The Context and State of Open Source Software Adoption in US Academic Libraries

1. Introduction

The pace of technological advances has drastically evolved academic libraries' operations and service provision. Adopting new technologies is a continuous challenge that academic libraries must accept, if they wish to remain the information service providers for higher education institutions (Palmer and Choi, 2014). Some mission-critical technologies for libraries include the integrated library system (ILS), which manages library holdings and subscriptions, and the digital library, which collects and manages digital assets (e.g., institutional repositories).

There are a variety of commercial or proprietary options for these systems. However, given today's shrinking budgets and ever-increasing need for technology, there has been an increasing interest in open source software (OSS) for academic libraries. OSS differs from proprietary software, requiring "'free distribution', readily-modifiable source code, and permission for developers to create derivatives from the original software (http://opensource.org/docs/definition.php)" (Choi and Pruett, 2015). These characteristics often create a lower total cost of ownership and more power to customize software (Metcalfe and Rahtz, 2006). Academic libraries may develop OSS in-house, and contract with a vendor or consortium for software services.

There is a growing variety of OSS adopted by academic libraries. Some examples include Koha and Evergreen (ILSs); Samvera and DSpace (institutional repositories); and Blacklight and VuFind (discovery interfaces). OSS is exciting since it offers lower costs, greater flexibility, and

other benefits. Many researchers have studied its adoption (e.g., Blackburn and Walker, 2010; Blanke *et al.*, 2012), usability (e.g., Brantley *et al.*, 2006), and economic value (e.g., Breeding, 2008) for academic libraries. However, most of the research has focused on the development or implementation of widely known OSS products in specific institutions, and thus offers limited implications.

The objective of this research is to monitor OSS adoption in US academic libraries through examining barriers and drivers to adoption, measuring institutional awareness and adoption stages, and analyzing essential characteristics of the libraries' parent institutions (e.g., public or private, degree offerings) in relation to the aforementioned research variables. We do this through an online survey of academic libraries' chief information officers (CIOs), chief technology officers (CTOs), or heads for IT.

2. Literature Review

Regardless of anyone's ideological viewpoint of OSS, it permeates our digital lives. Apache remains the top web server for the busiest and most active websites (https://news.netcraft.com/archives/2017/11/21/november-2017-web-server-survey.html). Firefox is the second most popular desktop browser (http://gs.statcounter.com/browser-market-share/desktop/worldwide/#monthly-201712-201712-bar). Many popular and well-known proprietary products, such as the Google Chrome browser and Android mobile operating system draw substantially from OSS projects such as Chromium and the Linux kernel (https://www.chromium.org/; https://developer.android.com/guide/platform/index.html). These OSS products derive advantage from their development model. More than a requisite public display of human-readable source code, OSS license terms escape copyright and patent law to

permit faster improvement and peer review of software (see

https://www.copyright.gov/circs/circ61.pdf; https://opensource.org/docs/definition.php). Many

industries seek to leverage this development model to improve their services and reduce IT costs.

Of course, the form of that leverage depends on the industry. Considering library

software, Altman (2001) and Poulter (2010) list the general disadvantages of OSS, e.g., that

forked projects or attrition can weaken an open development community, that total cost of

ownership (TCO) or lack of in-house expertise can prohibit adoption (Poulter, 2010, p. 658;

Upasani, 2016), and that poor interface design impinges its users (Altman, 2001, p. 6). They also

list the general advantages of OSS as lower general or initial costs, and fast or "lively"

development models within open development communities. In addition, libraries and the OSS

movement share the ideals of "free access" to and collaboration regarding information, and the

movement arguably enables the libraries' mission of patron privacy and resource preservation

(Puckett, 2012; Altman, 2001). Chudnov (1999, p. 41) conflates libraries and OSS with

community-based initiative, and gives evidence of an even earlier precedence for this conflation

in higher education:

> In an email to me, free software guru Richard Stallman […] noted that way back in 1971,
>
> there was an openness policy at a computer facility he used at Harvard. "They had a firm
>
> policy: the source code for all the software installed for general use on the computer must
>
> be on display for people to look at. The stated reason was, 'We are an educational
>
> institution, and we are here for people to learn about computers. That should include
>
> learning how the software on this computer works .....' Libraries should actively

discourage the concealment of generally useful knowledge, and that includes proprietary

software" (Chudnov, 1999, p. 41).

The current literature has uncovered existing and potential benefits of OSS for mission-critical

IT in academic libraries.

The bulk of OSS research in academic libraries have employed case studies, and

comparisons and assessments of well-defined, monolithic software applications such as DSpace,

Koha, and Evergreen (Palmer and Choi, 2014). Many library OSS case studies share information

on select features of software, software implementation issues, and the administrative or

institutional context. As an example for digital repository software, Cherukodan *et al.* (2013)

explain DSpace's Google Analytics integration and collection analysis features, and the creation

of user communities. They also note institutional need and administrative support as a driver for

their OSS adoption. Wang (2011) shares the difficulties of DSpace implementation in a small

university law library, the necessity of a vendor to complete installation and customize features,

and the ultimate cost savings from OSS adoption. This same trichotomy of features,

implementation, and organizational drivers applies to case studies for less-common library OSS,

such as the electronic resources management (ERM) system (Taylor *et al.*, 2010; Imre *et al.*,

2013). These latter two studies also highlight typical and necessary integration issues of OSS

ERMs with other mission-critical library software and services, including proprietary systems.

Software comparison and assessment studies (e.g., Krishnamurthy, 2008; Hanumappa *et al.*,

2014) overview general software functions and available software packages, and may review the

organizations and development communities behind them. Other comparison studies (e.g.,

Bankier and Gleason, 2014) examine features in greater detail, within a particular class of

software. In a rare attempt to glean broader implications, Singh (2013) uses a multiple-case study and interview format with mostly open-ended questions, to find best practices and considerations for open source ILS migration. While the case and comparison studies provide valuable guidance, survey methods (used in this study) can derive broader implications with greater generalizability, that inform academic libraries' OSS adoption decisions.

There is established literature in information systems (IS) as well as several studies in higher education and libraries that consider barriers and drivers to OSS adoption. Some common barriers relate to the knowledge base surrounding particular products and include apprehension over outside support, lack of documentation, lack of internal technical experience, no knowledge of available options to implement OSS, or no knowledge of specific OSS products (Ellis and Belle, 2009; Kuechler *et al.*, 2013; Morgan and Finnegan, 2007; Paré *et al.*, 2009; Rafiq, 2009; van Rooij, 2007b). In fact, Macredie and Mijinyawa (2011) found that some of the U.K.'s "small to medium sized" IT companies had difficulty finding the support and information from hardware vendors necessary to implement OSS. Libraries in developed and developing countries also face challenges with OSS support and documentation (Rafiq, 2009). An organization's pre-existing commitments or values often preclude OSS adoption. Advantageous contracts from proprietary vendors, previous adoption of proprietary software, compatibility issues with current IT systems, and general resistance to innovation or change in IT (Ellis and Belle, 2009; Glynn *et al.*, 2005; Kuechler *et al.*, 2013; Macredie and Mijinyawa, 2011; Paré *et al.*, 2009) can create such preclusions. Morgan and Finnegan (2007) report that companies in the U.K.'s "secondary software sector" perceive that unaccountability in OSS development communities makes low quality software support. From an international perspective, Rafiq (2009) found that professionals in special libraries favored the usability of proprietary library software over library

OSS. Low quality OSS code and lack of internal staff was a concern for U.K. libraries and U.S. higher education CIO's and chief academic officers (CAO's) (Dalling and Rafferty, 2013; van Rooij, 2007b), and library budgets constrain OSS adoption in Pakistan (Rafiq and Ameen, 2009). Budget constraints and lack of internal staff lie outside respondents' control, and certainly mirror challenges in U.S. academic libraries.

Yet stakeholders across various sectors and industries still consider OSS despite challenges. The most common and cited drivers to OSS adoption are its lower costs, greater number of functions, and ready adaptation to various work systems (Dalling and Rafferty, 2013; Ellis and Belle, 2009; Glynn *et al.*, 2005; Kuechler *et al.*, 2013; Macredie and Mijinyawa, 2011; Morgan and Finnegan, 2007; van Rooij, 2007a & b). These drivers are also common for libraries in developed and developing countries (Rafiq, 2009). OSS is an attractive option for stakeholders who need to openly test the software's suitability beforehand, modify source code for niche needs, and/or work with older hardware in organizations, notably in U.K. libraries (Dalling and Rafferty, 2013), U.S. higher education institutions (van Rooij, 2007a), and the highly regulated U.S. energy sector (Kuechler *et al.*, 2013) (see also Glynn *et al.*, 2005). For other organizations, OSS is a way to break reliance on unfavorable arrangements from software vendors or support options (Dalling and Rafferty, 2013; Kuechler *et al.*, 2013; Morgan and Finnegan, 2007). Glynn *et al.* (2005) confirmed that management support was a driving factor to assimilate OSS in a major hospital and other organizations. These studies in higher education and libraries, and the mature IS literature on barriers and drivers to OSS adoption present a useful framework for OSS adoption research in U.S. academic libraries.

Beyond the balance sheet of actual barriers and drivers, user perceptions of OSS are also important in relation to awareness, adoption intent, and adoption level. From the broader context

of higher education software, van Rooij (2007b) observed that CIOs and CAOs have fears about proprietary education software vendors' market position, especially regarding price increases and lack of software functionality, and perceive OSS as a community-driven "counterpoint" to vendors. The same CAO respondents also viewed the number and skill of internal IT staff as crucial for a successful OSS project, and CIO respondents felt concern about enduring support and development. Rafiq (2009) found that libraries have a mostly positive perception toward library OSS, although private-sector libraries see less functionality than their public-sector counterparts. From the same study, libraries in developed countries are significantly more likely than their counterparts in developing countries to associate OSS with library philosophy, improved library expertise and skills, variable support commitments, but poor documentation; and conversely, libraries in developing countries are significantly more likely than their counterparts in developed countries to view OSS as cheaper but less functionally rich, than proprietary software. Staff in one consortium of public libraries had already adopted an open source ILS, Evergreen, and claimed more functionality than the previous ILS for creating reports, looking up patron information, checking resources from other consortium libraries, and reserving materials; but had misgivings about Evergreen's slow "system response times", and certain usability issues (Barbara and Hsin-liang, 2014). Dalling (2011, p. 43) also studied librarian perceptions of open source ILS and found that UK academic libraries are reluctant or prefer not to switch from proprietary ILS vendors, and approach OSS conservatively – preferably through peer feedback. However, many of those respondents have considered and are excited about aspects of OSS adoption, and apprehensions come from lack of in-house skills and libraries' lack of familiarity with OSS. In India, most librarians are aware of and support OSS for various reasons but cite a lack of in-house capability to adopt the popular open source ILS, Koha

(Gireesh Kumar and Jayapradeep, 2015). In a more recent mixed-method study (survey and interview) of the top 20 academic and 20 research libraries in China, Jabeen et al. (2018) found ample interest in OSS, but their lack of in-house expertise and training stifled adoption. Some common threads in these studies that examine perceptions are 1) that higher education and libraries are generally aware of OSS and 2) libraries and higher education organizations have more positive perceptions of OSS in conjunction with in-house skills and external support and hosting options.

We survey the US academic libraries' CIOs, CTOs, or heads for IT to identify drivers and barriers to library OSS adoption in these institutions. From the same sample, we derive the current state of library OSS adoption (i.e., awareness and adoption stage or intention), and how characteristics of each library's parent institution (i.e., institution type: public or private, and degrees offered) relate to the research variables. The generalizability from this study will inform stakeholder actions and encourage library OSS adoption.

3. Method

3.1. Data collection and measures

The National Center for Education Statistics (NCES) conducts a nationwide biannual survey of about 3,700 postsecondary institutions and offers an overview of U.S. academic libraries (https://nces.ed.gov/surveys/libraries/academic.asp). The list of institutions, with their website addresses (N = 3,668), was obtained from the center. Email addresses of library CIOs, CTOs, or heads for IT were collected manually from those websites. Library deans' or directors' email addresses were collected, and they were requested to forward the survey invitation to their CIOs, CTOs, or heads for IT. This was to increase the survey's reach. A total of 4,486 survey

invitations were sent on July 15, 2015, that included 1,810 library CIOs, CTOs, or heads for IT and 2,676 library deans or directors. The survey was closed after two weeks. A set of 179 valid responses were collected. As an incentive, survey participants could enter to win one of five $50 Amazon gift cards. The survey questionnaire was developed based on extant OSS research, with both close- and open-ended questions (e.g., Kuechler *et al.*, 2013; Glynn *et al.*, 2005; Paré *et al.*, 2009; Rafiq, 2009; van Rooij, 2007a). We have included the questionnaire in the Appendix.

3.2. Descriptive statistics

Table 1 shows the sample, which consists of 80 public (45.0%) and 99 private (55.0%) institutions. This spread is very similar to the latest NCES survey, which lists 41% as public and 59% as private (Phan et al., 2014, p 4). According to the Carnegie Classification of Institutions of Higher Education, 'degrees offered' has five categories: Doctoral/research, masters, baccalaureate, community colleges, and trade and vocational institutions (van Rooij, 2007a, p. 196). That doctoral/research institutions represent 21.2% of our respondents, yet comprise 8% of all academic libraries, and that masters institutions represent 41.3% of our respondents, yet comprise 17.0% all academic libraries (see Phan, 2014, p. 4), might indicate that research-oriented institutions are more interested in OSS and thus show greater participation in the survey (see van Rooij, 2007a).

[Insert Table 1 here]

4. Findings and discussion

In this section, we discuss the implementation of OSS in US academic libraries from the following perspectives: key barriers and drivers, awareness, current use, level of use, and intent to adopt.

4.1. Barriers

To determine OSS adoption barriers, survey respondents were asked how they agree with each of 15 statements (factors B1 to B15) on a scale of 1 to 7, where 1 was strongly disagree, 4 was neither agree nor disagree, and 7 was strongly agree. The battery of 15 statements were derived from the literature mentioned in the method section (3.1).

The means for B2-B11, and B14-B15 (see Table 2) were higher than the neutral point of four, confirming that the majority of respondents considered those factors as barriers to adopting OSS in their libraries.

The means for factors B13 and B12 were only slightly below the neutral point (3.93 and 3.79, respectively). B1 was close to "somewhat disagree" (3.26). Later, section 4.3 illustrates the consistency of B1 with data from tables 8 and 9; the means for the two awareness items were higher than 5, indicating that awareness is not a serious concern for OSS adoption in academic libraries.

Lack of staffing to maintain OSS (B6) received the highest mean (5.92). Academic library CIOs, CTOs, or heads for IT likely perceive that OSS adoption requires additional staff. Lack of technical expertise to implement and customize OSS (B7) procured the next highest mean (5.58). A number of previous studies have noted this barrier within libraries and other contexts (e.g., Chau and Tam, 1997; Li *et al.*, 2005; Morgan and Finnegan, 2007; Nagy *et al.*, 2010; Paré *et al.*, 2009; Rafiq, 2009; Rafiq and Ameen, 2009). Choi and Pruett (2015) suggested

libraries recruit undergraduates from computer science (CS) departments, build dual-degree programs between CS and library science (MLS). Also, as iSchools and their MLS programs offer more courses in programming languages, libraries with barriers in technical expertise can advertise their needs to students who have taken such courses.

Lastly, we did not find any significant mean difference in any barrier (B1-B15) by institution type and degrees offered.

[Insert Table 2 here]

39 respondents answered an open-ended question that elicited barriers other than the 15 factors. Some answers addressed more than one barrier, and thus a total of 45 comments were analyzed.

Table 3 shows that 11 out of 45 comments reiterated the top three results from Table 2. Six comments (55.0%) posited a lack of staffing to maintain OSS (B6), four comments (36.0%) highlighted a lack of technical expertise to implement and customize OSS (B7), and one is related to concern over receiving support (B8). Thus, about 24% of comments (11/45) re-emphasized these three factors (B6, B7, B8) as the most significant and challenging barriers to library OSS adoption.

[Insert Table 3 here]

The remaining 34 comments described barriers unrelated to B1-B15. Table 4 lists 16 comments (47.1%) related to institutional-level issues such as control by centralized IT, university policies against OSS, etc. This suggests that academic libraries need their respective institution's support

for OSS adoption in policy and IT strategy. Another three barriers, that garnered two or three comments each, were: 1) consortium arrangements that used a proprietary product, 2) lack of favorable perception or support (apart from anti-OSS policies) from administration, and 3) scarce OSS adoption from peer institutions. Ten minor comments (10/34, 29.4%) fall in the 'other' category.

[Insert Table 4 here]

4.2. Drivers

To determine OSS adoption drivers, survey respondents were asked how they agree with each of 10 statements (factors D1 to D10) on a scale of 1 to 7, where 1 was strongly disagree, 4 was neither agree nor disagree, and 7 was strongly agree. The battery of 10 statements were derived from the literature mentioned in the method section (3.1).

Table 5 shows the means for drivers D2, D5, D4, D9, and D1 were above five – somewhat agree; and D10, D7, D3, D8, and D6 were above four – neither agree nor disagree. Therefore, all ten proposed drivers were found to positively influence OSS adoption in academic libraries.

Possibility to tailor (D2) and low cost (D5) scored the highest means. The literature often cites these two factors as critical drivers for OSS adoption (e.g., Macredie and Mijinyawa, 2011; Rafiq, 2009; van Rooij, 2007a). Higher education CIOs consider these two factors as most influential for their OSS adoption (van Rooij, 2007a). Similarly, UK higher education libraries perceived strong advantages in the possibility to tailor open source library management systems (LMSs) and the low cost of those systems (Dalling and Rafferty, 2013).

Three other drivers had mean scores over five. These include avoidance of vendor lock-in (D4), ability to download and test the software in advance (D9), and greater flexibility and functionality of OSS (D1). Extant research has also frequently discussed these motivators as important for OSS adoption (e.g., Dalling and Rafferty, 2013; Kuechler *et al.*, 2013; Ven *et al.*, 2007).

Lastly, we did not find any significant mean difference in any driver (D1-D10) by institution type and degrees offered.

[Insert Table 5 here]

The open-ended question soliciting other drivers (besides D1-D10) garnered 21 responses. Some responses addressed more than one driver, so the analysis included 29 comments. Table 6 shows that 9 out of 29 comments reiterated the top three drivers from Table 5. Four comments (44.4%) highlighted low cost (D5), three (33.3%) emphasized customizability (D2), and two (22.2%) noted avoidance of vendor lock-in (D4). Thus, 31% of the total comments emphasize these three factors (D2, D4, and D5) as the strongest drivers to library OSS adoption.

[Insert Table 6 here]

Most comments however (20/29, 69.0%), posited drivers other than D1-D10 (see Table 5). OSS ideology, the ability to innovate, and consortium participation drew three responses (3/20, 15%) each and are in Table 7. Administration and centralized IT, that are against OSS adoption, are more likely to resonate with library advocacy that highlights these three drivers, since the drivers

align with innovation goals in higher education (https://www.aau.edu/key-issues/innovation-competitiveness); and the Kuali community has set precedence for mission-critical OSS in the industry (https://kuali.org/about/). OSS ideology is often found to be an important driver for OSS development participation and adoption (e.g., Glynn *et al.*, 2005; Rafiq, 2009; Rafiq and Ameen, 2009; Stewart and Gosain, 2006). To strengthen Chudnov (1999) and Altman (2001)'s arguments from the literature review section, a mutual preference for open standards especially connects libraries and OSS ideology (see https://opensource.org/osr/; Coyle, 2002), and may have influenced responses in this area. Two comments (10.0%) claim support availability was an important driver. Finally, nine minor comments (45.0%), e.g., ease of use and supportive and vibrant user communities, fall in the 'other' category.

[Insert Table 7 here]

4.3. Awareness

Beyond barriers and drivers, this research presents the current state of OSS adoption in academic libraries. The IT managers' awareness of OSS is the first step for the respective organization to adopt the same (Glynn *et al.*, 2005). Therefore, we first assessed our respondents' level of awareness, and then, contingent on their use of OSS, examined their adoption level or intent to adopt.

To measure awareness, respondents were asked to rate their agreement with two similar statements on a scale of 1 - 'strongly disagree' to 7 - 'strongly agree'. The mid-point was 4 - 'neither agree nor disagree'.

The two statements included the words "often" and "well aware" to assess a higher level of awareness, since our respondents were CIOs, CTOs, or heads of IT at libraries and likely knew the basics of library OSS.

The mean scores for each awareness statement, in Table 8, were higher than 5 (AWA1: 5.04, AWA2: 5.29). Institution type and degrees offered did not significantly affect mean scores for level of awareness. However, Table 9 shows the means slightly increase from 'Associate' to 'Doctoral/Research'. This suggests CIOs, CTOs, or heads of IT in doctoral/research institutions may hear more often about library OSS. Results regarding awareness mirror a survey from van Rooij (2007a, p. 198) who found that out of all Carnegie Classifications, CAOs at 'associate' institutions were much more likely, and those at doctoral/research institutions were least likely, to be unaware of OSS.

[Insert Table 8 here]

[Insert Table 9 here]

4.4. Use

To investigate adoption level and the intent to adopt, we asked respondents (yes/no) if their library was currently using OSS. As Table 10 shows, slightly less than half of respondents (46.9%) confirmed its use. There were similar percentages of confirmed use for each institution type (Public - 51.2%; Private - 43.4%). When confirmed OSS use was cross tabulated with degrees offered (see Table 11), the doctoral/research institutions had a much higher percentage (71.1%) than associate level institutions (18.8%), and their masters and baccalaureate

counterparts had more evenly split results (47.3% and 47.1%, respectively). This is somewhat consistent with findings in section 4.3 and suggests that doctoral/research institutions use more library OSS than associate level institutions. Taken together that a disproportionate response rate from research-oriented institutions may be a proxy for interest in OSS (see section 3.2), and that non-doctoral institutions have lower adoption rates, it may be useful for OSS-related funders, companies, and consortia to focus their marketing and program development efforts toward non-doctoral institutions.

[Insert Table 10 here]

[Insert Table 11 here]

4.5. Adoption level

To further investigate adoption levels among confirmed library OSS adopters, we employed four levels of assimilation from Glynn *et al.* (2005) and asked respondents to choose the level that best described their library's adoption of OSS. The assimilation levels in descending order were general deployment, limited deployment, commitment, and evaluation/trial. The original survey instrument from Glynn *et al.* (2005) included two additional levels of assimilation, interest and awareness. This study omits these two levels, since they only assess those in the pre-adoption state.

Over half of confirmed library OSS adopters (44/84, 52.4%) indicated they were in the general deployment phase, i.e. using OSS for a core library IS (see Table 12). A notable group of libraries are in the 'commitment' phase (27.4%), i.e. committed to use OSS as a major component

of a library project. The lowest scoring assimilation levels were evaluation/trial (11.9%) and limited deployment (8.3%). If the majority who use library OSS are at the general deployment phase and 88% are past the evaluation/trial phase, then perhaps libraries become more loyal to library OSS products or development models once they commit to an OSS product. The bulk of libraries at the top adoption levels may verify success and can encourage non-adopters to join their peers.

[Insert Table 12 here]

Cross tabulation of adoption level with parent institution type (see Table 13) revealed that, for both public and private institutions, half were in the general deployment phase and the next largest number were in the commitment phase. Cross tabulation of adoption level with degrees offered (see Table 14) shows 63.0% of doctoral/research institutions and 40% of masters institutions were in the general deployment phase. There were not enough baccalaureate and associate institutions using library OSS to consider them in the analysis. Similar to the findings in sections 4.4 and 4.5, doctoral/research institutions seem more likely to attain general deployment of library OSS.

[Insert Table 13 here]

[Insert Table 14 here]

4.6. Future adoption intention

Respondents whose libraries do not use OSS were asked to rate their likelihood to adopt such on a scale of 1 - 'very unlikely' to 5 - 'very likely'. It was a surprise to find that about 80.0% chose either 'not sure', 'somewhat unlikely', or 'very unlikely' (see Table 15). The mean for the question regarding future intention to adopt was only 2.52 - lower than the neutral point of three, or 'not sure' (Table 16). This highlights the need to uncover what motivates academic libraries to re-consider library OSS adoption, and remedy barriers. It is also useful for future studies to distinguish future adoption intention and adoption-levels within library divisions. For example, library OSS may be concentrated in scholarly communications (e.g., institutional and data repositories, publishing platforms, researcher information systems) but less so in other areas. OSS-related funders, companies, and consortia can then align their offerings with growing library divisions.

[Insert Table 15 here]

5. Conclusion

More academic libraries are adopting OSS to reduce costs, eliminate dependence on commercial vendors, and more importantly, provide users with better-customized technologies. However, extant research is mostly case studies on well-known OSS products and provides anecdotal observations. From an online survey, this research offers insights with greater generalizability applicable to US academic libraries interested in adopting OSS. It snap-shots the current state of OSS adoption in US academic libraries and serves as a baseline for future research endeavor. Also, it provides funding agencies and administrators with guidelines to encourage successful deployment of OSS in higher education.

As a limitation of the study, we used catch-all terms such as library CIOs, CTOs, or heads for IT on our survey invitation. This may have negatively impacted our response rate. However, when the email addresses of those library CIOs, CTOs, or heads for IT were collected manually from their institution's websites, we looked for positions related to IT and information systems. The invitation also provided sufficient details about the study, and thus the invited library deans and directors were likely to have forwarded it to the appropriate person. In addition, as presented in section 3.2, the ratio of public vs. private institutions in our sample is very similar to the latest NCES survey (Phan et al., 2014, p 4), indirectly supporting the representativeness of the our sample.

From the survey, the most significant barriers to OSS adoption in US academic libraries are lack of staffing to maintain OSS and lack of technical expertise to implement and customize OSS. The most significant drivers are the possibility to tailor and low cost. Our open-ended questions disclose several additional barriers and drivers. We recommend that academic libraries consult these identified barriers and drivers when considering OSS adoption. Despite slight differences between Carnegie Classifications, respondents were highly aware of OSS, and awareness is not a concern at this time. Half of respondents said they currently use an OSS product(s) in their libraries, which is encouraging. However, associate level institutions use OSS much less than doctoral/research institutions. We suggest future research that investigates how to close this gap. Our findings in section 4.5 suggest academic libraries may become more loyal to OSS products once they commit to an OSS product. Promoting these findings in the academic library community could help raise adoption interests among non-adopters. From section 4.6, we were surprised at the determination of non-adopters to stay as such. Delving into ways to foster

OSS adoption in these institutions and a more granular observation of OSS in various library

divisions are important directions for future research.

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Appendix. Survey questionnaire

Institution type and degrees offered

Q1. What is the type of your parent institution?

❑ Public
❑ Private

Q2-1. Please choose one of the categories below that best describes your parent institution:

❑ Doctoral/Research with undergraduate and graduate programs
❑ Masters with undergraduate and selected graduate programs
❑ Baccalaureate with no graduate programs
❑ Two-year institution offering Associate degrees such as public community colleges as well as private non-profit and for-profit trade and vocational institutions
❑ Other

Q2-2. If you have chosen "other" in the above question, please specify:

Barriers (1: Strongly Disagree; 7: Strongly Agree)

Q3-1. Barriers to OSS adoption in your library:

B1. Lack of awareness of OSS availability
B2. Prior investments in proprietary software
B3. Lack of budget
B4. Poor documentation
B5. Concern over the quality of OSS
B6. Lack of staffing to maintain OSS
B7. Lack of technical expertise to implement and customize OSS
B8. Concern over receiving support
B9. Concern over compatibility of OSS with the current systems
B10. Lack of employees who possess understanding of OSS and aid its introduction (e.g., boundary spanners)
B11. Lack of user-friendliness of OSS compared to proprietary software
B12. Lack of control over the OSS development community
B13. Favorable arrangement with a proprietary vendor (e.g., bulk purchasing discount)
B14. Lack of software specification and hardware-support from vendors for OSS
B15. Lack of organizational innovativeness (e.g., resistance to change)

Q3-2 If you can think of any other barriers, please specify:

Drivers (1: Strongly Disagree; 7: Strongly Agree)

Q4-1. Driver to OSS adoption in your library:

D1. Greater flexibility and functionality of OSS
D2. Possibility to tailor to your library's specific needs
D3. Top management support
D4. Avoidance of vendor lock-in
D5. Low cost (e.g., license cost-saving)
D6. Greater security
D7. Favorable market condition for OSS adoption
D8. Potential to support niche and legacy systems
D9. Ability to download and test the software in advance
D10. Independence from suppliers in choosing support and maintenance

Q4-2. If you can think of any other drivers, please specify:

Awareness (1: Strongly Disagree; 7: Strongly Agree)

Q5. Awareness

AWA1. I often see or hear information about library OSS.
AWA2. I am well aware of OSS availability for libraries.

Use, adoption level, and future adoption intention

Q6-1. Is your library currently using an OSS product(s)?

❑ Yes
❑ No

Q6-2. If yes to the above question, please choose one of the levels below that best describes your library's OSS adoption state:

❑ Our library has adopted specific OSS products and has initiated evaluation or trial
❑ Our library has committed to use a specific OSS product in significant way or for a production project
❑ Our library has established a program of regular but limited use of the OSS product
❑ Our library is using OSS products for at least one large and mission critical system

Q6-3 If no to the above question, how likely is your library to adopt OSS in the near feature?

❑ Very unlikely
❑ Somewhat unlikely
❑ Not sure
❑ Somewhat likely
❑ Very likely

Table 1. Institution type and degrees offered

	Public		Private		Total respondents	
	Freq.	%	Freq.	%	Freq.	%
Degree						
Doctoral/Research	24	30.0	14	14.1	38	21.2
Masters	21	26.3	53	53.5	74	41.3
Baccalaureate	4	5.0	13	13.1	17	9.5
Associate	29	36.3	3	3.0	32	17.9
Other	2	2.5	16	16.2	18	10.1
Total	80	100	99	100	179	100

Table 2. Barriers to OSS adoption

Barriers	N	Mean	S.D.
Lack of staffing to maintain OSS (B6)	179	5.92	1.39
Lack of technical expertise to implement and customize OSS (B7)	179	5.58	1.67
Concern over receiving support (B8)	179	5.35	1.49
Prior investments in proprietary software (B2)	179	5.11	1.52
Lack of employees who possess understanding of OSS and aid its introduction (e.g., boundary spanners) (B10)	179	4.97	1.81
Concern over compatibility of OSS with the current systems (B9)	179	4.78	1.64
Concern over the quality of OSS (B5)	179	4.56	1.60
Lack of budget (B3)	179	4.32	1.83
Poor documentation (B4)	178	4.29	1.33
Lack of user-friendliness of OSS compared to proprietary software (B11)	179	4.26	1.64
Lack of software specification and hardware-support from vendors for OSS (B14)	179	4.25	1.54
Lack of organizational innovativeness (e.g., resistance to change) (B15)	179	4.01	1.77
Favorable arrangement with a proprietary vendor (e.g., bulk purchasing discount) (B13)	179	3.93	1.62
Lack of control over the OSS development community (B12)	179	3.79	1.58
Lack of awareness of OSS availability (B1)	179	3.26	1.82

Table 3. Comments reiterating the barriers in Table 2

Barriers	Freq.	%	Sample comments
B6	6	55.0	- *We have a lack of IT staff. Our 3 IT employees service the entire institution and we have 2 only 2 library employees. Lack of time is the greatest challenge.* - *Size of staff, other responsibilities and activities means there is not enough time to implement, troubleshoot, customize or provide ongoing monitoring and maintenance.* - *Ours are largely based on lack of IT staffing.*

B7	4	36.0	- There is also the risk of getting "over our heads" with technology we don't quite understand, possibly eroding trust of our colleagues in the library or in campus IT. - Customize the code to be special in our own right. In other words, to have a unique quality.
B8	1	9.0	- The user community has reason to be responsive to the community as a whole, but no reason to be responsive to individual customers. For-profit organizations must keep their customers happy; non-profit (e.g., open-source) communities don't have that incentive.
Total	11	100.0	

Table 4. Other barriers

Barriers	Freq.	%	Sample comments
Institutional-level issues	16	47.1	- Although library IT staff have expertise in OSS, we have centralized IT at our institution who are less familiar with such solutions and tend to actively resist implementing them. - Lack of institutional standards. - University policies against open source. - We have centralized IT and our IT department is very against adopting open source technologies because they do not have the staff to maintain it. - University System provided software, local selection is not always possible. - We have to get campus IT to agree to let us use OSS, and then they have to find the time to load and customize whatever it is that we want to use.
Part of a consortium	3	8.8	- We are in a consortium for our automation system. Although we have a voice in changing to a new one, it would take a committee to move to an OSS system. - Involvement with a state consortium that has chosen a proprietary product.
Administration-related issues	3	8.8	- Lack of administrative support is big issue as well. - Perception of administrators.
Lack of peer OSS adoption	2	5.9	- Lack of peer OSS adoption as a fall back for their feedback and input. - No models among our peers in the state.
Other	10	29.4	- Security concerns. - Fear of frequent changes to the OSS. - The fact that we need to make an upfront commiment [sic] to OSS community around the expectation of advanced commitment to development. It is hard to make the resource commitment, e.g. lots of unknowns. - Concern over ongoing stability of OSS products (i.e. will they still be developed and supported 5-10 years from now) - It's system specific, but a generalized lack of options with enough development to meet current needs - ie: ILS systems.

Total	34	100.0	

Table 5. Drivers to OSS adoption

Drivers	N	Mean	S.D.
Possibility to tailor to your library's specific needs (D2)	179	5.44	1.18
Low cost (e.g., license cost-saving) (D5)	179	5.44	1.40
Avoidance of vendor lock-in (D4)	179	5.21	1.25
Ability to download and test the software in advance (D9)	179	5.12	1.33
Greater flexibility and functionality of OSS (D1)	179	5.09	1.20
Independence from suppliers in choosing support and maintenance (D10)	179	4.99	1.30
Favorable market condition for OSS adoption (D7)	179	4.45	1.16
Top management support (D3)	179	4.39	1.54
Potential to support niche and legacy systems (D8)	179	4.38	1.28
Greater security (D6)	179	4.03	1.27

Table 6. Comments reiterating the drivers in Table 5

Barriers	Freq.	%	Sample comments
D5	4	44.4	- *Cost savings has been the primary driving force for our OSS adoption.* - *Cost is number one driver by a very large margin.* - *could lower total operational costs*
D2	3	33.3	- *I also like the amount of control we gain over the system, how it looks, how it acts, customization, etc.* - *could address specific library needs not currently provided by vendor.*
D4	2	22.2	- *Alternative to the major vendors.* - *free from vendor lock-in*
Total	9	100.0	

Table 7. Other drivers

Drivers	Freq.	%	Sample comments
OSS ideology	3	15.0	- *Philosophical preference for open source over proprietary software.* - *Perhaps the greatest driver is an ethical one; supporting OSS is consistent with library ideals like open access.*
Ability to innovate	3	15.0	- *Being able to innovate.* - *Ability to innovate based on local needs, but not necessary related to the system itself, but to the greater ecosystem of related systems.*
Part of a consortium	3	15.0	- *Opportunity to participate in consortial [sic] partnerships. We seek to improve services by working with others.* - *We're in a consortium of small libraries which means a solution discovered at one library could be shared at minimal cost with our consortium partners.*

Support availability	2	10.0	*- Availabililty [sic] of support providers - competition keeps support cost down* *- Again - the factor is the hosting/managing vendor.*
Other	9	45.0	*- Availability of OSS applications of specific interest.* *- ease of use and quick learning curve* *- supportive and vibrant user sharing communities (listservs, blogs, etc.)* *- learning self-reliance* *- building community by establishing ties through their peers*
Total	20	100.0	

Table 8. Institution type and awareness

	I often see or hear information about library OSS (AWA1)			I am well aware of OSS availability for libraries (AWA2)		
	N	Mean	S.D.	N	Mean	S.D.
Type						
Public	80	4.98	1.51	80	5.31	1.43
Private	99	5.09	1.54	99	5.27	1.43
Total	179	5.04	1.52	179	5.29	1.42

Table 9. Degrees offered and awareness

	I often see or hear information about library OSS (AWA1)			I am well aware of OSS availability for libraries (AWA2)		
	N	Mean	S.D.	N	Mean	S.D.
Degree						
Doctoral/Research	38	5.32	1.40	38	5.50	1.31
Masters	74	5.18	1.41	74	5.38	1.38
Baccalaureate	17	5.00	1.80	17	5.18	1.33
Associate	32	4.47	1.65	32	4.91	1.71
Other	18	4.94	1.63	18	5.28	1.36
Total	179	5.04	1.52	179	5.29	1.42

Table 10. Institution type and use

		Use		Total
		Yes	No	
Type				
Public	Count	41	39	80
	% within Type	51.2%	48.8%	100.0%
	% within Use	48.8%	41.1%	44.7%
	% of Total	22.9%	21.8%	44.7%
Private	Count	43	56	99

		% within Type	43.4%	56.6%	100.0%
		% within Use	51.2%	58.9%	55.3%
		% of Total	24.0%	31.3%	55.3%
Total	Count		84	95	179
	% within Type		46.9%	53.1%	100.0%
	% within Use		100.0%	100.0%	100.0%
	% of Total		46.9%	53.1%	100.0%

Table 11. Degrees offered and use

		Use		Total
		Yes	No	
Degree				
Doctoral/Research	Count	27	11	38
	% within Degree	71.1%	28.9%	100.0%
	% within Use	32.1%	11.6%	21.2%
	% of Total	15.1%	6.1%	21.2%
Masters	Count	35	39	74
	% within Degree	47.3%	52.7%	100.0%
	% within Use	41.7%	41.1%	41.3%
	% of Total	19.6%	21.8%	41.3%
Baccalaureate	Count	8	9	17
	% within Degree	47.1%	52.9%	100.0%
	% within Use	9.5%	9.5%	9.5%
	% of Total	4.5%	5.0%	9.5%
Associate	Count	6	26	32
	% within Degree	18.8%	81.3%	100.0%
	% within Use	7.1%	27.4%	17.9%
	% of Total	3.4%	14.5%	17.9%
Other	Count	8	10	18
	% within Degree	44.4%	55.6%	100.0%
	% within Use	9.5%	10.5%	10.1%
	% of Total	4.5%	5.6%	10.1%
Total	Count	84	95	179
	% within Degree	46.9%	53.1%	100.0%
	% within Use	100.0%	100.0%	100.0%
	% of Total	46.9%	53.1%	100.0%

Table 12. Adoption level

Use level	Freq.	%
Our library is using OSS products for at least one large and mission critical system (General Deployment)	44	52.4
Our library has committed to use a specific OSS product in significant way or for a production project (Commitment)	23	27.4

Our library has adopted specific OSS products and has initiated evaluation or trial (Evaluation/Trial)				10	11.9
Our library has established a program of regular but limited use of the OSS product (Limited Deployment)				7	8.3
Total				84	100

Table 13. Institution type and adoption level

Type		Use level				Total
		(1)	(2)	(3)	(4)	
Public	Count	4	13	2	22	41
	% within Type	9.8%	31.7%	4.9%	53.7%	100.0%
	% within Use level	40.0%	56.5%	28.6%	50.0%	48.8%
	% of Total	4.8%	15.5%	2.4%	26.2%	48.8%
Private	Count	6	10	5	22	43
	% within Type	14.0%	23.3%	11.6%	51.2%	100.0%
	% within Use level	60.0%	43.5%	71.4%	50.0%	51.2%
	% of Total	7.1%	11.9%	6.0%	26.2%	51.2%
Total	Count	10	23	7	44	84
	% within Type	11.9%	27.4%	8.3%	52.4%	100.0%
	% within Use level	100.0%	100.0%	100.0%	100.0%	100.0%
	% of Total	11.9%	27.4%	8.3%	52.4%	100.0%

(1) Evaluation/Trial, (2) Commitment, (3) Limited Deployment, (4) General Deployment

Table 14. Degrees offered and adoption level

Degree		Use level				Total
		(1)	(2)	(3)	(4)	
Doctoral/Research	Count	3	6	1	17	27
	% within Degree	11.1%	22.2%	3.7%	63.0%	100.0%
	% within Use level	30.0%	26.1%	14.3%	38.6%	32.1%
	% of Total	3.6%	7.1%	1.2%	20.2%	32.1%
Masters	Count	5	12	4	14	35
	% within Degree	14.3%	34.3%	11.4%	40.0%	100.0%
	% within Use level	50.0%	52.2%	57.1%	31.8%	41.7%
	% of Total	6.0%	14.3%	4.8%	16.7%	41.7%
Baccalaureate	Count	1	2	1	4	8
	% within Degree	12.5%	25.0%	12.5%	50.0%	100.0%
	% within Use level	10.0%	8.7%	14.3%	9.1%	9.5%

		(1)	(2)	(3)	(4)	Total
	% of Total	1.2%	2.4%	1.2%	4.8%	9.5%
Associate	Count	0	1	0	5	6
	% within Degree	0.0%	16.7%	0.0%	83.3%	100.0%
	% within Use level	0.0%	4.3%	0.0%	11.4%	7.1%
	% of Total	0.0%	1.2%	0.0%	6.0%	7.1%
Other	Count	1	2	1	4	8
	% within Degree	12.5%	25.0%	12.5%	50.0%	100.0%
	% within Use level	10.0%	8.7%	14.3%	9.1%	9.5%
	% of Total	1.2%	2.4%	1.2%	4.8%	9.5%
Total	Count	10	23	7	44	84
	% within Degree	11.9%	27.4%	8.3%	52.4%	100.0%
	% within Use level	100.0%	100.0%	100.0%	100.0%	100.0%
	% of Total	11.9%	27.4%	8.3%	52.4%	100.0%

(1) Evaluation/Trial, (2) Commitment, (3) Limited Deployment, (4) General Deployment

Table 15. Future adoption intention

Future intention	Freq.	%
Very unlikely	19	20.0
Somewhat unlikely	29	30.5
Not sure	27	28.4
Somewhat likely	19	20.0
Very likely	1	1.1
Total	95	100.0

Table 16. Institution type, degrees offered, and future adoption intention

	N	Mean	S.D.		N	Mean	S.D.
Type				Degree			
Public	39	2.59	1.14	Doctoral/Research	11	2.00	1.00
Private	56	2.46	1.01	Masters	39	2.38	0.99
				Baccalaureate	9	2.89	0.78
				Associate	26	2.77	1.21
				Other	10	2.60	1.08
Total	95	2.52	1.06	Total	95	2.52	1.06

Appendix. Survey questionnaire

Institution type and degrees offered

Q1. What is the type of your parent institution?

❑ Public
❑ Private

Q2-1. Please choose one of the categories below that best describes your parent institution:

❑ Doctoral/Research with undergraduate and graduate programs
❑ Masters with undergraduate and selected graduate programs
❑ Baccalaureate with no graduate programs
❑ Two-year institution offering Associate degrees such as public community colleges as well as private non-profit and for-profit trade and vocational institutions
❑ Other

Q2-2. If you have chosen "other" in the above question, please specify:

Barriers (1: Strongly Disagree; 7: Strongly Agree)

Q3-1. Barriers to OSS adoption in your library:

B1. Lack of awareness of OSS availability
B2. Prior investments in proprietary software
B3. Lack of budget
B4. Poor documentation
B5. Concern over the quality of OSS
B6. Lack of staffing to maintain OSS
B7. Lack of technical expertise to implement and customize OSS
B8. Concern over receiving support
B9. Concern over compatibility of OSS with the current systems
B10. Lack of employees who possess understanding of OSS and aid its introduction (e.g., boundary spanners)
B11. Lack of user-friendliness of OSS compared to proprietary software
B12. Lack of control over the OSS development community
B13. Favorable arrangement with a proprietary vendor (e.g., bulk purchasing discount)
B14. Lack of software specification and hardware-support from vendors for OSS
B15. Lack of organizational innovativeness (e.g., resistance to change)

Q3-2 If you can think of any other barriers, please specify:

Drivers (1: Strongly Disagree; 7: Strongly Agree)

Q4-1. Driver to OSS adoption in your library:

D1. Greater flexibility and functionality of OSS
D2. Possibility to tailor to your library's specific needs

D3. Top management support
D4. Avoidance of vendor lock-in
D5. Low cost (e.g., license cost-saving)
D6. Greater security
D7. Favorable market condition for OSS adoption
D8. Potential to support niche and legacy systems
D9. Ability to download and test the software in advance
D10. Independence from suppliers in choosing support and maintenance

Q4-2. If you can think of any other drivers, please specify:

Awareness (1: Strongly Disagree; 7: Strongly Agree)

Q5. Awareness

AWA1. I often see or hear information about library OSS.
AWA2. I am well aware of OSS availability for libraries.

Use, adoption level, and future adoption intention

Q6-1. Is your library currently using an OSS product(s)?

- ❑ Yes
- ❑ No

Q6-2. If yes to the above question, please choose one of the levels below that best describes your library's OSS adoption state:

- ❑ Our library has adopted specific OSS products and has initiated evaluation or trial
- ❑ Our library has committed to use a specific OSS product in significant way or for a production project
- ❑ Our library has established a program of regular but limited use of the OSS product
- ❑ Our library is using OSS products for at least one large and mission critical system

Q6-3 If no to the above question, how likely is your library to adopt OSS in the near feature?

- ❑ Very unlikely
- ❑ Somewhat unlikely
- ❑ Not sure
- ❑ Somewhat likely
- ❑ Very likely