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Improving Library Efficiency to Meet Patron's Needs: A Data Envelopment Analysis Benchmarking Model

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Abstract--Technological innovation and the information age have increased patrons' expectations of the services and resources that academic libraries provide. Libraries are responding to patrons' needs by providing digital resources and services, and collaborative spaces that invite communication and knowledge sharing. In order to effectively meet patrons' needs, libraries are striving to efficiently manage their human, materials, and fiscal resources.

Libraries have traditionally measured efficiency by developing single factor productivity indexes. However, these qualitative methods do not adequately address the efficiency aspect which measures the transformation of resources (inputs) into services (outputs). Data envelopment analysis (DEA) measures the relative efficiencies of a decision making unit with multiple inputs and outputs. The DEA methodology has been applied to libraries over the past twenty years.

This paper proposes a DEA evaluation model that faculty, in their advisory and advocacy shared governance roles, can employ to strengthen their libraries. The model is demonstrated by analyzing the efficiency of the Portland State University Branford Price Millar Library to its peer institution libraries for the academic year 2011-2012.

I. INTRODUCTION

The information age has significantly impacted academic libraries roles in higher education. Patrons' diverse needs require that academic libraries provide dynamic services and resources. Within budget constraints, academic libraries are exploring the appropriate mix of human resources and material collections needed to effectively and efficiently meet patrons' complex needs.

Historically, many librarians have measured library efficiency through qualitative patron surveys and single factor productivity indexes. Despite the application of data envelopment methods to libraries by economists and operations researchers, there has not been widespread adoption by librarians due to the complexity. The goal of this study is to present a data envelopment analysis (DEA) evaluation model that librarians can understand, adapt, and use in analyzing the efficiencies of their libraries.

II. LITERATURE REVIEW

Over the past two decades, patrons' needs have shifted academic libraries' priorities from capital-intensive to human resources and information-intensive [1]. Library space is transitioning from book and serial stacks to collaborative spaces for working, accessing information and communicating with colleagues [2]. Advances in technology have introduced an array of virtual services and digital

resources [3]. Patrons expect that library staff will be available 24/7 and skilled in navigating and managing complex information. Libraries are expected to efficiently contain costs and to effectively maximize the educational impact for students [4].

The library literature has primarily focused on the effectiveness aspect of libraries by assessing which services meet the expectations of patrons [4][5][6]. These qualitative assessments provide useful information for strategic planning and quality improvement processes. However, these methods do not adequately address the efficiency aspect which measures the transformation of resources (inputs) into services (outputs) [4].

Librarians have traditionally measured efficiency by developing single factor productivity indexes [7]. For example, a per unit circulation transaction cost is calculated by several libraries. The library with the lowest per unit circulation transaction cost becomes the efficient standard that all other libraries should strive to emulate. However, libraries serve patron populations with diverse needs and may not need to provide the same type or level of service as other libraries [8]. For example, a library may invest a higher level of resources in processing interlibrary loan transactions and less on purchasing new materials for the collection. Another issue is that a single factor productivity index only measures one area of a library's performance. It is challenging to combine several single factors to measure total library efficiency because each library would need to assign relative weights that reflect the level of service they provide [9]. The data envelopment analysis model (DEA) addresses many of the limitations of single factor productivity indexes.

DEA measures the relative efficiencies of a decision making unit (DMU) with multiple inputs and outputs [10]. Each library being compared is a single DMU. All DMUs are compared to each other to identify an efficiency frontier. DMUs on the efficiency frontier are operating at full efficiency. All DMUs receive an efficiency score for comparison purposes. DEA allows the weights of each input and output to vary until an ideal combination is identified that will maximize each DMU's efficiency score. Set weight restrictions can be added to inputs and outputs, but are not required.

Since its inception in 1978 by Charnes, Cooper, and Rhodes, DEA has been used in over 1500 studies to compare banks, schools, hospitals, libraries and other institutions [10][11]. The methodology and application is well established in the areas of operations research and economics [12][13][14][15]. Within the field of economics, DEA has been applied to primarily public libraries in the United

Kingdom, Australia and the United States since the early 1990's [16][17][18][19]. Chen's DEA model, from an economics perspective, examined the efficiency of academic libraries in Taiwan [19]. Easun's California public school libraries DEA model is the first published study of DEA within the field of library and information science [16]. Shim's U.S. ARL (Association of Research Libraries) members DEA model is the only academic libraries DEA study published within the field of library and information science [4]. Despite these studies, DEA has not been widely adopted within the field of library and information science. Shim suggests that this is due to the majority of DEA research about libraries being published by non-librarians outside the library and information science literature [4].

DEA is an appropriate methodology for library benchmarking for the following reasons: 1) It assesses efficiency based on multiple inputs and outputs without requiring output price or profit data, 2) It quantifies inefficiencies and shows a target to reach full efficiency, and 3) It identifies best practice libraries and encourages continuous learning processes to improve [20].

III. METHODS

This study analyzes the efficiency of the PSU Library compared to its peer institution libraries for the academic year 2011-2012. Data is from the U.S. Department of Education's National Center for Education Statistics Academic Libraries Survey [21]. The peer libraries are determined by PSU's Office of Institutional Research and Planning (OIRP) and by the Carnegie Classification of Institutions of Higher Education. Comparable universities were identified by the following Carnegie classification criteria: Public control, doctoral graduate program(s), high to very high research activity, having similar mission statements, and being located in the western United States.

PSU OIRP identified 9 competing libraries from public, urban research universities in the United States: George Mason University (GMU), Indiana University/Purdue University at Indianapolis (IUPUI), San Diego State University (SDSU), The University of Texas at Arlington (UTA), University of Illinois at Chicago (UIC), University of Memphis (UM), University of Toledo (UT), University of Wisconsin at Milwaukee (UWM), and Western Michigan University (WMU) [22].

The Carnegie Classification of Institutions of Higher Education identified 26 competing libraries from public, research universities with doctoral programs in the western United States: University of Alaska-Fairbanks (UA-F), Arizona State University (ASU), University of Arizona (UA), Northern Arizona University (NAU), California State University-Sacramento (CSU-S), San Francisco State University (SFSU), Idaho State University (ISU), University of Idaho (UI), The University of Montana (TUM), Montana State University (MSU), University of Nevada-Las Vegas (UN-LV), University of Nevada-Reno (UN-R), Oregon State

University (OSU), University of Oregon (UO), Utah State University (USU), University of Utah (UU), University of Washington-Seattle (UW-S), Washington State University (WSU), University of California-Berkeley (UC-B), University of California-Davis (UC-D), University of California-Irvine (UC-I), University of California-Los Angeles (UC-LA), University of California-Riverside (UC-R), University of California-San Diego (UC-SD), University of California-Santa Barbara (UC-SB), and University of California-Santa Cruz (UC-SC) [23]. Due to incomplete reported data, University of California-Berkeley was excluded from analysis.

Data Envelopment Analysis (DEA) was selected as the appropriate research methodology to benchmark the PSU Library. As previously mentioned, DEA has been used in several published benchmarking studies of libraries [24][16][17][4][18][19][25]. These studies and discussions with fellow librarians provided insights into the development of the three models and the appropriate selection of specific inputs and outputs. An input orientation was selected due to the pressure on libraries to reduce the resources (inputs) they use to provide quality services and resources (outputs) to their patrons. Super-efficiency with constant returns to scale was added to the models to provide an efficiency ranking for all libraries (DMUs). Super-efficiency is a tie-breaking process for ranking efficient libraries (DMUs) by excluding the library (DMU) being evaluated from its peers [26][27]. The models were run through the Benchmarking package in the statistical software program R Studio [28].

A. Human Resources Model

The human resources model compares how efficiently libraries utilize their staff in providing services and resources (Fig. 1). The inputs include: Weighted total professional librarian and staff FTE, weighted total support staff FTE, and total student staff FTE. Professional staff generally have more service capability than support staff and student staff. A weight restriction was applied in the model where weighted total professional librarian and staff FTE equaled the sum of total professional librarian and staff FTE plus total support staff FTE plus total student staff FTE. Support staff generally have more service capability than student staff. Another weight restriction was applied where weighted total support staff FTE equaled the sum of total support staff FTE plus total student staff FTE.

The outputs include: Total interlibrary loans (ILL) transactions provided, total ILL transactions received, total circulation transactions, total workshop attendance, total weekly service hours, total weekly gate count, and total books and serials purchased. Support and student staff generally process ILL transactions, circulations transactions, assist with adding new book and serials to the collection, and staff service desks. Professional librarian and other staff develop and present workshops, engage in collection development activities including adding books and serials to the collection, and staff reference desks.

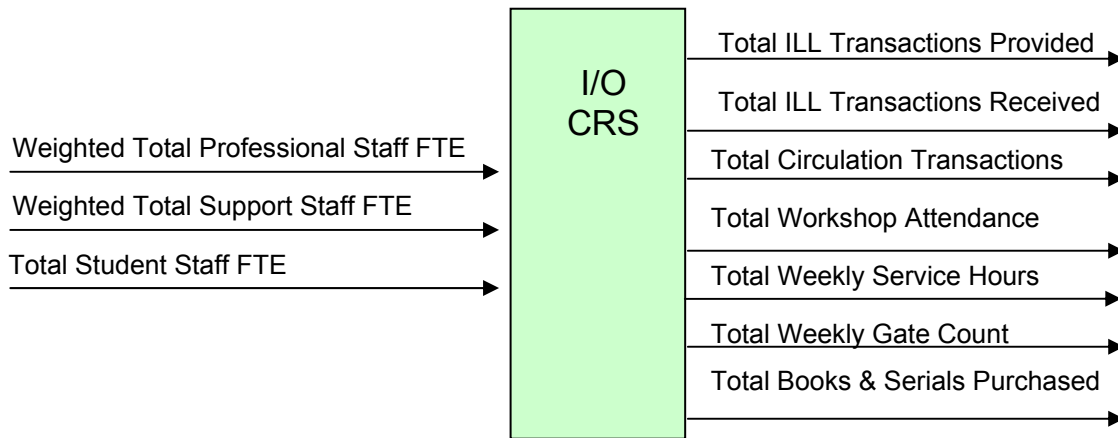


Figure 1. Human Resources Model

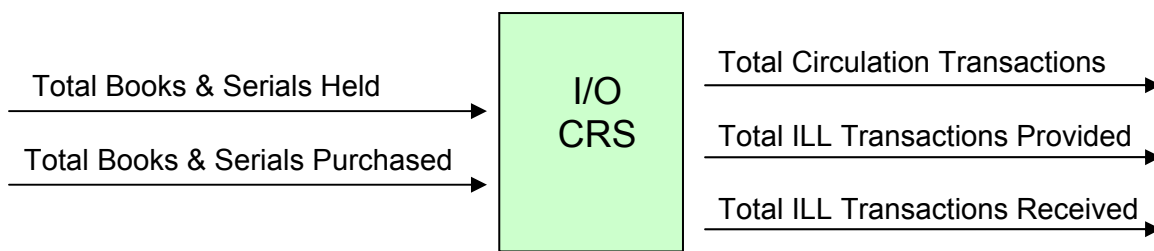


Figure 2 Materials Model

B. Materials Model

The materials model compares how efficiently libraries convert their holdings into use by patrons (Fig. 2). The inputs include: Total books and serials held, and total books and serials purchased. The outputs include: Total interlibrary loans (ILL) transactions provided, total ILL transactions received and total circulation transactions. Efficient collection development practices ensure better access and increased circulation of scholarly resources.

C. Budget Model

The budget model compares how efficiently libraries allocate their budget between staff, material acquisitions, and service hours (Fig. 3). The input is total library expenditures. The outputs include: Weighted total professional librarian and staff FTE, weighted total support staff FTE, total student staff FTE, books and serials purchased, total weekly service hours, and total weekly gate count. The same weight restrictions, as in the human resource model, are applied to staff in this model. Personnel and materials acquisition costs are the primary expenditure drivers in library budgets. Weekly service hours and gate count reflect patron physical and virtual access to all library services and resources.

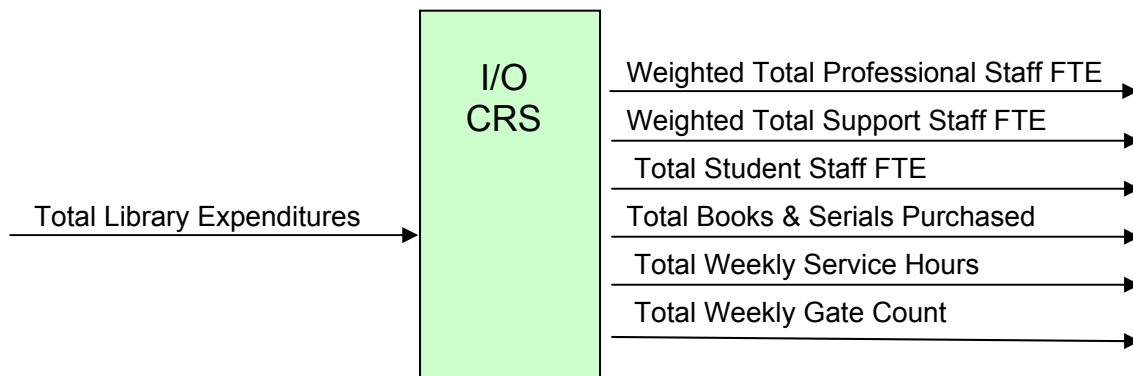


Figure 3 Budget Model

IV. ANALYSES AND RESULTS

A. Human Resources Model

The human resources model compares how efficiently libraries utilize their staff in providing services and resources (Fig. 4). The PSU Library had the highest super-efficiency score (1.7413) in the human resources model. A review of the data indicates that the PSU Library used a relatively small number of support staff and student FTE and had high collection usage, as reflected by ILL and circulation transactions. The UC-SB Library had the next highest super-efficiency score (1.7362). With twice as many staff as the PSU Library, the UC-SB Library's physical space and programming activities encourage approximately four times as many patrons to visit the library. However, UC-SB patrons are using the collection less than PSU Library patrons, according to total ILL and circulation transactions.

The PSU Library is identified as the primary peer for eight libraries (Table 1). These libraries could potentially learn human resources best practices from the PSU Library. The PSU Library has a higher super-efficiency score than its

top five peers. However, the PSU Library could potentially benefit from best practices with the following strategies:

- Increase the number of new serials and books added to the local collection by hiring additional librarians for collection development, and shifting appropriate tasks from the librarians to support and student staff. Consult with the UW-S Library and IUPUI Library for best practices.
- Increase circulation transactions by automating processes, shifting appropriate tasks to student staff, and completing implementation of the ORBIS consortia catalog. Consult with the SFSU Library and UW-S Library for best practices.
- Increase workshop attendance by hiring additional librarians to develop and provide information literacy training, and shifting appropriate tasks from the librarians to support and student staff. Consult with the WSU Library, SFSU Library and MSU Library for best practices.
- Increase patrons' visits by re-designing the physical space and introducing new programming. Consult with the MSU Library for best practices.

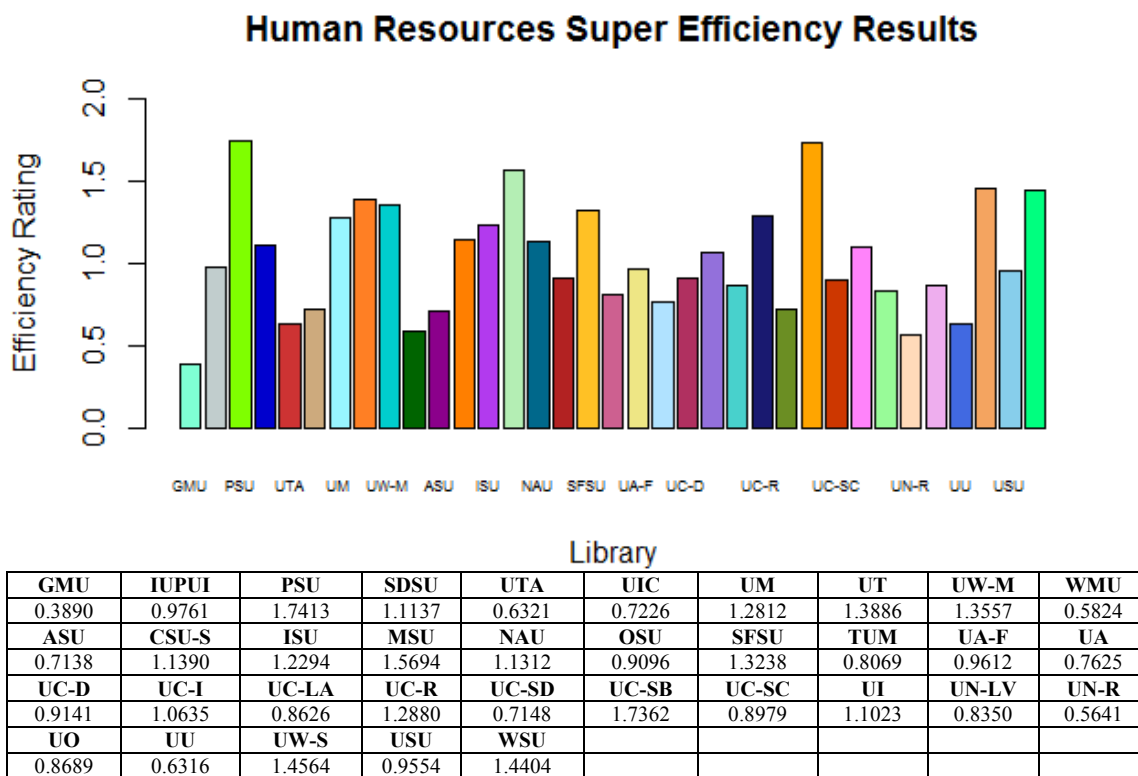


Figure 4 Human Resources Model Results

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TABLE 1 HUMAN RESOURCES MODEL RESULTS - PEER LIBRARIES

	Peer 1	Peer 2	Peer 3	Peer 4	Peer 5
GMU	UI (0.4271)	UT (0.2588)	UC-R (0.1302)	UW-M (0.0886)	WSU (0.0498)
IUPUI	PSU (0.9175)	UC-R (0.1529)	WSU (0.1144)	-	-
PSU	WSU (0.3794)	MSU (0.3183)	IUPUI (0.2996)	SFSU (0.1712)	UW-S (0.0159)
SDSU	MSU (0.8413)	CSU-S (0.4162)	UC-SB (0.1929)	UW-M (0.0971)	-
UTA	MSU (0.8254)	UW-M (0.1775)	SDSU (0.0978)	UC-R (0.0550)	UC-SB (0.0272)
UIC	PSU (1.5703)	-	-	-	-
UM	UC-R (0.6988)	MSU (0.2919)	PSU (0.0325)	-	-
UT	ISU (1.0360)	UC-R (0.1945)	UW-M (0.1336)	-	-
UW-M	UT (0.4063)	WSU (0.2913)	USU (0.2663)	PSU (0.1720)	UW-S (0.0660)
WMU	UM-W (0.3257)	PSU (0.2670)	UT (0.2294)	WSU (0.0477)	UC-R (0.0003)
ASU	CSU-S (0.7870)	UW-S (0.2972)	SFSU (0.2412)	PSU (0.1154)	-
CSU-S	UW-M (0.2678)	PSU (0.1977)	SDSU (0.1798)	UW-S (0.0659)	-
ISU	MSU (.04541)	UA-F (0.2327)	UT (0.0971)	UM (0.0396)	-
MSU	ISU (0.5727)	UI (0.4238)	UC-SB (0.1082)	PSU (0.0180)	-
NAU	PSU (0.7347)	UT (0.2271)	ISU (0.0554)	-	-
OSU	PSU (0.5139)	UW-M (0.4735)	UT (0.2007)	-	-
SFSU	PSU (1.1188)	UI (0.1173)	-	-	-
TUM	UT (0.2934)	ISU (0.2309)	UI (0.2089)	PSU (0.1761)	SFSU (0.0885)
UA-F	ISU (0.8443)	MSU (0.3637)	-	-	-
UA	PSU (0.5206)	UC-R (0.4458)	CSU-S (0.2413)	UT (0.1481)	UW-S (0.0636)
UC-D	UC-I (0.5378)	SFSU (0.3479)	PSU (0.1694)	UW-S (0.0476)	-
UC-I	UC-R (1.1630)	UW-S (.0857)	PSU (0.0431)	-	-
UC-LA	UW-S (0.9960)	UC-I (0.2817)	-	-	-
UC-R	UM (0.7703)	UC-I (0.3608)	UT (0.0273)	-	-
UC-SD	UC-I (0.5643)	SFSU (0.4064)	UC-R (0.1482)	UW-S (0.1344)	-
UC-SB	SDSU (1.7262)	MSU (0.6780)	UC-R (0.0174)	-	-
UC-SC	SFSU (0.4712)	PSU (0.2323)	UT (0.1506)	UC-R (0.0690)	UW-S (0.0311)
UI	MSU (0.6644)	SFSU (0.1840)	WSU (0.0625)	UW-M (0.0320)	UC-R (0.0175)
UN-LV	PSU (0.5544)	UW-M (0.3246)	UC-SB (0.2334)	MSU (0.0647)	UC-R (0.0155)
UN-R	CSU-S (0.4002)	UT (0.2686)	UW-M (0.0910)	PSU (0.0886)	-
UO	PSU (1.9501)	UC-R (0.2507)	-	-	-
UU	WSU (1.0526)	UW-M (.05486)	-	-	-
UW-S	UW-M (2.1941)	UC-LA (0.5995)	-	-	-
USU	UW-M (0.4622)	UT (0.1799)	UC-SB (0.0684)	PSU (0.0527)	-
WSU	UW-M (1.2089)	SFSU (0.5806)	PSU (0.3721)	-	-

Peer relationships are sorted by largest lambda values indicated in parentheses.

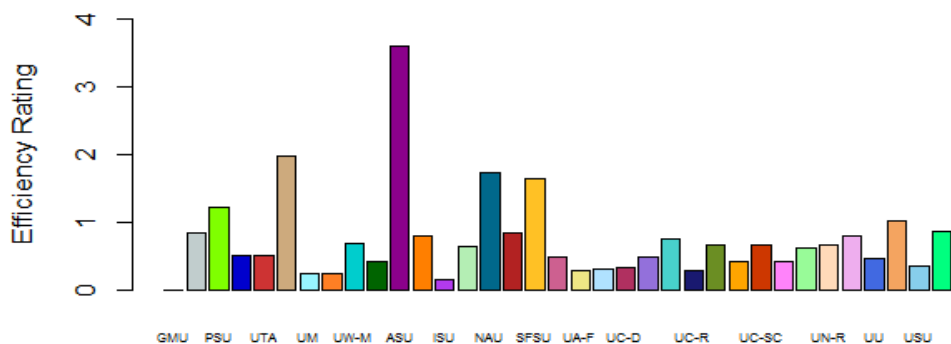
B. Materials Model

The materials model compares how efficiently libraries convert their holdings into use by patrons (Fig. 5). The ASU Library had the highest super-efficiency score (3.6075) in the materials model. A review of the data indicates that the ASU Library has the fifth largest collection size and the third highest volume of circulation transactions. The PSU Library had the fifth highest super-efficiency score (1.2278). With approximately one third the size of the ASU Library's collection, the PSU Library processes a higher volume of ILL transactions to meet patrons' needs. The GMU Library received a 0 super-efficiency score because it did not report any outputs (ILL and circulation transactions). The UIC Library received an infeasibility error because it did not report if any new books and serials (inputs) were added to the collection.

The PSU Library is identified as the primary peer for two libraries (Table 2). These libraries could potentially learn materials best practices from the PSU Library. The PSU Library has a higher super-efficiency score than two of its top three peers. However, the PSU Library could potentially benefit from best practices with the following strategies:

- Increase circulation transactions by updating collection development processes to ensure that relevant materials are acquired and maintained. Consult with the SFSU Library and NAU Library for best practices.
- Increase the local collection size to meet growing institutional needs and to reduce the reliance on ILL transactions. A budgetary investment will be required for new materials and additional librarians engaged in collection development. Consult with the NAU Library for best practices.

Materials Super Efficiency Results



Library

GMU	IUPUI	PSU	SDSU	UTA	UIC	UM	UT	UW-M	WMU
0.0000	0.8431	1.2278	0.4932	0.4926	1.9761	0.2266	0.2390	0.6824	0.4073
ASU	CSU-S	ISU	MSU	NAU	OSU	SFSU	TUM	UA-F	UA
3.6075	0.7906	0.1401	0.6414	1.7202	0.8320	1.6326	0.4702	0.2704	0.2974
UC-D	UC-I	UC-LA	UC-R	UC-SD	UC-SB	UC-SC	UI	UN-LV	UN-R
0.3216	0.4835	0.7421	0.2795	0.6648	0.4115	0.6537	0.4139	0.6106	0.6606
UO	UU	UW-S	USU	WSU					
0.8035	0.4479	1.0203	0.3372	0.8610					

Figure 5 Materials Model Results

TABLE 2 MATERIALS MODEL RESULTS - PEER LIBRARIES

	Peer 1	Peer 2	Peer 3	Peer 4
GMU	-	-	-	-
IUPUI	PSU (1.0258)	SFSU (0.1154)	-	-
PSU	NAU (7.9112)	SFSU (0.4679)	IUPUI (0.3509)	-
SDSU	NAU (7.3356)	SFSU (0.4220)	ASU (0.174)	-
UTA	NAU (4.4246)	SFSU (0.2194)	PSU (0.0125)	-
UIC	MSU (6.2469)	-	-	-
UM	NAU (2.0949)	PSU (0.2354)	-	-
UT	NAU (2.9774)	UW-S (0.0313)	SFSU (0.0144)	-
UW-M	NAU (1.0088)	SFSU (0.0837)	UW-S (0.0779)	-
WMU	NAU (6.1336)	SFSU (0.3267)	UW-S (0.0126)	-
ASU	MSU (18.8294)	NAU (5.8137)	-	-
CSU-S	NAU (1.6052)	SFSU (0.6186)	UW-S (0.0592)	-
ISU	NAU (8.9541)	SFSU (0.0486)	PSU (0.0179)	-
MSU	UIC (0.1452)	ASU (0.0348)	-	-
NAU	OSU (0.3996)	UIC (0.2794)	ASU (0.0037)	-
OSU	NAU (1.1453)	UW-S (0.0540)	SFSU (0.0501)	-
SFSU	PSU (0.6171)	ASU (0.1176)	UW-S (0.0099)	-
TUM	NAU (2.0305)	SFSU (0.2553)	PSU (0.1202)	-
UA-F	NAU (4.9631)	PSU (0.0854)	UIC (0.0230)	-
UA	NAU (1.0758)	SFSU (0.6356)	UW-S (0.0401)	-
UC-D	NAU (3.9330)	SFSU (0.6886)	UW-S (0.0963)	-
UC-I	NAU (4.8128)	SFSU (0.2809)	UW-S (0.1217)	-
UC-LA	SFSU (3.7732)	UW-S (0.5378)	-	-
UC-R	NAU (5.0062)	SFSU (0.2638)	UW-S (0.0168)	-
UC-SD	NAU (4.6447)	SFSU (0.3344)	UW-S (0.2657)	-
UC-SB	NAU (1.4167)	-	-	-
UC-SC	NAU (2.7103)	SFSU (0.3013)	UW-S (0.0748)	-
UI	NAU (2.2240)	SFSU (0.2617)	UIC (0.0570)	ASU (0.0010)
UN-LV	NAU (3.5005)	SFSU (0.5015)	UW-S (0.0514)	-
UN-R	NAU (3.2827)	SFSU (0.2309)	UW-S (0.0461)	-
UO	NAU (1.3899)	PSU (0.9357)	-	-
UU	NAU (8.9291)	SFSU (0.9806)	UW-S (0.0226)	-
UW-S	SFSU (5.8890)	NAU (2.5291)	-	-
USU	NAU (4.1885)	SFSU (0.2905)	UW-S (0.0041)	-
WSU	NAU (8.0083)	PSU (0.9038)	-	-

Peer relationships are sorted by largest lambda values indicated in parentheses.

C. Budget Model

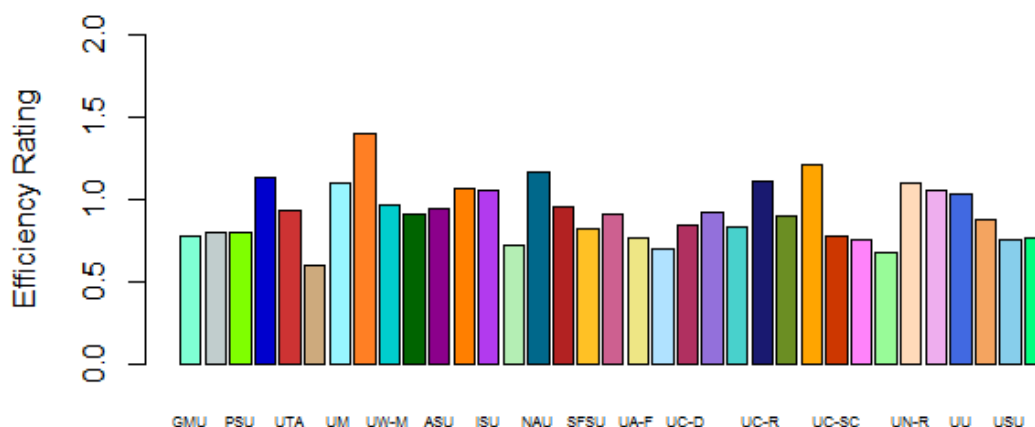
The budget model compares how efficiently libraries allocate their budget between staff, material acquisitions, and service hours (Fig. 6). The two libraries with the highest super-efficiency scores in the budget model are: UT Library (1.3988) and UC-SB Library (1.2098). Both libraries achieved a high level of performance by allocating their budgets in specific areas. The UT Library used the third smallest number of weighted professional and support staff FTE and added more new books and serials to their collection than the majority of their peers. The UC-SB Library's physical space and staff led programming activities encouraged at least twice as many patrons to visit the library compared to almost all of their peers. The PSU Library (0.7952) was in the lower third of peer super-efficiency scores. The PSU Library had the seventh smallest budget,

sixth smallest number of total staff FTE, and tied for 10 smallest number of weekly service hours.

The CSU-S Library is identified as the primary peer for fifteen libraries (Table 3). These libraries could potentially learn budget best practices from the CSU-S Library. The PSU Library has a super-efficiency score that is lower than its top four peers. The PSU Library could potentially benefit from best practices with the following strategies:

- Increase patron's visits by increasing weekly hours of operation and student FTE available at service desks. Consult with the CSU-S Library, NAU Library and UT Library for best practices.
- Increase the number of new serials and books added to the local collection by hiring additional librarians for collection development, and shifting appropriate tasks from the librarians to additional support staff. Consult with the UM Library for best practices.

Budgetary Super Efficiency Results



Library									
GMU	IUPUI	PSU	SDSU	UTA	UIC	UM	UT	UW-M	WMU
0.7733	0.8036	0.7952	1.1330	0.9366	0.6001	1.1022	1.3988	0.9661	0.9099
ASU	CSU-S	ISU	MSU	NAU	OSU	SFSU	TUM	UA-F	UA
0.9486	1.0707	1.0536	0.7178	1.1715	0.9543	0.8233	0.9112	0.7663	0.6939
UC-D	UC-I	UC-LA	UC-R	UC-SD	UC-SB	UC-SC	UI	UN-LV	UN-R
0.8380	0.9218	0.8264	1.1103	0.8982	1.2098	0.7760	0.7587	0.6777	1.1040
UO	UU	UW-S	USU	WSU					
1.0525	1.0273	0.8767	0.7574	0.7691					

Figure 6 Budget Model Results

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TABLE 3 BUDGET MODEL RESULTS - PEER LIBRARIES

	Peer 1	Peer 2	Peer 3	Peer 4	Peer 5
GMU	NAU (0.6176)	UO (0.4170)	UU (0.1719)	-	-
IUPUI	NAU (1.4978)	UM (0.3449)	-	-	-
PSU	CSU-S (0.6583)	NAU (0.2925)	UM (0.0405)	UT (0.0048)	-
SDSU	CSU-S (1.7676)	UC-SB (0.0008)	-	-	-
UTA	CSU-S (0.7327)	NAU (0.4648)	UU (0.1530)	-	-
UIC	NAU (0.9954)	UU (0.2628)	CSU-S (0.1868)	-	-
UM	UC-R (0.6387)	CSU-S (0.2663)	UT (0.1186)	-	-
UT	CSU-S (0.6652)	ISU (0.5048)	UM (0.2458)	-	-
UW-M	CSU-S (0.7215)	NAU (0.2867)	UT (0.1934)	SDSU (0.0768)	-
WMU	UN-R (1.1444)	UT (0.1453)	-	-	-
ASU	UN-R (0.9599)	UU (0.5459)	-	-	-
CSU-S	SDSU (0.4647)	UO (0.1013)	UT (0.0357)	UC-R (0.0222)	-
ISU	UT (0.6515)	SDSU (0.0500)	-	-	-
MSU	UT (0.4064)	SDSU (0.2475)	ISU (0.1664)	-	-
NAU	CSU-S (0.8818)	UT (0.1855)	-	-	-
OSU	CSU-S (1.2680)	UT (0.1212)	NAU (0.0647)	-	-
SFSU	CSU-S (0.8774)	UN-R (0.1109)	-	-	-
TUM	CSU-S (0.9202)	ISU (0.1970)	UT (0.0256)	-	-
UA-F	ISU (0.7187)	SDSU (0.2332)	NAU (0.1295)	-	-
UA	UM (0.7071)	UN-R (0.3928)	UO (0.1346)	CSU-S (0.1213)	UU (0.1148)
UC-D	UM (0.9161)	UU (0.1675)	UO (0.1501)	CSU-S (0.0605)	-
UC-I	UM (0.9311)	UC-R (0.5556)	CSU-S (0.3569)	-	-
UC-LA	UO (1.8635)	UM (0.5693)	UU (0.1935)	-	-
UC-R	UM (1.4176)	CSU-S (0.0197)	UC-SB (0.0133)	-	-
UC-SD	UM (1.1246)	UU (0.3367)	UO (0.3120)	-	-
UC-SB	SDSU (1.9927)	-	-	-	-
UC-SC	UN-R (0.4443)	CSU-S (0.4425)	UM (0.1371)	-	-
UI	ISU (0.4056)	SDSU (0.3023)	NAU (0.1363)	-	-
UN-LV	CSU-S (1.1826)	NAU (0.7243)	UC-SB (0.0585)	-	-
UN-R	CSU-S (1.6821)	-	-	-	-
UO	CSU-S (2.2023)	UM (0.3033)	NAU (0.1636)	-	-
UU	UN-R (2.1694)	NAU (0.8315)	-	-	-
UW-S	CSU-S (2.6302)	UM (0.5818)	UO (0.5409)	-	-
USU	CSU-S (0.7117)	NAU (0.2699)	UO (0.0354)	-	-
WSU	CSU-S (0.4219)	UO (0.2057)	UU (0.1567)	NAU (0.1364)	-

Peer relationships are sorted by largest lambda values indicated in parentheses.

V. LIMITATIONS AND FUTURE RESEARCH OPPORTUNITIES

One of the key limitations of the study is the data available for the selection of inputs and outputs. Digital resources and services have expanded rapidly over the past two decades and are an integral part of libraries today [29]. The model could be strengthened with the inclusion of digital resources and services data [30].

Shim questions how information from DEA can be transformed into actionable, practical recommendations for library efficiency improvement [4]. From the perspective of a librarian, he states that how the DEA model functions is difficult to understand, the results can be difficult to interpret, and that most skilled DEA practitioners are economists that evaluate libraries from a distance [31]. He proposes the following solutions: 1) Form a small group of libraries that will adopt DEA as a benchmarking methodology, 2) Collaborate with DEA researchers so that librarians can learn the methodology, 3) Follow up on DEA benchmarking results with case studies that validate results, and 4) Identify processes and practices at efficient libraries, and disseminate the knowledge in the library community.

Future research should combine the DEA efficiency results and the patron service survey effectiveness results to guide the Library with continuously improving processes, resources and services. The PSU Library might also consider incorporating the Malmquist Productivity Index into the model to assess productivity changes over time [32]. Another potential area for future research could be adding student success factors to the model to assess for educational impact.

VI. CONCLUSION

Academic libraries, such as the PSU Library, are struggling to adapt to evolving technologies, a disinvestment of state government financial support, and the rapidly rising cost of materials. This study demonstrates how DEA can easily be used, as an evaluation tool, by faculty in their advisory and advocacy shared governance roles to strengthen their libraries. Compared to peer libraries, the PSU Library should pursue the following strategies to improve efficiency:

- Increase the number of new serials and books added to the local collection by increasing the materials budget, hiring additional librarians for collection development, and shifting appropriate tasks from the librarians to additional

support staff. Consult with the UW-S Library, IUPUI Library, UM Library and NAU Library for best practices.

- Increase circulation transactions by automating processes, shifting appropriate tasks to student staff, completing implementation of the ORBIS consortia catalog, and updating collection development processes to ensure that relevant materials are acquired and maintained. Consult with the SFSU Library, UW-S Library and NAU Library for best practices.
- Increase workshop attendance by hiring additional librarians to develop and provide information literacy training, and shifting appropriate tasks from the librarians to support and student staff. Consult with the WSU Library, SFSU Library and MSU Library for best practices.
- Increase patrons' visits by re-designing the physical space, introducing new programming, increasing the weekly hours of operation, and increasing student FTE available at service desks. Consult with the MSU Library, CSU-S Library, NAU Library and UT Library for best practices.

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