac	0.39	0.21	1.84	0.07	-0.03	0.82	0.15	0.007
C_LOG_FT	0.36	0.11	3.14	<.01	0.13	0.58	0.22	0.020
C_LOG_CIRC	-0.06	0.12	-0.46	0.65	-0.29	0.18	-0.03	0.000
C_LOG_GATE	-0.03	0.16	-0.18	0.86	-0.35	0.29	-0.01	0.000
DC_GIP_Other	0.35	0.09	3.78	<.01	0.17	0.54	0.21	0.029
DC_GIP_STEM	1.20	.13	9.50	<.01	.95	1.45	.51	0.182
DC_GIP_Comp	1.04	.11	9.66	<.01	.83	1.26	.62	0.188
Step 4								
(Constant)	3.52	0.07	48.87	<.01	3.38	3.66		
C_LOG_FTStu+Fac	0.37	0.22	1.74	0.08	-0.05	0.80	0.15	0.006
C_LOG_FT	0.32	0.15	2.15	0.03	0.03	0.62	0.20	0.009
C_LOG_CIRC	-0.23	0.25	-0.93	0.35	-0.72	0.26	-0.13	0.002
C_LOG_GATE	0.28	0.30	0.92	0.36	-0.32	0.88	0.12	0.002
DC_GIP_Other	.36	.10	3.75	<.01	.17	.54	.22	0.027
DC_GIP_STEM	1.27	.15	8.43	<.01	.97	1.56	.53	0.135
DC_GIP_Comp	.95	.13	7.22	<.01	.69	1.21	.56	0.099
DC_GIP_Other X FT	-.14	.23	-.58	.56	-.60	.33	-.05	0.001
DC_GIP_STEM X FT	-.32	.39	-.82	.41	-1.10	.45	-.06	0.001
DC_GIP_Comp X. FT	.75	.32	2.36	.02	.12	1.37	.22	0.011
DC_GIP_Other X Circ	.54	.32	1.67	.10	-.10	1.17	.18	0.005
DC_GIP_STEM X Circ	.53	.36	1.45	.15	-.19	1.24	.11	0.004
DC_GIP_Comp X Circ	-.25	.35	-.72	.47	-.95	.44	-.08	0.001
DC_GIP_Other X Gate	-.85	.40	-2.15	.03	-1.64	-.07	-.22	0.009
DC_GIP_STEM X Gate	-.14	.61	-.24	.81	-1.35	1.06	-.02	0.000
DC_GIP_Comp X Gate	-.24	.40	-.59	.56	-1.03	.56	-.06	0.001

In conclusion, all the models showed an influence of institution size (Full-time Students Plus Faculty) on External Research Dollars. The series of regressions provided mixed evidence regarding the research hypotheses. Some significant effects of Circulation, Full-Text Articles, and Gate Count were observed, supporting rejection of Regression Hypothesis 1, “There will be no significant effect of Circulation, Full-Text Articles, and Gate Count on External Research Dollars, after controlling for Full-Time Students plus Faculty.” While all the 2012 models showed an effect of Full-Text Articles on External Research Dollars, none of the 2012 models did. This difference could be due to sample size, however, more research would be needed to form a well-supported conclusion. None of the models showed an effect of Gate Count on External Research Dollars. And, only one model showed a significant effect of Circulation on External Research Dollars (Carnegie Basic, using the 2012 dataset).

Furthermore, Regression Hypothesis 2, “There will be no significant effect of Carnegie Classification – Basic, Carnegie Classification – Undergraduate Instruction Program, Graduate Coexistence, and Carnegie Classification – Graduate Instruction Program on predicting External Research Dollars,” was rejected: there were significant effects on the prediction of External Research Dollars when these classification variables were included in the models. However, sometimes only certain groups suggested significant differences, although the patterns were the same across both years. For Carnegie Basic, Doctoral institutions showed advantages over Baccalaureate in terms of External Research Dollars, but Master’s institutions were not significantly different from Baccalaureate. For Graduate Coexistence, High Graduate Coexistence had advantages over No Graduate Coexistence, but Some Graduate Coexistence schools did not differ from No Graduate Coexistence. With respect to Graduate Instruction Program, all of the Carnegie groups with Doctoral programs were significantly different than schools with Master's programs.

Finally, Regression Hypothesis 3, "There will be no significant interaction effect between Circulation, Full-Text Articles, and Gate Count and the Carnegie Classifications on External Research Dollars," also had mixed results, because no interactions were detected for Carnegie Basic and Carnegie Graduate Coexistence, but there were two significant, if small, interaction coefficients for Graduate Instruction Program.

Chapter 5: Discussion

This section will first highlight the most pertinent results from each of the analyses: SEM, MANCOVA, and regression, as well as consider any methodological findings researchers should consider when conducting further statistical analysis with these datasets. What can the current data tell us about how our expenditures and staffing relate to services, and in turn, our services to library use? Are there systematic differences in libraries between types of institutions? How does library use relate to External Research Dollars?

Next, the discussion will return to the theoretical framework constructed at the beginning of this paper to discuss the extent to which the results inform initial questions raised:

- Can these findings help illustrate the connections between library services, library use, and high-impact practices?
- Can these findings help illustrate the connections between library services, library use, and the university's research mission?
- Can these findings help articulate libraries' strategic advantages?

Finally, the paper will suggest an approach to filling the gap between what the current data can show us about libraries' business strategy and the picture libraries would like to be able to present to illustrate how libraries are relevant to both high-impact educational practices and the institution's research mission.

Structural Equation Modeling Discussion

This study tested several measurement models using a type of SEM called confirmatory factor analysis. The main goal of combining indicators into latent variables is to think in terms of "entire systems of conceptual relationships" that can begin to represent complex environments (MacKenzie, 2001, p. 159). Latent variables also test whether indicators group together to make meaningful factors.

None of the measurement models – even the one-factor models – met the chosen criteria for fit, despite the fact that the indicator variables are correlated. One reason may be that the variables in these models were not designed to measure latent constructs, but to gather statistical information of common interest to libraries. The researcher thought there was logical reason for these variables to form constructs, since her library experience suggested strong associations between groups of variables, but statistically, they did not hold together well. The many large positive residuals observed in the measurement models suggest the indicators are influenced by something else outside the model. This "something else" could possibly be a covariate, such as Carnegie Classification, or another factor of interest, but could also be unsystematic variance.

After examining the results from the MANCOVA and regressions, the researcher proposed several additional path models to test with SEM, first focusing just on Doctoral institutions. Libraries with more Participants in Group Presentations were predicted to have greater Full-Text Articles and Interlibrary Loans because of greater awareness by students and faculty of library resources and services. Ongoing Expenditures was included as a predictor of both Full-Text Articles and Interlibrary Loans because if a library spends sufficient dollars on its subscriptions, then patrons should be finding what they need at their local library and not require so many Interlibrary Loans. Full-time Students plus Faculty continued to be used as a covariate.

The championed model failed the S-B x^2 test, but met the other criteria. Sixty-two percent of the variance in Full-Text Articles and 50% of the variance in Interlibrary Loans was explained by the model. While clearly there were other factors at play, these were still large amounts of variance explained. Interestingly, while it was hypothesized Ongoing Expenditures and Interlibrary Loans would have a negative relationship, the path had a positive coefficient. In fact, for every *sd* increase in Ongoing Expenditures, Interlibrary Loans increased by .51 *sd*. This relationship could suggest that these two variables are signs of an underlying construct like "research intensity," rather than one "causing" the other. Ongoing Expenditures was the major driver in the entire model, explaining more than twice the amount of variance in both Full-Text Articles and Interlibrary Loans than Participants in Group Presentations did, which did not even have significant coefficients for the parameters.

Because the MANCOVA tests showed differences between Doctoral institutions and both Baccalaureate and Master's institutions but no significant differences between Baccalaureate and Master's institutions, the researcher decided to test the championed alternative path model using a sample combining Baccalaureate and Master's institutions (2012). It is important to remember this sample did not include smaller Baccalaureate schools.

The championed model with the Baccalaureate and Master's dataset again failed to meet the S-B x^2 test, but met the criteria set for the other fit indexes. About the same amount of variance was explained in Full-Text Articles and Interlibrary Loans, but more variance was explained for Ongoing Expenditures (57% compared with 47%). While Ongoing Expenditures was still a primary driver in this model, it explained much less variance in Full-Text Articles for Doctoral schools, with a standardized coefficient of .27 for Baccalaureate Plus Master's compared with the standardized coefficient of .55 for the Doctoral schools. For Baccalaureate + Master's, therefore, something else is influencing Full-Text Articles in place of some of the influence from Ongoing Expenditures that Doctoral schools experience.

Participants in Group Presentations was still not a significant predictor of Full-Text Articles for Baccalaureate plus Master's, but it was a significant predictor of Interlibrary Loans: for every *sd* increase in Participants, Interlibrary Loans increased by .26 *sd.* This is supported by Leykan (2008) who found that use of Interlibrary Loan by academic departments varied in conjunction with liaison activity. Soria, Fransen, & Nackerud (2013) also found statistically significant correlations between Interlibrary Loans and database, electronic journal, electronic book usage, reference, and library instruction classes.

Comparing the Doctoral and Baccalaureate plus Master's datasets was hampered by the difference in sample sizes (N=189 and N=367, respectively). It is unclear, for example, if the fact that the parameter estimate between Participants in Group Presentations and Interlibrary Loans was significant for the Baccalaureate plus Master's institutions but not Doctoral was because of a meaningful difference or because the power of the Baccalaureate plus Master's sample size was great enough to detect the effect. The fact that Full-Time Students and Faculty was a stronger covariate for Baccalaureate plus Master's could be because there was more variance among these schools than in the more homogenous Doctoral group. It is interesting, however, that across both models, Ongoing Expenditures had a positive relationship with Interlibrary

Loans, meaning whatever is driving these two variables may be shared regardless of institution type.

The size of the difference in coefficients between Ongoing Expenditures and Full-Text Articles also suggested that while Ongoing Expenditures has a large role to play in Full-Text Article use at Doctoral Schools, it plays less of a role at Baccalaureate plus Master's schools. And since Participants in Group Presentations was not a significant predictor, something was likely missing from the Baccalaureate plus Master's model. For the Baccalaureate and Master's schools, there was a large standardized residual (6.40) between Ongoing Expenditures and Participants in Group Presentations, indicating that for Baccalaureate and Master's schools, these two have a relationship beyond the number of students and faculty that is unexpressed by the model.

The differences in the results from running the same model with two populations (Doctoral and Baccalaureate plus Master's) suggests that continuing to separate these groups, or including Carnegie Classification in the path model in some way, is important. The MANCOVA analyses also suggested that the differences among institution types were significant.

Exploring more path models may be helpful for illuminating the data beyond multiple regression. For example, some simple regressions in this study were performed to test the importance of the covariate Full-Time Students Plus Faculty and Carnegie Classification, Basic. These showed that the twelve library variables did influence Circulation, Full-Text Articles, and Gate Count. When the twelve library variables were added to regression models, predictive power on Circulation increased by 18%; for Full-

Text Articles, 7%, and for Gate Count, 5%. Path models provide an additional tool for continuing to learn about these relationships.

While the ACRL and ALS data may not work well in SEM measurement models, SEM may be used to incorporate measurement instruments such as LibQUAL+ satisfaction survey into hybrid models rather than study the ALS and ACRL survey results alone. For example, a hybrid model could include latent variables for "library satisfaction" based in LibQUAL+ in conjunction with observed variables from surveys like ACRL and ALS, building off the bivariate correlation study by Hunter and Perret (2011). At the present time, such studies would need to be conducted by ARL because they are the only ones with access to the institutional level data and because SEM requires a large sample size.

In summary, the SEM models did not explain how expenditures and staffing relate to library services or how services relate to library use. The second set of path models confirmed earlier research (Fagan, 2014a) suggesting that Ongoing Expenditures has a strong relationship with Full-Text Articles beyond the number of students and faculty at an institution, but without providing a logical rationale. The second set of path models also supported the idea that there are systematic differences in libraries between Doctoral and Baccalaureate Plus Master's institutions.

Carnegie Classification Group Differences (MANCOVAs)

A series of MANCOVAs tested for group differences across institutions by Carnegie Classification, controlling for Full-Time Students Plus Faculty. Reverse-log-transforming the adjusted means produced by MANCOVA produced geometric means by which groups could be compared while maintaining the adjustment for the covariate. The magnitude of these means therefore does not match the arithmetic means that would result from the original data, both because the geometric mean is a different measure of central tendency, and because these geometric means control for the effects of the covariate.

Carnegie Classification—Basic

The Carnegie Basic classification influenced group mean differences with respect to Full-Text Articles. Doctoral schools in this study had 37% higher mean for Full-Text Articles than Master's institutions, or about 100,000 articles, and 67% times greater than Baccalaureate (about 150,000 articles). These differences could be explained by the increase in research intensity as students progress from undergraduate to graduate education, as well as the increased research activities of faculty. Doctoral schools also had a 37% higher mean for Circulation than Master's institutions, or about 9,800 circulations. Although the differences between Baccalaureate and Master's schools' Circulation were not significant, it is interesting to note that the Baccalaureate schools' mean Circulation was higher than Master's—that is, the pattern of means did not match Full-Text Articles. This suggests circulation of physical items may be an indicator of something different than Full-Text Articles.

Regarding Gate Count, Baccalaureate institutions had higher means than Master's or Doctoral schools, although only the difference between Baccalaureate and Master's was statistically significant. Baccalaureate schools had 35% higher gate count than Master's, or 2,734 more visits per year. This points to a meaningful difference in the use of library buildings at Baccalaureate institutions compared to the other schools.

For the other twelve library variables, Doctoral schools had the highest means for Interlibrary Loan, Librarian / Professional FTE, Staff FTE, Ongoing Expenditures, and One-Time Expenditures, but Baccalaureate and Master's programs did not differ significantly from one another—remembering that the Baccalaureate schools in the sample did not include a proportional number of small schools. It makes some sense that Doctoral schools would have the highest means; many have noted how graduate research is generally more specialized than undergraduate research, requiring deeper disciplinary collections and heavy use of interlibrary loan (Du & Evans, 2011; Egan, 2005; Frank & Bothmann, 2007; Herrera, 2003; Vezzosi, 2009). Vendors of library subscription resources often price journal packages by institution type as well as FTE, which could explain the higher cost of Ongoing Expenditures. However, looking at the variable Library Budget as a Percent of Institutional Expenditures for the three groups does not show a corresponding advantage for Doctoral schools. While Doctoral schools' Ongoing Expenditures were more than double that of the next highest group (Baccalaureate institutions), and the staff they are paying is about 50% larger, Doctoral institutions' budgets average just 1.9% of total institutional expenditures in this sample, while Baccalaureate institutions' budgets average 2%. Thus, Doctoral libraries are having to shoulder greater expenditures without a proportional show of support from the institution. It could be that these institutions have additional or larger categories of non-library expenditures, or it could be they fund their libraries less heavily.

All together, these results suggest that studies using national library datasets should consider that Doctoral institutions may be substantially different than Baccalaureate and Master's institutions. This may mean controlling for the effect of doctoral schools, or studying the populations separately. It also suggests that if larger Baccalaureate and Master's institutions are of interest, there might not be a need to control for differences between these populations. However, it is important to remember that this study's sample excluded many small schools due to missing data, so the "Baccalaureate institutions" discussed here are not the full array of U.S. Baccalaureate schools.

These results also begin to reveal how much more there is to learn. While the researcher offered some conjectures to explain group mean differences, many factors are not known. For example, Doctoral schools have 7.2 more Librarian / Professional Staff, and 5.3 more Support Staff than Baccalaureate schools, even after controlling for the number of students and faculty. What are these people doing? Are they doing more of the same services as their counterparts at Baccalaureate schools? Or are they performing additional services required only at Doctoral institutions?

Carnegie Classification—Residential

The results for MANCOVAs examining the Residential aspect of the Carnegie Classification Size & Setting showed a medium effect of these groups on the linear combination of Circulation, Full-Text Article Requests, and Gate Count after controlling for either covariate ($\square^2$=.06 for the original covariate), and a large effect size on the linear combination of the other twelve variables ($\square^2$=.16 for the original covariate). Highly Residential Schools (the group with the most full-time students living on campus) had a large advantage over Primarily Residential schools, which usually ranked higher than Non-Residential Schools. In terms of geometric mean differences, Highly Residential schools had 15,821 more Circulations than Primarily Residential Schools;

33,680 more Full-Text Article requests; and 3,529 additional visitors, all controlling for Full-Time Students and Faculty. Overall, the positive relationship between the residential nature of schools and library services and library use variables supports the idea that libraries contribute to the increased engagement resulting from a greater presence on campus. The fact that Residential status did not have a significant effect on Full-Text Articles (which are online resources) helps to confirm that this relationship is not spurious but relates to the library's collocation with students.

One intriguing result was that Non-Residential schools had the highest Reference means for a geometric mean advantage of 2,305 Reference Transactions, while for Participants in Group Presentations (and most other variables), Highly Residential schools had the highest means, for an advantage of 1,027 over Primarily Residential schools. Because significant results only showed for the covariate including part-time students, this finding would need follow-up research, but it suggests that Reference may have an important role for libraries where there are many students living off-campus.

In summary, the differences across libraries based on Residential Status indicates a moderate relationship between students' on-campus presence, face-to-face library services, and use of physical materials and buildings. Furthermore, Residential Status does not seem to affect use of Full-Text Articles, indicating that these library services may be as effective remotely as they are on campus.

Carnegie Classification—Undergraduate Instruction Program, Program Balance

Schools classified as Arts-and-Sciences-Focused had a higher group mean than the other groups in the category Program Balance for all the variables, with Professional-

Focused institutions usually having the lowest group means. Large effect sizes included Circulation ($\square^2$=.15), Interlibrary Loan ($\square^2$=.21), Librarian / Professional FTE ($\square^2$=.16), Staff FTE ($\square^2$=.13), Ongoing Expenditures ($\square^2$=.22), and One-Time Expenditures ($\square^2$=.12).

As with some of the other Carnegie Classifications, follow-up study would be needed to try to determine why Arts-and-Science-Focused institutions have higher library use numbers. For example, the advantage of Arts-and-Science-Focused schools over the next group, Arts-and-Sciences-Plus-Professional, was 24,025 Circulations. These schools also had higher means on many library services and staff variables. Is it truly this Carnegie Classification causing these differences, or are there other factors at play? In addition to other relationships in the data, there could be characteristics that would directly relate to libraries, such as the degree to which assignments involving research or other library use are given at different types of institutions. Do Arts-and-Science-Focused institutions currently have greater implementation of high-impact educational practices? And if so, how are these affected by library use and services?

Carnegie Classification—Undergraduate Instruction Program, Graduate Coexistence

The Carnegie Classification Undergraduate Instruction Program, Graduate Coexistence had small effect sizes on Circulation, Full-Text Articles, and Gate Count (all $\square^2$=.05). Although schools with High Graduate Coexistence had the highest means for Circulation and Full-Text Articles, schools with No Graduate Coexistence had the highest means for Gate Count. Schools with High Graduate Coexistence had advantages of 9,516 Circulations and 105,840 Full-Text Articles, respectively, over Some Graduate

Coexistence schools, while No Graduate Coexistence schools had 3,377 more visitors than High Graduate Coexistence schools. This aligns with the finding that Carnegie Basic Baccalaureate institutions had a higher Gate Count than Master's or Doctoral schools. While it seems likely that Graduate Coexistence shares some covariance with Carnegie Basic, is there something about the "coexistence" aspect that is distinct?

Graduate Coexistence had a large effect on Interlibrary Loan (η^2=.16), Librarian / Professional FTE (η^2=.14), and Ongoing Resources (η^2=.08). Interlibrary Loans at High Graduate Coexistence schools were 2,560 higher, and One-Time Resources were $98,760 higher than at Some Graduate Coexistence schools. It was puzzling why "Some Graduate Coexistence" was the lowest ranked for all variables with significant mean differences, although its mean was just statistically lowest for Interlibrary Loan and Ongoing Resources. For most variables, High Graduate Coexistence (*N*=98) and No Graduate Coexistence (*N*=66) showed no statistical differences. Some Graduate Coexistence (*N*=251) did have a substantially larger group size, but the variances on the dependent variables were still close to that of the other groups.

Graduate Coexistence groups' mean differences were very similar to the Carnegie Classification—Basic, although the results were harder to interpret and apply. For this reason, it seems that unless the concept of Graduate Coexistence is of specific theoretical interest, this category may not be useful for library data models.

Carnegie Classification—Graduate Instruction Program

The Carnegie Classification Graduate Instruction Program had a medium effect size on Circulation (η^2=.07), and small effects on Full-Text Articles (η^2=.05) and Gate Count (η^2=.05). Although the univariate tests showed an overall difference among groups, in only a few cases did groups have statistically different means. Similar to Carnegie Basic, Doctoral Comprehensive Schools (with or without a medical school) had higher Circulation than the other categories. For Full-Text Articles, however, Doctoral Comprehensives with a Medical School had a much higher mean (162,715 more Full-Text Articles) than those without a medical school. For Full-Text Articles, Doctoral Schools with a STEM emphasis had the second highest means, with Master's Schools, Business emphasis a third. This suggests a relationship between the library's provision of Full-Text Articles and institutional types with the highest research emphases. If this finding is reproduced in future research, it will bear mention because it suggests libraries play a role in the fulfilling these universities' business strategy related to research productivity. Administrators may want to determine more specific reasons for the advantages provided by their library relative to their institutional mission. Surely the 162,715 additional Full-Text Articles needed at a Doctoral Comprehensive with a Medical School relate to the increased need for medical research articles, which relates to the $517,862 additional in Ongoing Expenditures spent by libraries at Doctoral Comprehensives with Medical Schools. This hearkens back to resource dependence theory (Malatesta & Smith, 2014), which could provide a framework for libraries to demonstrate value to their institutions.

A regular pattern can be seen across Graduate Instruction Programs for many of the other library variables, with the two Doctoral Comprehensive categories and STEM schools having the highest means for Interlibrary Loan, Staff FTE, Ongoing Expenditures, and One-Time Expenditures, echoing findings from Smith (2011), who also found that Library Expenditures increased from Master's to Research universities.

These findings do not necessarily indicate institutional support, however, as STEM Schools had the second lowest mean for Library Budget as a Percent of Institutional Expenditures despite their high means for library expenditures, Staff FTE, and Interlibrary Loan.

In summary, the Graduate Instruction Program variable also seems to emphasize the same concepts as Carnegie Basic, although providing more granular information related to which institution types use Full-Text Articles. This suggests Full-Text Articles is an important indicator for Doctoral Comprehensives with a Medical School, STEM schools, and Business schools.

Comparison across Carnegie Classifications

Looking across Carnegie Classifications, it was interesting to see which dependent variables responded the most dramatically to group differences. Tables 52 through 55 bring together the multivariate and univariate effect sizes on the DVs across the MANCOVAs. The effect sizes are partial eta squared (η^2), which is the proportion of variance explained by that variable that is not explained by other variables in the model. For Residential Status, results from using both the original covariate and the alternative covariate are presented.

It is important to remember the covariate has controlled for a significant amount of variance: in the models with the three dependent variables, the covariate Full-Time Students Plus Faculty explained 60% to 77% variance in the combined DVs, and for the models with the twelve library variables, the covariate explained between 79% to 90% of the variance in the combined DVs. After controlling for the covariates, the amount of variance explained by the Carnegie groups on the combined DVs Circulation, Full-Text

Articles, and Gate Count ranged from 4% to 7% across the models, and on the DV composed of twelve library variables, the effects of group differences explained between 8% and 21% of the variance. This suggests there are systematic differences in library variables among different types of institutions, but that the institutional types don't tell the whole story.

Table 52. Multivariate Effect Sizes (partial □^{2}) for Circulation, Full-Text Articles, and Gate Count.

Multivariate Effect Sizes on Combined DVs (Pillai's Trace)	Basic	Residential Status (uses FTStu+Fac as Covariate)	Residential Status (uses PT+FT Stu+Fac as Covariate)	Program Balance	Graduate Coexist	Graduate Instruction
Covariate	0.60	0.74	0.77	0.78	0.68	0.60
Group Mem.	0.04	0.03	0.06	0.06	0.04	0.06

Table 53. Multivariate Effect Sizes (partial □^{2}) for each Carnegie Classification, twelve library variables combined.

Multivariate Effect Sizes on the Combined DVs (Pillai's Trace)	Basic	Residential Status (uses FTStu+Fac as Covariate)	Residential Status (uses PT+FT Stu+Fac as Covariate)	Program Balance	Graduate Coexist	Graduate Instruction
Covariate	0.79	0.89	.87	0.90	0.83	0.79
Group Mem.	0.20	0.16	.20	0.12	0.17	0.07

For the multivariate DV with three variables (Table 52), Program Balance predicted 7% of the variance, followed by the Residential Status and Graduate Instruction Program. The Basic and Graduate Coexistence classifications predicted just 4% of the variance in the composite DV. For the multivariate DV with twelve library variables

(Table 53), the Basic Carnegie Classification predicted 21% of the variance, followed by Residential Status and Graduate Coexistence. Program Balance predicted 13% of the variance in the multivariate DV, and the Graduate Instruction Program predicted 8%.

Looking at the univariate effects of group membership on the variables (Tables 54 and 55) shows patterns that may suggest two dimensions composing a library's "business strategy" on campus. Perhaps academic libraries support a function "Research Productivity" that relates most to groupings such as Carnegie Basic and Graduate Instruction Program, while perhaps libraries' support for "high-impact practices" relate more to the observed Residential Status and Program Balance group differences. It remains to be determined whether high-impact practices such as first-year seminars, learning communities, service learning, and undergraduate research, and capstone experiences (Brownell & Swaner, 2009) relate to Residential Status or Program Balance

Table 54. Univariate Effect Sizes (partial η^2) for Circulation, Full-Text Articles, and Gate Count.

Univariate Effect Sizes on the Individual DVs	Basic	Residential Status (uses FTStu+Fac as Cov.)	Residential Status (uses PT+FT Stu+Fac as Cov.)	Program Balance	Graduate Coexistence	Graduate Instruction
Covariate - Circulation	0.36	0.57	0.57	0.59	0.41	0.31
Covariate - Full-Text Articles	0.36	0.59	0.58	0.61	0.47	0.39
Covariate - Gate Count	0.51	0.58	0.66	0.65	0.57	0.50
Group Mem. - Circulation	0.03	NS	0.08	0.15	0.05	0.07
Group Mem. - Full-Text Articles	0.03	0.04	NS	0.04	0.05	0.05
Group Mem. – Gate Count	0.03	NS	0.08	0.07	0.05	0.05

Table 55. Univariate effect sizes (partial $\square^2$) for each Carnegie Classification, twelve library variables.

	Univariate Effect Sizes on the Individual DVs	Basic	Residential Status (uses FTStu+Fac as Covariate)	Residential Status (uses PT+FT Stu+Fac as Covariate)	Program Balance	Graduate Coexistence	Graduate Instruction
Covariate (FT Stu+Fac)	LOG_PartGrpPrez	0.56	0.70	0.68	0.71	0.63	0.55
	LOG_Ref	0.37	0.51	0.50	0.59	0.43	0.34
	LOG_ILL	0.20	0.47	0.45	0.48	0.30	0.15
	LOG_ResCirc	0.24	0.38	0.37	0.41	0.25	0.22
	LOG_ProfFTE	0.54	0.75	0.75	0.79	0.62	0.51
	LOG_StaffFTE	0.51	0.68	0.67	0.73	0.57	0.44
	LOG_AvgProf	0.10	0.12	0.13	0.16	0.10	0.11
	LOG_AvgStaf	0.02	0.09	0.09	0.09	0.05	0.04
	LOG_Ongoing	0.45	0.69	0.67	0.72	0.54	0.35
	LOG_Onetime	0.25	0.52	0.51	0.54	0.37	0.25
	LOG_PCT2	0.03	0.03	0.02	0.02	0.01	0.03
	LOG_Purpose	NS	0.03	0.03	0.04	NS	0.01
Group Mem.	LOG_PartGrpPrez	NS	NS	0.06	NS	NS	NS
	LOG_Ref	NS	0.04	NS	0.03	0.04	NS
	LOG_ILL	0.05	0.09	0.12	0.21	0.16	0.10
	LOG_ResCirc	NS	0.07	0.08	0.06	0.03	NS
	LOG_ProfFTE	0.14	0.06	0.14	0.16	0.14	0.23
	LOG_StaffFTE	0.07	NS	0.06	0.13	0.08	0.15
	LOG_AvgProf	NS	NS	NS	0.06	NS	NS
	LOG_AvgStaf	0.03	NS	NS	NS	NS	NS
	LOG_Ongoing	0.23	0.09	0.17	0.22	0.19	0.30
	LOG_Onetime	0.09	0.08	0.12	0.12	0.08	0.13
	LOG_PCT2	NS	NS	NS	0.10	0.03	0.07
	LOG_Purpose	NS	NS	NS	0.05	0.04	NS

group differences, or library services, so libraries should begin exploring these connections. Graduate Coexistence, which is a component of Undergraduate Instruction Program that also relates to the presence of graduate programs, may differentiate schools that address both strategies from those that tend toward one or the other.

Looking at the variables one-by-one shows some may relate more to High-Impact Practices, some to Research Productivity, and some to both.

- Circulation had the most variance for Residential Status, Program Balance, and Graduate Instruction Program. Within these groupings, Highly Residential Schools, Arts & Sciences schools, and Doctoral Comprehensive schools had the highest means. Thus, Circulation may be an indicator of both High-Impact Practices and Research Productivity.
- Full-Text Articles had some of the lowest effect sizes, suggesting that it may be something useful to all groups; however, the rankings are still interesting. Doctoral schools, Highly Residential schools (when part-time students were included in the covariate), High Graduate Coexistence, and Doctoral Comprehensive Schools with a Medical school had the highest means within their groupings. Full-Text Articles seems like it is related to both High-Impact Practices and Research Productivity, but perhaps in different ways; the alternative path models tested showed that Ongoing Expenditures was more important for predicting Full-Text Articles at Doctoral Schools than at Baccalaureate Plus Master’s schools. Tenopir (2014) has begun to investigate how to measure article *sharing*, because articles are often used without downloading them.

- Gate Count showed moderate effect sizes for Residential Status and Program Balance. For Gate Count, Highly Residential schools and Arts & Sciences-focused schools had the highest means. Although the effect of Carnegie—Basic was small for Gate Count, Baccalaureate had the highest mean Gate Count. Thus, Gate Count seems more closely related to High-Impact Practices than Research Productivity.
- Participants in Group Presentations showed no significant effects across Carnegie groups except with respect to Residential Status, where the most residential schools had the highest mean Participants. Otherwise, the number of students instructed seems proportional to the number of full-time students and faculty at that institution, regardless of the type of school that it is. While theoretically group presentations seems related to High-Impact Practices, more investigation is needed to explore this relationship.
- Reference Transactions also varied by Residential Status, although Non-Residential Schools had the highest mean. Reference Transactions may also vary by Program Balance and Graduate Coexistence, but the power of these tests was questionable. Again, more research could illuminate the extent to which Reference may relate to institutional outcomes.
- Interlibrary Loans, Librarian / Professional FTE, and Staff FTE varied significantly across all the groups, with moderate to large effect sizes, suggesting these variables are relevant to all strategies. Doctoral schools, Highly Residential schools, Arts & Sciences focused schools, High Graduate Coexistence schools, and Doctoral Comprehensive and STEM schools have

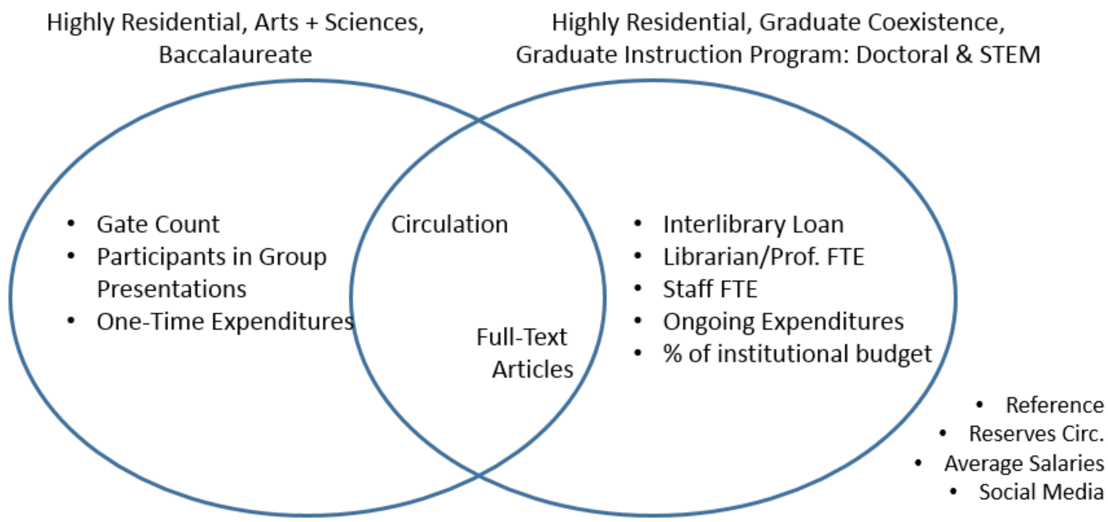
the highest means for these variables. Although there may be a relationship between these variables and High-Impact Practices, their relationship with Research Productivity seems highly likely.

- Reserves Circulation was only significant for Residential Status, where Highly Residential schools had greater means than Primarily Residential, but not necessarily for Non-Residential schools. The relative non-significance of Reserves Circulation, increase in electronic reserves, and the overall decline in Reserves Circulations observed by Martell (2008) from 1995-2006 suggest it may not be a meaningful indicator.
- Ongoing Expenditures had the largest effect sizes across all groups, especially for Basic, Program Balance, and Graduate Instruction Program. Doctoral schools, Arts-and-Sciences-Focused schools, High Graduate Coexistence, Doctoral Comprehensive and STEM schools had the highest means within their groups. Thus, Ongoing Expenditures seems linked to Research Productivity.
- One-Time Expenditures had moderate effect sizes across all groups, with larger effects on Residential, Program Balance, and Graduate Instruction Program groups. Highly Residential, Arts & Sciences, and Doctoral Comprehensive with No Medical School had the highest means within their groups. Thus, One-Time Expenditures seems more related to High-Impact Practices.
- Average salary variables were not very important for differentiating among groups.

- Percent of Institutional Budget group mean differences were significant just for Graduate Instruction Program. The group with the highest mean, Doctoral Comprehensive without a Medical School, only showed statistical differences from the two lowest groups, STEM schools and business-dominant Master's schools, business dominant. The rankings of groups on this variable suggest that schools with expensive graduate programs do not spend as much on their libraries. The schools that use the most Full-Text Articles find their libraries the lowest funded.
- The MANCOVA tests were not sufficiently powerful to detect group differences on the Social Media variable. This variable should be the focus of future research to determine its potential usefulness.

Figure 44 attempts to provide a visualization that summarizes the two dimensions. Highly Residential schools tend to have higher Circulation, Gate Count, One-Time Expenditures, Interlibrary Loans, and Participants in Group Presentations. These variables all seem to relate to being on campus and visiting the library, perhaps to check out items, and to attend a library instruction class. When part-time students are included in the covariate, Full-Text Articles are also higher at Highly Residential schools. Non-residential schools have the highest Reference Transactions, indicating a different modality of engagement between libraries and non-resident students.

Figure 44. Library variables grouped in two dimensions related to Carnegie Classification groups.



Note: Variables shown outside the diagram may not be relevant factors for these dimensions

Compared with the other types of schools in their groups, Doctoral schools and other categories suggesting research productivity have the highest Full-Text Articles counts, Ongoing Expenditures, and Interlibrary Loans. Although not always statistically significant, those with expensive graduate programs (Business, STEM) also tend to have less-well funded libraries, with lower library budgets in proportion to total institutional expenditures. One interpretation might be that such institutions treat libraries more cheaply, but another might be that these schools have additional expenses or larger expenses than those without such programs.

Many of the findings related to Carnegie Classifications raised more questions than answers. A future study could explore alternate ways to conceptualize institutional types that relate more to the variables underlying the Carnegie Classifications. For example, instead of looking at Residential status as a categorical variable, the number of on-campus versus off-campus, and part-time vs full-time students could be used in a linear regression model. Instead of using the Carnegie Basic categories to differentiate Doctoral from Master's, numbers of programs or students could be used. Finally, although Circulation, Full-Text Articles, Gate Count, and other library use variables were used as dependent variables in this study, it is important to remember that they are not outcomes. They can be valuable indicators of activity, but do not show the university the library's contribution to student, faculty, or institutional outcomes.

Discussion of Regressions to Predict Research Dollars

A series of regression equations attempted to predict External Research Dollars from Circulations, Full-Text Articles, and Gate Count, controlling for Full-Time Students Plus Faculty. Both 2010 and 2012 datasets showed adding Carnegie Classification Basic variables to the model had a significant effect on External Research Dollars, improving the model by 13% in 2010 and 24% in 2012. This makes sense, since Doctoral schools logically have larger research programs than Baccalaureate or Master's. Similarly, Graduate Coexistence demonstrated a significant relationship with External Research Dollars in both 2010 and 2012, contributing 13% and 15% of the variance, respectively. When Graduate Instruction Program was entered into its model, it also increased predictive ability, 13% in 2010, and 28% in 2012. Doctoral institutions and High Graduate Coexistence Schools had the highest coefficients in their categories for both years, which makes logical sense given the relationship between these institutions' research missions and External Research Dollars. Doctoral Schools-STEM and Doctoral Schools-Comprehensive had the highest coefficients in 2010 and 2012 compared to Master's schools, respectively, although there was not much difference between them.

The superiority of these groups in terms of External Research Dollars over Master's schools also makes sense, because of their expanded research missions.

The interest in performing these regressions was to examine how library use might influence External Research Dollars. Seeing how Carnegie Classifications influenced the model was a secondary consideration. For all classifications, only the 2012 dataset revealed a significant effect of Full-Text Articles on External Research Dollars and no model showed a significant effect of Gate Count. The effect could therefore be due to increased power resulting from sample size, or a change from 2010 to 2012, or a combination of the two.

For Carnegie Classification Basic, only the 2012 data showed an effect of the library variables on External Research Dollars in the final models. However, the magnitude and sign of the coefficients in 2010 suggested the same pattern: Full-Text Articles had a positive correlation with External Research Dollars, and Circulation had a negative correlation. In 2012, with Carnegie Basic in the model, for each *sd* increase in Full-Text articles, External Research Dollars increased .46 *sd*, and for each *sd* increase in Circulations, External Research Dollars *decreased* by .41 *sd*. For the Carnegie Classification Graduate Coexistence, in 2012 only, Full-Text Articles contributed 3% unique variance to the Step 3 model, and for every *sd* increase in Full-Text Articles, External Research Dollars increased by .25 *sd*. For the model with Graduate Instruction Program included, only with 2012 did the library use variables add to the prediction of External Research Dollars (increasing prediction by 7%). In the final model, for every *sd* increase in Full-Text Articles, External Research Dollars increased by .20 *sd.* The only significant interaction coefficients were in the Graduate Instruction Program model;

while the individual effects were not interpreted due to very small effect sizes and this study was exploratory, future research should continue to enter interaction terms in the model. The increase in power with 2012's larger sample size was able to detect significant effects of Full-Text Articles on External Research Dollars for each of the Carnegie Classifications tested only when the Carnegie variables were also in the equation. Increases due to Full-Text Articles ranged from .20 to .46 *sd* increase in External Research Dollars for each *sd* increase in Full-Text Articles across the models.

In summary, the institution's mission has a relationship with external research funding above and beyond institution size. There is some evidence for a positive relationship between Full-Text Articles and External Research Dollars, but more research could confirm or further illuminate the nature of the relationship. Additionally, there was one model showing less use of the library's physical materials at institutions with high external research funding. These regressions were examples of analyses connecting library use indicators such as Circulation, Full-Text Articles, and Gate Count to institutional outcomes such as External Research Dollars. While such connections are worthy of exploration, External Research Dollars makes more sense as an outcome for some schools (e.g., Doctoral) than others. Libraries need to determine the key dependent variables for their type of institution in order to choose an appropriate strategy for having an effect on outcomes of relevance.

Discussion of Methodological Issues

In addition to the results related to the research questions, this study illuminated some methodological issues. First, although the idea of using two different years' worth of data seemed appealing for the purposes of cross-validation, the datasets had different amounts of missing data, making some variables different. For example, One-Time Expenditures for 2010 was a variable created by summing Monographs plus Other Library Materials, and Ongoing Expenditures 2010 was a variable created by summing Current Serials plus Miscellaneous. In 2012, One-Time Expenditures and Ongoing Expenditures existed in their own right. This made it difficult to know whether differences in results across the datasets were due to these differences, or the increased power of the 2012 sample size, or due to qualities of substantive interest. For example, only the 2012 dataset revealed a significant effect of library use variables on External Research Dollars. Is this because something changed from 2010 to 2012 about the relationship between libraries and research? Or in the reporting of Research Dollars? For example, 2010 was the first year the NSF began to include non-science and engineering fields. Perhaps greater reporting from these fields emerged in 2012. Future research will be required to explore these questions.

A question asked early in this paper was whether there were strong correlations among the three variables Circulation, Full-Text Articles, and Gate Count. The hypotheses were that Circulation and Gate Count would be positively correlated, Circulation and Full-Text Articles slightly correlated, and Gate Count and Full-Text Articles uncorrelated. Partial bivariate correlations and the results of the MANCOVA analyses suggest that these variables are related (Table 56). According to Hemphill's guidelines, the correlations between Circulation and Full-Text Articles, and Gate Count and Full-Text Articles are small, and the correlations between Circulation and Gate Count are medium. These make logical sense, since visiting the library building seems logically related to checking out physical items. However, it could be interesting for future research to see how this relationship may have changed over time, especially if one is able to differentiate libraries with a campus delivery service.

Table 56. Correlations among Circulation, Full-Text Articles, and Gate Count (2012 dataset).

	Partial Bivariate Correlation (2012)	MANCOVA (Basic)	MANCOVA (Residential)	MANCOVA (Program Balance)	MANCOVA (Grad Coex.)	MANCOVA (Grad Instruction Program)
Circ-Full-Text	0.33	0.20	0.19	0.15	0.16	0.19
Circ-Gate	0.10	0.34	0.34	0.27	0.32	0.34
Full-Text-Gate	0.25	0.16	0.14	0.12	0.14	0.14

With one exception, this study used the covariate Full-Time Students Plus Faculty to control for institutional size. Previous library research has often divided some variables, but not others, by the number of student FTE (Jones, 2007; Hunter & Perret, 2011). Throughout this study, the covariate Full-Time Students Plus Faculty had large correlations with the other variables, and effect sizes of the covariate's influence on dependent variables were large. Thus, the results of this study indicate use of this type of covariate is important, and should be used more consistently and deliberately.

While this covariate had a meaningful effect across the study, it masked differences between part- and full-time enrollments. Full-time Students Plus Faculty also seemed theoretically problematic for the MANCOVA involving the Carnegie Classification Size and Setting (Residential Status). Therefore, the covariate Full-Time and Part-Time Students Plus Faculty was tested with two MANCOVAS involving Residential Status. Although the ranked order of groups was almost the same for both covariates, the effect sizes for the group differences, and therefore the remaining mean values, were greater after controlling for the alternative covariate. A future study could further investigate the potential for using full *and* part-time students plus faculty as a covariate. IPEDS provides a variable "Estimated full-time equivalent undergraduate enrollment academic year" that could have been a useful way to include full and part-time undergraduates without a significant loss of data. This variable will be strongly considered for use in future studies.

The log transformation applied to the data helped to "normalize" the data, but even after the log transformation the covariate still had significant effects with large effect sizes. For example, among the MANCOVAs, effect sizes of the covariate on the multivariate DV ranged from partial η^2 of .68 to .89. The log transformation of variables required extra steps when interpreting results because results had to be reverse-transformed into the original units, and some statistics, such as standard deviation, cannot be reverse-transformed (Bland & Altman, 1996a). The reverse log transformation produced geometric means rather than the more familiar arithmetic means. The geometric mean is a measure of central tendency that reduces the influence of extreme observations on the data; therefore, the geometric mean seems more useful when working with ACRL and ALS national datasets (cf. Olivier, Johnson, & Marshall, 2008). A final thought about methodology is that this study's samples were significantly reduced by missing data. Future research could explore the opportunities to impute missing data values in an attempt to try to avoid needing to listwise delete so many cases.

This study's explorations included a variable "Social Media" that represented the extent to which libraries used Social Media for various purposes. The specific validity of the indicator is up for debate and should be the subject of additional research. The idea that libraries' use of social media is a theoretical indicator that could predict library use also requires more exploration. While at least two studies have found that promoting digital special collections through social media increases use (Bagget & Gibbs, 2014; Elder & Westbrook, 2012), other studies have found that students may be unaware of social media beyond Facebook and may be unlikely to friend the library (Wu et al., 2014). Because this variable was missing for so many cases, it was a disadvantage for a study like this one. However, future research could examine the Social Media variables directly in pursuit of questions focused on Social Media technology and purpose.

Limitations

This study had several limitations. First, none of the models in this study factored in differences related to part-time or graduate students. Yet, there are probably differences related to these groups with respect to libraries. Another limitation was the large amount of missing data. Future studies could use data imputation methods to mitigate this issue, or focus on fewer numbers of variables. This study used data from 2010 and 2012, but some variables in 2010 and 2012 datasets were tracked differently. The two years' sample sizes were also different.

In general, this study would have been better informed by a stronger theoretical basis; however, the library field has been slow to create theories connecting the variables in this study with outcomes, or to adapt theory from other fields. Because of the sweeping changes in the information marketplace and in higher education, libraries need new theories to inform their work. Because of the lack of theory, this study was largely exploratory, meaning many models did not fit. Furthermore, there was not always a theoretical explanation of results. These are disadvantages of exploratory research. However, the findings did suggest some directions for the library profession to pursue.

Situating Findings Within the Theoretical Framework

What did the results of this research illuminate about libraries' strategic approach to allocating resources in a way that aligns with university strategy? In the library context, business strategy may usefully be thought of as how an organization or unit aligns itself with its parent organization's strategic plan. The MANCOVA analyses which explored differences between Carnegie Groups seem to have potential to describe the alignment of library missions with institutional missions.

Highly Residential schools tended to have higher Circulation, Gate Count, One-Time Expenditures, Interlibrary Loans, and Participants in Group Presentations. These variables all seem to relate to being on campus and visiting the library, perhaps to check out items, and to attend a library instruction class. Non-Residential schools had the highest reference transactions, indicating a different modality of engagement between libraries and non-resident students. These relationships do not mean the result of the relationship between the library and the on-campus environment is having any particular student outcome, but it does at least point to a logical alignment.

In the same way, there appears to be a strategic relationship between Doctoral schools (and other categories suggesting research productivity) with higher Full-Text Articles counts, Ongoing Expenditures, and Interlibrary Loans. Considering the results of the regressions on External Research Dollars, there was a demonstrated relationship between Full-Text Articles and External Research Dollars, at least when Carnegie Basic, Graduate Coexistence, or Graduate Instruction Program categories were included in the model. There was also one model showing a negative correlation between Circulation and External Research Dollars when controlling for Carnegie Basic classification. It would be interesting to explore this further: do different types of graduate programs affect Circulation differently?

The first part of this paper brought up the issue of quality and staffing: does an increase in staffing result in any increase in library outputs? While the salary variables seemed to have little role to play in any of the models, Librarian / Professional FTE and Staff FTE varied according to every Carnegie class, with higher numbers of both types of staff at Doctoral schools, Highly Residential schools, Arts & Sciences focused schools, High Graduate Coexistence schools, and Doctoral Comprehensive and STEM schools. This relationship is not an evaluation of quality of service, in the same way that a Doctoral school does not in any way provide a “higher-quality” education than a Baccalaureate—the two just have different missions. The relationship supports the idea that more library staff are required for graduate programs and schools with more on-campus engagement. However, these findings do not explain why more staff might be needed at these types of schools. Because none of the SEM models with staff variables fit, they did not further illuminate these relationships.

Although the above findings provide hints and clues, ultimately the answer to whether the ACRL and ALS surveys provide ways to connect library strategic decisions with campus strategies, such as high-impact educational practices or attracting external research dollars, the answers are “no” or at least, “not well.” The variables Circulation, Full-Text Articles, and Gate Count show patterns of library activity, but not relationships with student, faculty, or institutional outcomes. If presentations at the 2014 Library

Assessment Conference are any indication, modern libraries' strategies seem focused on two areas: high-impact educational practices and research outcomes. And while the ACRL and ALS data may have elements to contribute to the assessment of these areas, they are incomplete.

Riehle and Weiner (2013) found that literature about five of the high-impact practices (capstone experiences, learning communities, service learning and community-based learning, undergraduate research, and writing-intensive courses) included information literacy competencies, confirming that information literacy is highly relevant to these practices. For example, the information literacy competency "Access the needed information effectively and efficiently" appeared in literature about all five of the competencies they investigated. Single-institution studies have explored connections between libraries and learning communities (Crowe, 2014), information literacy and general education experience (Pemberton & Siefert, 2014), and participation in an undergraduate research journal, information literacy, and student learning (Weiner, 2014).

The datasets examined in this dissertation did not contain variables intended to measure libraries' contribution to high-impact educational practices, but some of them seemed like they could be more proximal than others. Participants in Group Presentations, Interlibrary Loans, Reference Transactions, and Reserves Circulations seemed logical as indicators of engagement between a library user and library services. Furthermore, Circulation, Gate Count, and Full-Text Articles all provide an indication that library users are incorporating library information into their work. Goodall and Pattern (2011) and Soria, Fransen, and Nackerud (2013) have found positive correlations between online library usage and academic achievement. The degree to which a library uses Social Media seemed like another potential indicator of the library's effort to engage with patrons. Finally, the researcher hoped to draw a connection between engagement with library services such as Participants in Group Presentations, and the library use variables such as Circulations, Full-Text Articles, and Gate Count.

The SEM measurement models with the latent variable "Engagement with Library Services" did not support the formation of a construct from these indicators. Path models created to test connections between single indicators, one of which was Participants in Group Presentations, also failed to fit. Some path models created after the rest of the statistical analyses had been completed did fit, but while Ongoing Expenditures was a significant predictor of Full-Text Articles, Participants in Group Presentations was not, although it did predict Interlibrary Loans. Previous research by Fagan (2014a) had also shown a stronger relationship between Ongoing Expenditures and Full-Text Articles than Participants in Group Presentations or Reference Transactions and Full-Text Articles. Therefore, the evidence for using Presentations in Group Presentations, Reference Transactions, and other library service "counts" to predict library use indicators is not strong.

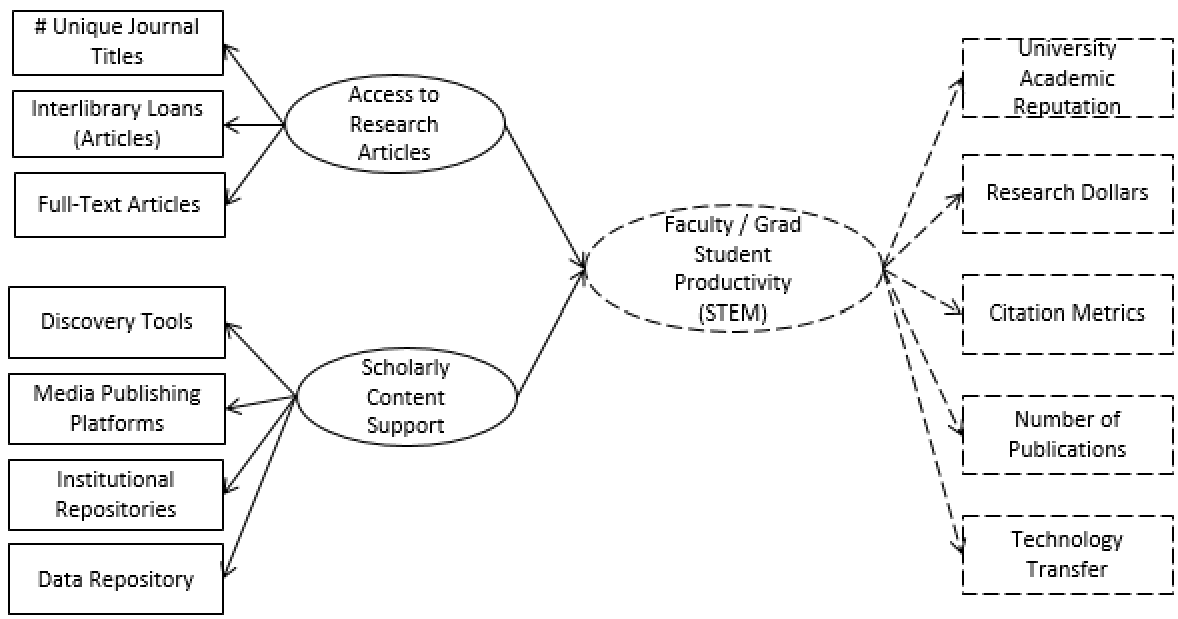
A major issue seems to be teasing apart the idea of "providing library resources" versus "instructing and engaging with users." These two concepts have different goals. In fact, current surveys of library users along these lines often split these concepts into "student goals" and "faculty goals" (Schonfeld, Asher, & Gendron, 2014). Providing library resources may well be measured by the relationship between Ongoing Expenditures and Full-Text Articles, which was upheld by previous and the current research. But the effects of instructing and engaging with users may not increase Full-Text Articles, Circulation, or Gate Count. They may instead increase the results of the high-impact practices more directly.

What seems to be missing from the national datasets is more granular information about resource allocation, specifically, staffing. Variation in the number of professional and support staff existed for every Carnegie grouping—but it is unclear why Arts-and-Sciences-Focused institutions need more staff, or what the extra staff on Highly Residential campuses are doing. It could be useful to know specifically, how many hours staff spend devoted to the services that matter to the library and university mission. Libraries keep detailed information about the types and formats of materials added to the collection (e.g., microforms), but no information about the staff hours spent to provide services. In the models in these studies, the only metrics available related to staffing were number of professional staff, support staff, and student workers. Salaries are also available. But some of the more interesting changes in libraries have been shifts in how staff are spending their time.

Figure 45 shows one view of how library investments (solid rectangles) support faculty and graduate student productivity (focusing more on the sciences and technology), which could potentially be measured by the dashed rectangles. Libraries currently measure the number of full-text articles and interlibrary loans (although they don't separate articles and books for Interlibrary Loans, which would be useful).

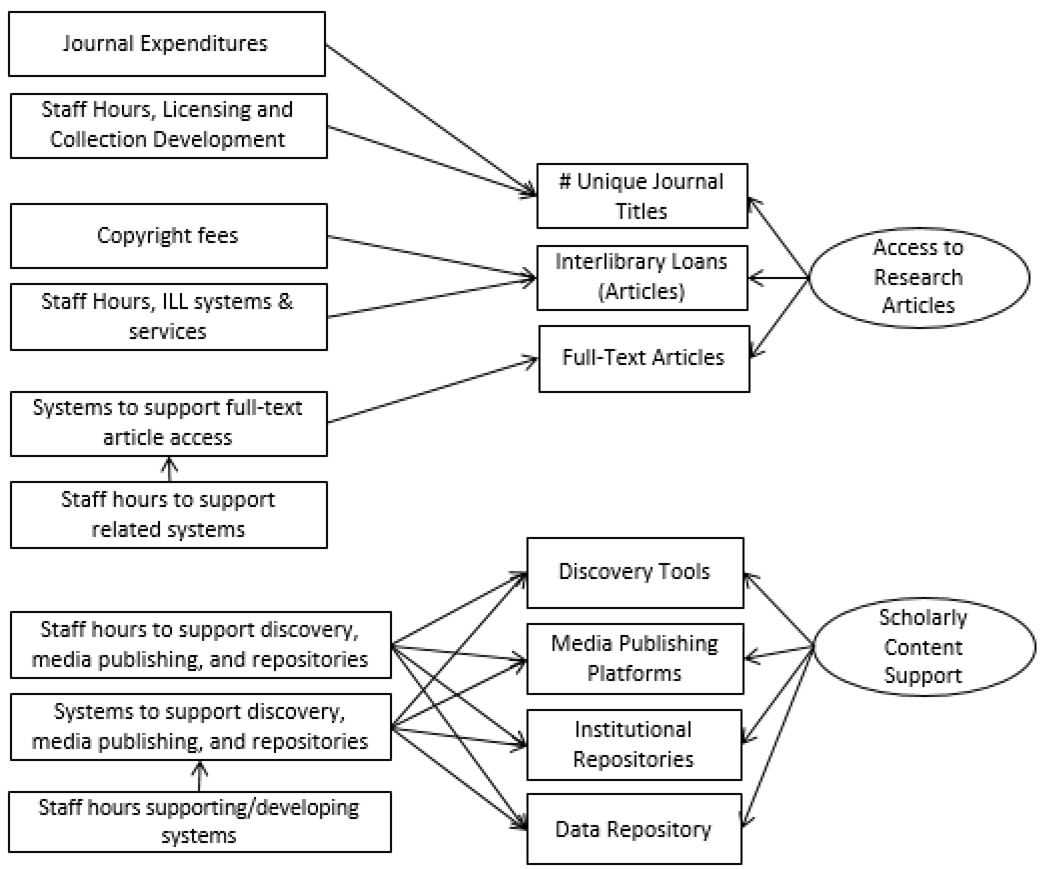
What libraries don't measure is the work that goes into cultivating and licensing journal collections, performing the interlibrary loans, or supporting the systems that permit search and discovery of full-text articles and journals. Libraries now have professional staff dedicated to supporting media publishing platforms, institutional repositories, and data repositories. The time of these staff is an investment. In addition, these skill sets are distinctive to libraries, providing a competitive advantage for libraries in terms of the "imperfect imitability" described by Peteraf (1993).

Figure 45. Diagram showing how library investments (solid rectangles) support faculty and graduate student productivity (STEM focus).



Without tracking the type of time spent, libraries have no way to connect expenditures on staff with the university's mission. Figure 46 provides a diagram of just a few of the ways staff hours directly support library services theorized to affect research productivity. This idea has been the subject of an exploratory study by Crumpton and Crowe (2014), who surveyed faculty at the University of North Carolina, Greensboro to determine specific university needs related to research data support and identify library services relevant to these needs. The results of the present study suggest that learning about this area is especially important for STEM schools and Doctoral institutions, which have significantly greater ongoing and one-time expenditures, interlibrary loan services, and numbers of staff per full-time student and faculty member, but are given less money in proportion to total institutional budget than Baccalaureate and Master's institutions.

Figure 46. Diagram showing how staff hours spent on library services support faculty and graduate student productivity.



Libraries also play a critical role in non-STEM disciplines. A similar view, Figure 47, shows how what a library does to support access to primary sources can support faculty and graduate student productivity in the Humanities. Although libraries do track

Circulation, they do not track the other solid rectangles. A similar figure to Figure 46 could be created for Figure 47 to show staff hours dedicated to providing access to digital archives as well as the cost of the archives themselves, and the staff hours dedicated to supporting special collections as well as the collections themselves.

Figure 47. Diagram showing how library investments (solid rectangles) support faculty and graduate student productivity (Humanities focus).

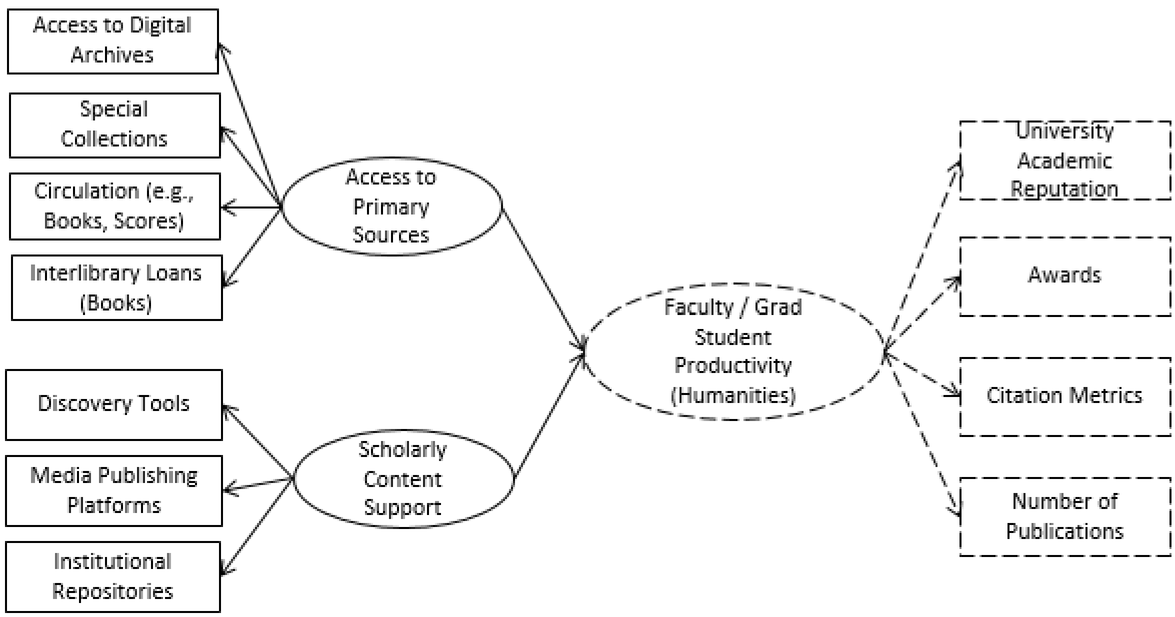
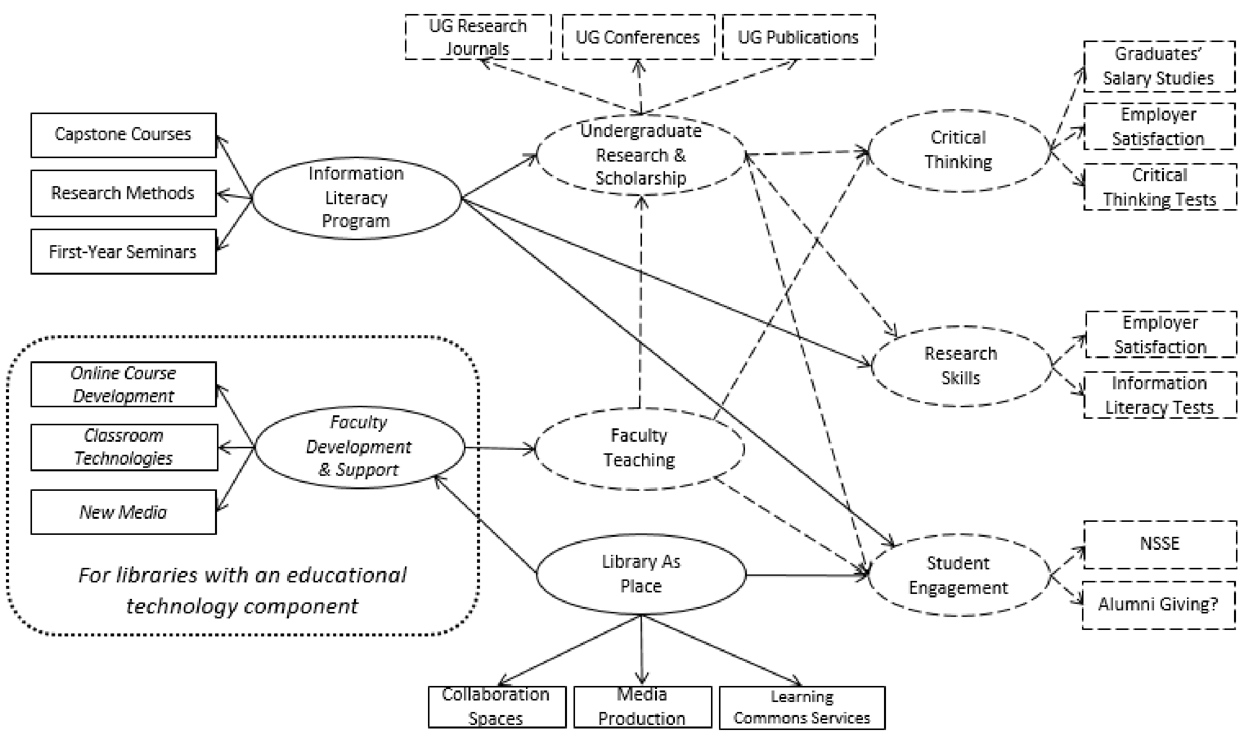


Figure 45-47 have a heavy focus on library collections, digital scholarship, and services related to them. Materials expenditures, systems expenditures, and staff hours in direct support of these functions likely have a strong impact on faculty and graduate productivity. However, this concept of providing resources is only part of a library's mission.

Thinking with respect to information literacy programs, faculty development and support, and the modern library building, a model could be created where these activities influence the core activities of faculty teaching and undergraduate research and scholarship, thereby having effects on the high-impact educational practices discussed earlier, represented here by critical thinking, research skills, and student engagement (Figure 48). Furthermore, information literacy programs have a direct effect on research skills and student engagement, and the library as a place has a direct effect on student engagement. Booker, Detlor, and Serenko (2012) found that library instruction had a positive effect on users' intentions to use the online library in the early stages of research. Weiner (2014) has explored relationships between information literacy and student participation in an undergraduate research journal.

Figure 48. Diagram showing how library investments (solid rectangles) support undergraduate research and scholarship, critical thinking, research skills, and student engagement.

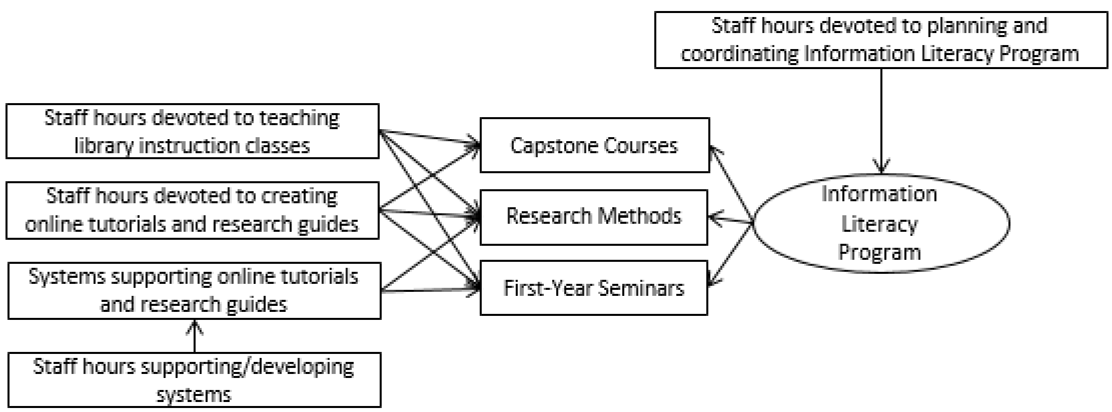


The idea of library as a place for collaboration, media production, and learning commons activities is supported by Opperman and Jamison (2008, p. 571), who noted the transformation of the physical library into a "destination dedicated to discovery and learning," and Yoo-Lee, Lee, and Velez (2013), who have encouraged the profession to include the type of use of library spaces in studies of library use.

Librarians and other professional staff spend enormous numbers of hours developing information literacy programs, teaching information literacy classes, and providing direct support to high-impact parts of the curriculum such as first-year seminars, research methods courses, and capstone courses. At some schools, libraries and educational technology services are integrated, and then the "library" is also offering faculty development and support services such as online course development, classroom technology support, and instruction in the use of new media in the classroom. Even at schools where libraries and educational technologies are not integrated, librarians are beginning to examine how their services might directly contribute to teaching (Fleming-May, Mays, & Pemberton, 2014). Libraries now dedicate personnel or partner with other units on campus to provide learning commons services, media production facilities, and collaboration spaces within library buildings. In this environment of heterogeneous capabilities and resources (Peteraf, 1993), libraries have the opportunity to distinguish themselves if they can articulate their unique strengths.

Interestingly, the activities and outcomes in Figure 48 can happen without an extensive library collection. Although one could make a case that "more" is always better, the truth is that good undergraduate research can be supported by "some good journals" and access to "some primary sources." What makes a difference in the outcomes in Figure 48 is the quality of the staff and spaces and the programmatic approach. Collaborative, friendly librarians and instructional technologists building high-quality relationships with faculty and students is what's important. Thinking of Garvin's (1998) theories of quality, this supports the idea that investment in staff will produce higher quality library services. Looking at just the "Information Literacy Program" piece, for example, staff hours are spent on a variety of activities to produce a successful instruction program (Figure 49).

Figure 49. Diagram showing how staff hours contribute to a library's information literacy program.



The levers in the models related to supporting research productivity, Figures 45 and 47, are theoretically more related to extensive materials collections. However, it is still important to recognize that the cost of the staff-hours to support these collections is a significant expense.

The figures illustrating faculty / graduate student productivity and high-impact practices relate to one another as well. Undergraduate research could be positively or negatively affected by a strong graduate research program, depending on the programmatic implementation of the university. Libraries may have a direct influence on such interactions: this study showed that schools with a high graduate coexistence between undergraduate and graduate instruction programs had higher interlibrary loans, number of professional staff, and ongoing resource expenditures. Perhaps schools with high graduate coexistence have both strong high-impact educational practices and high faculty/graduate productivity.

The specifics of models connecting library activities to things like high-impact practices may vary by instructional program. This study found that Arts & Sciences-focused schools had higher means on most library variables than Professional-focused schools. Yet the professions (health, business, education) seem like they could benefit equally if not more from high-impact practices that produce greater critical thinking, problem solving, and research skills, because these are skills important to employers (LEAP, 2013). Libraries at schools with a stronger Professional focus may be able to make persuasive arguments for resources by exploring more closely how the practices of libraries at Arts & Sciences focused schools are netting advantages in library use variables and student outcomes variables.

Hearkening back to strategic management theories, these figures provide examples of how a library might visualize its strategic advantages (Barney, 1991). They postulate some of the specific ways that libraries' investments of staff hours and materials expenditures affect core activities of the university, as well as the outcomes to which the library's work relates. The figures are not meant to be complete or accurate for all types of institutions. They are meant to illustrate that to explain *what* an academic library does, more information is needed about the expenditures of staff hours, systems, and materials in specific areas. They also illustrate the importance of hypothesizing specific relationships. It is easy—and meaningless—to say "library services have a positive effect on student outcomes by supporting teaching, learning, and research." It is better to try to explain *which* library services have effects on teaching, *which* on learning, and *which* on research, and which student outcomes *specifically* are affected by the presence of the library services in the overall model. Also, there is an opportunity to demonstrate how library staff provide distinctive capabilities in the heterogeneous campus environment (Peteraf, 1993).

This discussion underscores the critical importance of specifying organizational strategy up front. Libraries are not clearly identifying the dependent variables on which they intend their services to have impact. This study used Circulation, Full-Text Articles, and Gate Count as indicators of library use because they were available. These may be good indicators by which one could measure the effectiveness of a programmatic change designed to increase use. But they are not measures of student learning or faculty research productivity.

Any suggestions for new measures will encounter logistical barriers in how to measure "services" across institutions. This is why staff hours is proposed as the unit of measurement. Staff hours are a huge constraint in academic libraries, one that is often not given attention as such. Reference librarians may spend hours tracking down an elusive fact for an enthusiastic patron without pausing to think of whether those hours could be better spent on another activity. An instruction librarian may obsess about revising her online tutorial to be sure the screenshots are perfectly up to date rather than step back and think about whether it will truly matter to the student's development of information literacy skills. Libraries obsess about measuring our materials and expenditures on them. Yet we neglect to measure an equally if not more important resource: our time.

Handing stopwatches out to librarians and other staff would be met with understandable resistance. What libraries should focus on are the logical connections, as some are just beginning to do (Archambault, 2014; Clarke, 2014; Crowe, 2014; Nolfi, Sasso, & Koelsch, 2014; Savage, 2014). Setting aside for the moment questions of how we would measure staff time, libraries need to identify the meaningful dependent variables that change, or that they want to see change, as a result of how library staff spend their time.

First, libraries should think strategically about which student and faculty outcomes are affected by our library services, spaces, and materials, and how and why. Retention has often been a focus because of the availability of the metric, but is that really where the library has the most impact? Perhaps critical thinking and research skills, now identified as valuable to employers, are areas where libraries have more of an opportunity to distinguish themselves because their distinctive organizational competencies give them a competitive advantage in these areas. After identifying the dependent variables of interest, libraries should think about which services and programs influence those variables. In the case of critical thinking, library instruction comes to mind, but the modern library offers many other types of events, from interdisciplinary colloquia to hackathons.

Once libraries form more logical connections, they may see ways to measure staff time differently. Instead of the numbers of staff, perhaps measuring the hours spent on the activity-groups that matter most. By having clearly tied activities to strategic outcomes, libraries will know exactly why they are hosting a hackathon (critical thinking). Rather than counting just the number of hours spent on direct library instruction, libraries could count the hours spent on activities designed to promote critical thinking.

This general approach may also illuminate shifts in types of staff. For example, in a 10-year longitudinal study, Regazzi (2012) found that large and doctoral institutions have increased staff spending well above the mean for all libraries, and across all institutions, librarian staff levels have increased by 9%, while other professional staff (non-librarians with professional qualifications) have increased 51%. The increase in use of "other professional staff" is most visible when looking at libraries grouped by Carnegie Classification: "for every one staff FTE added as Librarian staff to Doctoral research institutions, 13 other professional FTEs were added." What seems to be important in this context is which activities are consuming staff time and how staff skill sets and activities relate to what Barney calls "competitive advantage." Paraphrasing his questions for the library context:

- On what basis is the library seeking to distinguish itself as a provider of valued services to student and faculty? Production efficiency? Innovation? Customer service?
- Where in the value chain is the greatest leverage for achieving this differentiation?
- Which employees or employee groups provide the greatest potential to differentiate the library from other valued services on campus? (Barney & Wright, 1998, p. 41).

A library that is seeking to emphasize its role as a contributor to undergraduate research may want to distinguish itself through an excellent information literacy instruction program, and if educational technologies are part of the organization, through faculty development. The expertise of liaison librarians and instructional technologists provide high potential to differentiate the library from other units on campus. A library that is seeking to emphasize its contribution to faculty productivity may instead wish to distinguish itself on efficient, seamless delivery of full-text articles and rapid interlibrary loan service. Staff who specialize in supporting article delivery systems, interlibrary loan staff, and personalized research services for high-stakes research centers might be a focus.

Future Research

Following from the previous discussion, a vast area for future research is to explore connections between library services, high-impact practices, and high-impact practices' outcomes (e.g., Collins & Holmes, 2014; Nolfi, Sasso, and Koelsch, 2014), as well as connections between library services and research productivity (Rawls, 2014). A good way to start might be for a few libraries or a consortium to agree on an approach to modeling their business strategies and which variables to measure, then to share data with one another for the purposes of validating and improving the approach. Some variables that appear immediately useful are:

- Unique Journal Titles, Total Journals Expenditures, Count of Subscription Databases, and Total Databases Expenditures, which could help clear up some of the questions surrounding Ongoing Expenditures
- Interlibrary Loans Borrowed—Articles and Interlibrary Loans—Books

- Campus Delivery Service Circulations.
- Staff hours spent on categories of activities (c.f., Figure 46).

The ideas discussed in this paper related to connecting the library's work with high-impact practices could potentially be adapted to the online learning environment. However, the specific activities in which librarians and professional staff engage may be quite different. In addition, the increase in enrollments in distance education programs may affect online library use differently than physical library use. Some variables that could be helpful would include:

- Number of Participants in Online Library Instruction
- Number of Online Library Instruction Classes
- Number of Online Learning Objects
- Number of Online Courses with Embedded Library Content.
- Staff hours spent on categories of activities (c.f., Figure 49).

Obviously, all these variables would need to be more clearly defined, but that would be the purpose for starting with a small group of libraries.

This study had intended to also explore the effect of an institution's involvement in distance learning on library services, but this was not completed due to time constraints. Distance enrollment data can be obtained from the IPEDS Data Center (http://nces.ed.gov/ipeds/datacenter/) and merged with ACRL or other datasets using the IPEDS identifier. Libraries were to be grouped into percentiles using number of enrollments in at least some distance education courses, then groups were to be compared to determine the extent to which these groups varied on all the library services, expenditure, and use variables in this study. Enrollment in distance learning courses is tracked separately for undergraduates and graduates, so these populations could be also explored separately in conjunction with the Carnegie Classifications Undergraduate Instructional Program and Graduate Instructional Program.

Several of the findings from comparing Carnegie groups could use further investigation. The Carnegie Classification Undergraduate Instruction Program was split into Program Balance and Graduate Coexistence, and the Program Balance set suggested consistently higher levels of library service at Arts-and-Sciences-Focused institutions. The reasons for this bear exploration. Also, studies could be designed that use this classification without splitting it into two.

Carnegie Size and Setting was also split into two groups, to separate size from residential status in this study. Residential status showed a relationship to library service use—including the intriguing finding that Reference Transactions may be higher for Non-Residential students. For this reason, studying the effects of part-time enrollment on library use variables (not as a covariate, but as an independent variable) could be useful for future research. Part-time students are charged with the same assignments in courses as their full-time compatriots, so part-time students would have an influence on library resource use, although the specific nature of that use could vary. However, they could influence use of some types of resources and services more than others.

For any of the ideas discussed, alternative variables may be more indicative of institutional differences than the Carnegie classes or graduate programs. With many caveats, Bonaccorsi, Daraio, Lepori, and Slipersaeter (2007) noted PhD degrees per 100 undergraduates could be used to indicate research productivity at an institution. Other ideas include the proportion of expenditures on instruction and research to overall expenditures; proportion of expenditures on the library to overall expenditures; proportion of faculty in various ranks; proportions of degree types granted; and the proportion of external research dollars to a university’s budget.

Chapter 6: Conclusion

Libraries are not yet clearly articulating their business strategies. However, pieces of their strategy can be observed in data patterns in the ALTS and ALS survey results. To complete the picture, libraries would need to gather additional data. Choosing and collecting data is expensive. Therefore libraries should first "think locally" about their business strategies, and test ideas on their own or with a small group of libraries. Staffing hours seem like one unit of measurement that could provide information about libraries' investment in services that support institutional outcomes, including high-impact practices and research productivity.

In addition to learning how to measure their services in a way that will permit logical connections to student learning outcomes and research outcomes, libraries need to continue to think hard about which services will contribute the most to the institution's mission. Some library services many no longer have a significant contribution and new services might provide stronger support to students and faculty, even if they don't immediately seem like "library" services. Libraries that figure out the right apportionment of staff hours on activities relevant to the university's mission are going to be stronger contributors. And if libraries figure out a way to track this sort of data nationally, they have the potential to measure how their activities connect to university outcomes using powerful statistical techniques. In addition to demonstrating their value to the university's mission, the ability to measure contribution means libraries can test new ideas or alternative approaches in a way that will have meaningful impact on students and faculty.

Appendix A: Higher Education Research and Development Survey,

(http://www.nsf.gov/statistics/srvyherd/#sd)

- Annual. Successor to the Survey of Research and Development Expenditures at Universities and Colleges that expended at least $150,000 in separately budgeted R&D in the fiscal year.
- Began to include non-science and engineering fields in 2010.
- Institution-level data, easy to download (865 institutions in 2012).
- Information on R&D expenditures by field of research and source of funds
- Types of research and expenses and headcounts of R&D personnel.

Appendix B: Definitions for ACRL pre-2012 variables

Monographs: Report expenditures for volumes purchased counted on line (3).

Current Serials: Report expenditures for serials counted on line 5a. Exclude unnumbered monographic and publishers' series, and encumbrances

Other Lib Materials: Include expenditures for all materials not reported in Questions (16a) and (16b), e.g., backfiles of serials, charts and maps, audiovisual materials, manuscripts, etc. If expenditures for these materials are included in lines (16a) and/or (16b) and cannot be disaggregated, please report NA/UA and provide a footnote. Do not include encumbrances.

Miscellaneous: Include any other materials funds expenditures not included in questions (16a)-(16c), e.g., expenditures for bibliographic utilities, literature searching, security devices, memberships for the purposes of publications, etc. Please list categories, with amounts, in a footnote.

References

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin, 103*(3), 411-423. http://dx.doi.org/10.1037/0033-2909.103.3.411

Applegate, R. (2007). Charting academic library staffing: Data from national surveys. *College & Research Libraries, 68*(1), 59-68. http://dx.doi.org/10.5860/crl.68.1.59

Archambault, S. G. (2014). Charting your course: Using curriculum mapping to enhance information literacy. Presentation at the Library Assessment Conference, Seattle, WA, August 4-6. http://libraryassessment.org/bm~doc/8archambaultlightningtalk.pdf

Association of College and Research Libraries (ACRL). (2012). Instructions for completing the questionnaire. http://acrl.countingopinions.com

Association of College and Research Libraries (ACRL). (2014). Association of College and Research Libraries' Information Literacy Framework. http://acrl.ala.org/ilstandards/

Atkinson, J. (2003). Managing change and embedding innovation in academic libraries and information services. *New Review of Academic Librarianship, 9*(1), 25-41. http://dx.doi.org/10.1080/13614530410001692013

Baggett, M. P. & Gibbs, R. (2014). HistoryPin and Pinterest for digital collections: Measuring the impact of image-based social tools on discovery and access. *Journal of Library Administration, 54*(1), 11-22. http://dx.doi.org/10.1080/01930826.2014.893111

Bailey, S., & Slemons, M. (2014). Halt! who goes there? Assessing library use with turnstile data. Presentation at the Library Assessment Conference, Seattle, WA, August 4-6. http://libraryassessment.org/bm~doc/12baileylightningtalk.pdf

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99-120. http://business.illinois.edu/josephm/BA545_Fall%202011/S10/Barney%20(1991).pdf

Barney, J., & Wright, P. (1998). On becoming a strategic partner: the role of human resources in gaining competitive advantage. *Human Resource Management, 37*(1), 31-46. http://digitalcommons.ilr.cornell.edu/cahrswp/150/

Bell, S. J. (2014). Staying true to the core: Designing the future academic library experience. *portal: Libraries & the Academy, 14*(3), 369-382.

Bentler, P. (1998). Kurtosis, residuals, fit indices. Message posted to SEMNET@BAMA.UA.EDU.

Bland, J. M., & Altman, D. G. (1996a). Statistics notes: The use of transformation when comparing two means. *BMJ*, *312*: 1153. http://dx.doi.org/10.1136/bmj.312.7039.1153

Bland, J. M., & Altman, D. G. (1996b) Statistics notes: Transformations, means, and confidence intervals. *BMJ*, 312: 1079. http://dx.doi.org/10.1136/bmj.312.7038.1079

Bluemle, S. R., Makula, A. Y., & Rogal, M. W. (2013). Learning by doing: Performance assessment of information literacy across the first-year curriculum. *College &*

Undergraduate Libraries, 20(3), 298-313. http://dx.doi.org/10.1080/10691316.2013.829368

Bonaccorsi, A., Daraio, C., Lepori, B., & Slipersæter, S. (2007). Indicators on individual higher education institutions: Addressing data problems and comparability issues. *Research Evaluation, 16*(2), 66-78. http://dx.doi.org/10.3152/095820207X218141

Booker, L. D., Detlor, B., & Serenko, A. (2012). Factors affecting the adoption of online library resources by business students. *Journal of the American Society for Information Science & Technology, 63*(12), 2503-2520. http://dx.doi.org/10.1002/asi.22723

Borin, J., & Yi, H. (2011). Assessing an academic library collection through capacity and usage indicators: Testing a multi-dimensional model. *Collection Building, 30*(3), 120-125. http://dx.doi.org/doi:10.1108/01604951111146956

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen, & J. S. Long (Eds.), *Testing structural equation models* (pp. 136–162). Newbury Park, CA: Sage.

Brownell, J. E., & Swaner, L. E. (2009). High-impact practices: Applying the learning outcomes literature to the development of successful campus programs. *Peer Review, 11*(2), 26-30.

Bryant, F., & Satorra, A. (2012). Principles and practice of scaled difference chi-square testing. *Structural Equation Modeling*, 19, 372–398. http://dx.doi.org/10.1080/10705511.2012.687671

Cahalan, M., Mansfield, W., Justh, N., & Mathematica Policy Research. (2001). The status of academic libraries in the United States: Results from the 1996 academic library survey with historical comparisons. http://nces.ed.gov/pubs2001/2001301.pdf

Carnegie Foundation. (2014). Classification descriptions. http://classifications.carnegiefoundation.org/descriptions/index.php

Chang, B. P. (2014). Assessing the impact of a new library on graduate students' use of library spaces. Presentation at the Library Assessment Conference, Seattle, WA, August 4-6. http://libraryassessment.org/bm~doc/20changlightningtalk.pdf

Clarke, K. C. (2014). The role of a required information literacy competency exam in the first college year: What test data can, cannot, and might reveal. Presentation at the Library Assessment Conference, Seattle, WA, August 4-6. http://libraryassessment.org/bm~doc/8clarkelightningtalk.pdf

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). Applied multiple regression / correlation analysis for the behavioral sciences, 3rd edition. Mahwah, NJ: Lawrence Erlbaum.

Collins, K., & Holmes, J. (2014). Viral reference in the writing center: Towards assessment of a research help service’s impact on student learning. Presentation at the Library Assessment Conference, Seattle, WA, August 4-6. http://libraryassessment.org/bm~doc/20holmeslightningtalk.pdf

Coombs, K. A. (2005). Lessons learned from analyzing library database usage data. *Library Hi Tech, 23*(4), 598-609. doi:10.1108/07378830510636373

Crowe, K. (2014). Libraries and student success: A campus collaboration with high impact educational practices. Presentation at the Library Assessment Conference, Seattle, WA, August 4-6. http://libraryassessment.org/bm~doc/8crowelightningtalk.pdf

Crumpton, M., & Crowe, K. (2014). Defining the libraries' role in research: A needs assessment case study. Presentation at the Library Assessment Conference, Seattle, WA, August 4-6. http://libraryassessment.org/bm~doc/crowe-kathryn-lt-2014.pdf

D'Amico, E. J., Neilands, T. B., & Zambarano, R. (2001). Power analysis for multivariate and repeated measures designs: A flexible approach using the SPSS MANOVA procedure. *Behavior Research Methods, Instruments, & Computers, 33*(4), 479-484. http://link.springer.com/article/10.3758%2FBF03195405

Dahlen, S., & Baker, P. (2014). Assessing information literacy and critical thinking across the curriculum. Presentation at the Library Assessment Conference, Seattle, WA, August 4-6. http://libraryassessment.org/bm~doc/13DahlenPaper.pdf

Davis, P. M. (2004). For electronic journals, 'total downloads' can predict number of users. *portal: Libraries and the Academy, 4*(3), 379-392.

Du, J. T., & Evans, N. (2011). Academic library services support for research information seeking. *Australian Academic & Research Libraries 42*(2), 103-120. http://dx.doi.org/10.1080/00048623.2011.10722217

Duy, J., & Vaughan, L. (2006). Can electronic journal usage data replace citation data as a measure of journal use? An empirical examination. *Journal of Academic Librarianship, 32*(5), 512-517. http://dx.doi.org/10.1016/j.acalib.2006.05.005

Egan, N. (2005). The impact of electronic full-text resources on interlibrary loan: A ten-year study at John Jay College of Criminal Justice. *Journal of Interlibrary Loan, Document Delivery & Electronic Reserves, 15*(3), 23-41. http://dx.doi.org/10.1300/J474v15n03_05

Elder, D., Westbrook, R. N. and Reilly, M. (2012). Wikipedia lover, not a hater: Harnessing Wikipedia to increase the discoverability of library resources. *Journal of Web Librarianship, 6*(1), 32-44. http://dx.doi.org/10.1080/19322909.2012.641808

Fagan, J. C. (2014a). The effects of reference, instruction, database searches, and ongoing expenditures on full-text article requests: An exploratory analysis. *The Journal of Academic Librarianship, 40*(3-4), 264-274. http://dx.doi.org/10.1016/j.acalib.2014.04.002

Fagan, J. C. (2014b). The dimensions of library service quality: A confirmatory factor analysis of the LibQUAL+ instrument. *Library and Information Science Research 36*(1), 36-48. http://dx.doi.org/10.1016/j.lisr.2013.10.003

Fleming-May, R. A., Mays, R., & Pemberton, A. (2014). Academic libraries: Contributions to teaching. Presentation at the Library Assessment Conference, Seattle, WA, August 4-6. http://libraryassessment.org/bm~doc/15Fleming-MayLightningTalk1.pdf

Frank, P. P., & Bothmann, R. L. (2007). Assessing undergraduate interlibrary loan use. *Journal of Interlibrary Loan, Document Delivery & Electronic Reserves, 18*(1), 33-48. http://dx.doi.org/10.1300/J474v18n01_05

Garvin, David A. (1988). *Managing quality: The strategic and competitive edge*. New York: Free Press.

Gilchrist, D. G. (2014). Leading with strategy and evidence. Presentation at the Library Assessment Conference, http://libraryassessment.org/bm~doc/1gilchristkeynote.pdf

Goodall, D., & Pattern, D. (2011). Academic library non/low use and undergraduate student achievement: A preliminary report of research in progress. *Library Management, 32*(3), 150-170. http://dx.doi.org/10.1108/01435121111112871

Grant, R. M. (2010). *Contemporary strategy analysis, 7th edition*. West Sussex: Wiley.

Greenwood, J. T., Watson, A. P., & Dennis, M. (2011). Ten years of LibQual: A study of qualitative and quantitative survey results at the University of Mississippi 2001–2010. *The Journal of Academic Librarianship, 37*(4), 312-318. http://dx.doi.org/10.1016/j.acalib.2011.04.005

Griffin, M., & Taylor, T. I. (2013) Of fans, friends, and followers: Methods for assessing social media outreach in special collections repositories, *Journal of Web Librarianship, 7*(3), 255-271. http://dx.doi.org/10.1080/19322909.2013.812471

Grimes, P. W., & Charters, M. F. (2000). Library use and the undergraduate economics student. *College Student Journal, 34*(4), 557.

Grogg, J. W., & Fleming-May, R. A. (2010). Chapter 1: Assessing use and usage. *Library Technology Reports, 46*(6), 5-10.

Haddow, G. (2013). Academic library use and student retention: A quantitative analysis. *Library & Information Science Research, 35*(2), 127-136. http://dx.doi.org/10.1016/j.lisr.2012.12.002

Hemphill, J. F. (2003). Interpreting the magnitude of correlation coefficients. *American Psychologist 58*(1), 78-80. http://psycnet.apa.org/doi/10.1037/0003-066X.58.1.78

Herrera, G. G. (2003). Interlibrary loan user behaviors in an academic library. *Journal of Interlibrary Loan, Document Delivery & Electronic Reserve, 14*(2), 19-36. http://dx.doi.org/10.1300/J110v14n02_03

Hinchliffe, L., Oakleaf, M., & Malenfant, K. (2012, October). *What do we want to know: Articulating a research agenda for the value of academic libraries*. Presentation at the Library Assessment Conference, Charlottesville, VA. http://libraryassessment.org/bm~doc/Hinchliffe_Lisa_2012.pdf

Hsieh, M. L., & Holden, H. A. (2010). The effectiveness of a university's single-session information literacy instruction. *Reference Services Review 38*(3), 458-473. http://dx.doi.org/10.1108/00907321011070937

Hu, L., & Bentler, P.M. (1998). Fit indices in covariance structure modeling: Sensitivity to underparameterized model misspecification. *Psychological Methods, 3*, 424–453.

Hu, L., & Bentler, P.M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*, 1–55.

Hunter, B., & Perret, R. (2011). Can money buy happiness? A statistical analysis of predictors for user satisfaction. *Journal of Academic Librarianship, 37*(5), 402-408. http://dx.doi.org/10.1016/j.acalib.2011.06.004

Iverson, R. D., & Zatzick, C. D. (2011). The effects of downsizing on labor productivity: The value of showing consideration for employees' morale and welfare in high-performance work systems. *Human Resource Management, 50*(1), 29-44. http://dx.doi.org/10.1002/hrm.20407

Jaggars, D., Smith, S., & Heath, F. (2009). Does size matter? The effect of resource base on faculty service quality perceptions in academic libraries. *Proceedings of the 2008 Library Assessment Conference: Building Effective, Sustainable, Practical Assessment,* Seattle, Washington. 317-321.

Johnson, H. (1994). Strategic planning for modern libraries. *Library Management, 15*(1), 7-19.

Jones, Y. D. (2007). How much do the “best” colleges spend on libraries? *College & Research Libraries, 68*(4), 343-351. http://dx.doi.org/10.5860/crl.68.4.343

Jöreskog, K. G., & Sörbom, D. (2007a). LISREL (Version 8.80) [Computer software]. Lincolnwood, IL: Scientific Software International.

Jöreskog, K. G., & Sörbom, D. (2007b). PRELIS (Version 2.80) [Computer software]. Lincolnwood, IL: Scientific Software International.

Kelloway, E. K. (1998). Structural equation models: Theory and development. *Using LISREL for structural equation modeling: A researcher’s guide* (pp. 5-22). Thousand Oaks, CA: Sage.

Kennedy, C. (2006). The academic library and new graduate programs: A step-by-step procedure for evaluating the collection. *Kentucky Libraries, 70*(2), 18-20.

Killick, S. (2012, October). *Applying performance measurement to safeguard budgets: Qualitative and quantitative measurement of electronic journal packages.* Presentation at the Library Assessment Conference, Charlottesville, VA. https://dspace.lib.cranfield.ac.uk/handle/1826/8657

King, P., & Pendleton, A. J. (2009). The campus courier service: Campus delivery of books and journals at auburn university. *Journal of Interlibrary Loan, Document Delivery & Electronic Reserves, 19*(4), 317-323. http://dx.doi.org/10.1080/10723030903285437

Kline, R. B. (2011). *Principles and practice of structural equation modeling (3rd Edition).* New York: Guilford.

Kuh, G. D. 2008. High-impact educational practices: What they are, who has access to them, and why they matter. Washington, DC: Association of American Colleges and Universities.

Lee, G., Sanford, T., & Jungmi, L. (2014). Variables that explain changes in institutional rank in U.S. News & World Report rankings. *KEDI Journal of Educational Policy, 11*(1), 27-47.

Leykam, A., (2008). Exploring interlibrary loan usage patterns and liaison activities: the experience at a US university. *Interlending & Document Supply 36*(4), 218-224. http://dx.doi.org/10.1108/02641610810919570

LibQUAL+. General information. Retrieved from https://www.libqual.org/about/about_lq/general_info

Lippincott, J. K. (2010). Information commons: Meeting millennials' needs. *Journal of Library Administration, 50*(1), 27-37. http://dx.doi.org/10.1080/01930820903422156

Long, D. (2009). Going the extra mile: Designing a delivery service for remote borrowers. *Journal of Library & Information Services in Distance Learning, 3*(3), 182-191. http://dx.doi.org/10.1080/15332900903182697

Love, E., & Nohria, N. (2005). Reducing slack: the performance consequences of downsizing by large industrial firms, 1977-93. *Strategic Management Journal, 26*(12), 1087-1108. http://dx.doi.org/10.1002/smj.487

Lu, S. (2007). Trends in U.S. academic libraries: A statistical comparison of the academic libraries survey (1994-2004). *Chinese Librarianship, 24*, 5.

Mackenzie, S. B. (2001). Opportunities for improving consumer research through latent variable structural equation modeling. *Journal of Consumer Research, 28*(1), 159-166. http://dx.doi.org/10.1086/321954

Malatesta, D., & Smith, C. R. (2014). Lessons from resource dependence theory for contemporary public and nonprofit management. *Public Administration Review* (January-February), 14-25. http://dx.doi.org/10.1111/puar.12181

Markel, K. S., & Frone, M. R. (1998). Job characteristics, work-school conflict, and school outcomes among adolescents: Testing a structural model. *Journal of Applied Psychology, 83*(2), 277-287. http://psycnet.apa.org/journals/apl/83/2/277.pdf

Malenfant, K., & Brown, K. (2014). Assessment in action: High impact practices in academic libraries. Presentation at the Library Assessment Conference, Seattle, WA, August 4-6. http://libraryassessment.org/bm~doc/malenfant-kara-2014.pdf

Martell, C. (2008). The absent user: Physical use of academic library collections and services continues to decline 1995-2006. *The Journal of Academic Librarianship, 34*(5), 400-407. http://dx.doi.org/10.1016/j.acalib.2008.06.003

McCormick, A. C., & Zhao, C. (2005). Rethinking and reframing the Carnegie Classification. *Change: The Magazine of Higher Learning, 37*(5), 51-57. http://dx.doi.org/10.3200/CHNG.37.5.51-57

Mengel, E., & Lewis, V. (2012). Collaborative assessment: North American academic libraries' experiences using the Balanced Scorecard to measure performance and show value. *Library Management, 33*(6/7), 357-364. http://dx.doi.org/10.1108/01435121211266131

Miller, S. (2012, October). *Curricular relevance and/or use of databases to electronic collection assessment and benchmarking to demonstrate the value of electronic collections*. Presentation at the Library Assessment Conference, Charlottesville, VA, October 29–31. http://libraryassessment.org/bm~doc/Miller_Stephen_2012.pdf

Mu, X., Dimitroff, A., Jordan, J., & Burclaff, N. (2011). A survey and empirical study of virtual reference service in academic libraries. *Journal of Academic Librarianship, 37*(2), 120-129. http://dx.doi.org/10.1016/j.acalib.2011.02.003

Muthén, B. (1989). Latent variable modeling in heterogeneous populations. Presidential address to the Psychometric Society, July, 1989. *Psychometrika*, *54*, 557-585. http://www.statmodel.com/bmuthen/articles/Article_024.pdf

Nackerud, S., Fransen, J., Peterson, K., & Mastel, K. (2013). Analyzing demographics: Assessing library use across the institution. *portal: Libraries and the Academy 13*(2), 131-145.

National Center for Education Statistics (NCES). 2013. Library statistics program. Retrieved from http://nces.ed.gov/surveys/libraries/academic.asp

National Center for Education Statistics (NCES). (2012). Instructions for the Academic Library Survey – FY 2012. http://www.ala.org/offices/sites/ala.org.offices/files/content/ors/natlctrforedstats/ALS2012instructions.pdf

National Center for Education Statistics (NCES). (2011). *Documentation for the Academic Libraries Survey (ALS) public use data file: Fiscal year 2010.* http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2011367

National Center for Education Statistics (NCES). (2010). *Academic libraries: 2010 first look.* Retrieved from http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2012365

National Leadership Council for Liberal Education & America's Promise (LEAP). (2008). *College learning for the new global century.* Washington, DC: Association of American Colleges and Universities. http://www.aacu.org/sites/default/files/files/LEAP/GlobalCentury_final.pdf

National Leadership Council for Liberal Education & America's Promise (LEAP). (2013). *It takes more than a major: Employer priorities for college learning and student success.* https://www.aacu.org/sites/default/files/files/LEAP/2013_EmployerSurvey.pdf

Nicholas, D., & Huntington, P. (2006). Electronic journals: Are they really used? *Interlending and Document Supply, 34*(2), 74-77.

Nolfi, D. A., Sasso, M. D., & Koelsch, L. E. (2014). Collaborating with faculty to assess undergraduate information literacy in degree programs. http://libraryassessment.org/bm~doc/4nolfilightningtalk.pdf

OCLC. (2010). The library brand 2010. Retrieved from http://www.oclc.org/content/dam/oclc/reports/2010perceptions/thelibrarybrand.pdf

Olivier, J., Johnson, W. D., & Marshall, G. D. (2008). The logarithmic transformation and the geometric mean in reporting experimental IgE results: what are they and when and why to use them? *Annals of Allergy, Asthma & Immunology, 100*: 333-337. http://www.ncbi.nlm.nih.gov/pubmed/18450118

Opperman, B. V., & Jamison, M. (2008). New roles for an academic library: Current measurements. *New Library World, 109*(11/12), 559-573.

Owen, M. (1992). Research at small Canadian universities. *Canadian Journal of Higher Education, 22*(2), 1-14.

Pemberton, A., & Siefert, L. (2014). Assessing information literacy in general education: A collaborative approach using a metarubric. Presentation at the Library Assessment Conference, Seattle, WA, August 4-6. http://libraryassessment.org/bm~doc/8pembertonlightningtalk.pdf

Peteraf, M. A. (1993). The cornerstones of competitive advantage: A resource-based view. *Strategic Management Journal 14*(3), 179-191.

Powell, B., Gilleland, D., & Pearson, L. (2012). Expenditures, efficiency, and effectiveness in U.S. undergraduate higher education: A national benchmark model. *Journal of Higher Education, 83*(1), 102-127.

Pralahad, C. K. & Hamel, G. (1990, May-June). The core competence of the corporation. *Harvard Business Review*, pp. 79-91.

Project COUNTER. (2012, April). *COUNTER code of practice for e-resources.* http://www.projectcounter.org/code_practice.html

Radford, M. L., & Kern, M. K. (2006). A multiple-case study investigation of the discontinuation of nine chat reference services. *Library & Information Science Research, 28*(4), 521-547. http://dx.doi.org/10.1016/j.lisr.2006.10.001

Rawls, M. (2014). Can academic analytics tell us how libraries impact faculty scholarly research productivity? Presentation at the Library Assessment Conference, Seattle, WA, August 4-6. http://libraryassessment.org/bm~doc/21rawlspaper.pdf

Raykov, T., & Marcoulides, G. A. (2000). *A first course in structural equation modeling*. Mahwah, NJ: Lawrence Erlbaum.

Regazzi, J. J. (2012). The core competence of the corporation. *Harvard Business Review*, 1998-2008. *College & Research Libraries, 73*(75), 449-468.

Rempel, H. (2010). A longitudinal assessment of graduate student research behavior and the impact of attending a library literature review workshop. *College & Research Libraries, 79,* 532-547.

Rempel, H., & Davidson, J. (2008). Providing information literacy instruction to graduate students through literature review workshops. *Issues in Science and Technology Librarianship. 53*. http://www.istl.org/08-winter/refereed2.html

Riehle, C. F., & Weiner, S. A. (2013). High-impact educational practices: An exploration of the role of information literacy. *College & Undergraduate Libraries, 20*(2), 127-143. http://dx.doi.org/10.1080/10691316.2013.789658

Ruppel, M. (2006). Tying collection development's loose ends with interlibrary loan. *Collection Building 25*(3), 72-77.

Sallee, J. M., Resch, A. M., & Courant, P. N. (2008). On the optimal allocation of students and resources in a system of higher education. *The B. E. Journal of Economic Analysis & Policy: Advances in Economic Analysis & Policy, 8*(1), 1-24. http://home.uchicago.edu/~/sallee/optimal-allocation-of-stude.pdf

Savage, D. (2014). Collaborating across campus to articulate the value of research consultations. Presentation at the Library Assessment Conference, Seattle, WA, August 4-6. http://libraryassessment.org/bm~doc/16savagelightningtalk.pdf

Schoonover, D., Siriwardena, M., & Jones, R. (2013). Library express delivery service: The evolution of a campus delivery service at Florida State University. *Journal of Interlibrary Loan, Document Delivery & Electronic Reserves, 23*(4), 201-212. http://dx.doi.org/10.1080/1072303X.2014.895792

Schonfeld, R., Asher, A., & Gendron, H. (2014). Community surveys across institutions. Presentation at the Library Assessment Conference, Seattle, WA, August 4-6. http://libraryassessment.org/bm~doc/11schonfeldpanel.pdf

Schwieder, D., & Hinchliffe, L. (2012, October). *NCES datasets and library value: An exploratory study of the 2008 data*. Presentation at the Library Assessment Conference, Charlottesville, VA. October 29–31. http://libraryassessment.org/bm~doc/Schwieder_David_2012.pdf

Smith, G. A. (2011). Following the evidence: Approaches to assessment in academic libraries. Proceedings from *Kansas Library Association College and University Libraries Section.* Emporia, KS: *64*(1) 96-108.

Soria, K. M., Fansen, J., & Nackerud, S. (2013). Library use and undergraduate student outcomes: New evidence for students' retention and academic success. *portal: Libraries & the Academy, 13*(2), 147-164.

Stemmer, J., & Mahan, D. M. (2012, October). *Using library user surveys to assess the library's impact on student outcomes*. Presentation at the Library Assessment Conference, Charlottesville, VA. http://libraryassessment.org/bm~doc/Stemmer_John_2012.pdf

Stevens, J. (1996). *Applied multivariate statistics for the social sciences.* Mahwah, NJ: Erlbaum.

Stewart, C. (2011). An overview of ACRLMetrics. *Journal of Academic Librarianship, 37*(1), 73-76. http://dx.doi.org/10.1016/j.acalib.2010.11.015

Stewart, C. (2012). An overview of ACRLMetrics: Part II: Using NCES and IPEDs data. *Journal of Academic Librarianship, 38*(6), 342-345. http://dx.doi.org/10.1016/j.acalib.2012.09.018

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics, 5th edition.* Boston: Pearson.

Taylor, M., & Heath, F. (2012). Assessment and continuous planning: The key to transformation at the University of Texas libraries. *Journal of Library Administration, 52*(5), 424-435. http://dx.doi.org/10.1080/01930826.2012.700798

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal 18*(7), 509-533.

Tenopir, C. (2014). Beyond downloads: How are journal articles shared and used? Presentation at the Library Assessment Conference. Seattle, WA, August 4-6. http://libraryassessment.org/bm~doc/7shepherdpanelfinal.pdf

Tsai, P., & Shih, C. (2013). Responsible downsizing strategy as a panacea to firm performance: The role of dynamic capabilities. *International Journal of Manpower, 34*(8), 1015-1028. http://dx.doi.org/10.1108/IJM-07-2013-0170

Turner, A., Welch, B., & Reynolds, S. (2013). Learning spaces in academic libraries – A review of the evolving trends. *Australian Academic & Research Libraries, 44*(4), 226-234. http://dx.doi.org/10.1080/00048623.2013.857383

Vezzosi, M. (2008). Doctoral students' information behaviour: an exploratory study at the University of Parma (Italy). *New Library World 110*(1/2), 65-80.

Weiner, S. G. (2005). Library quality and impact: Is there a relationship between new measures and traditional measures? *Journal of Academic Librarianship, 31*(5), 432-7. http://dx.doi.org/10.1016/j.acalib.2005.05.004

Weiner, S. A. (2009). The contribution of the library to the reputation of a university. The *Journal of Academic Librarianship, 35*(1), 3-13. http://dx.doi.org/10.1016/j.acalib.2008.10.003

Weiner, S. G. (2014). What do students learn from participation in an undergraduate research journal? Presentation at the Library Assessment Conference, Seattle, WA, August 4-6. http://libraryassessment.org/bm~doc/10weinerpaper.pdf

Weston, R. & Gore, P. A. (2006). A brief guide to structural equation modeling. *The Counseling Psychologist, 34*, 719- 751. http://dx.doi.org/10.1177/0011000006286345

Whitmire, E. (2001). The relationship between undergraduates' background characteristics and college experiences and their academic library use. *College & Research Libraries, 62*(6), 528-40. http://dx.doi.org/10.5860/crl.62.6.528

Williams, A. P. (1995). Conceptualizing academic library use: Results of a survey of continuing education students in a small Canadian undergraduate university. *Canadian Journal of Higher Education, 25*(3), 31-48.

Williams, P., Khan, M., & Naumann, E. (2011). Customer dissatisfaction and defection: The hidden costs of downsizing. *Industrial Marketing Management, 40*(3), 405-413. http://dx.doi.org/10.1016/j.indmarman.2010.04.007

Wu, J. Chatfield, A. J., Hughes, A. M., Kysh, L., & Rosenbloom, M. (2014). Measuring patrons' technology habits: An evidence-based approach to tailoring library services. *Journal of the Medical Library Association 102*(2), 125-129. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3988763/

Yoo-Lee, E., Lee, T. H., & Velez, L. (2013). Planning library spaces and services for millennials: An evidence-based approach. *Library Management, 34*(6), 498-511. http://dx.doi.org/10.1108/LM-08-2012-0049

Zappen, S. H. (2010). Managing resources to maximize serials access: The case of the small liberal arts college library. *Serials Librarian, 59*(3/4), 346-359. http://dx.doi.org/10.1080/03615261003623104