Performance Measurement of Hawaii State Public Libraries: An Application of Data Envelopment Analysis (DEA)

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In view of continuing economic stagnation and consequent budgetary constraints facing the state, Hawaii public libraries have been concerned with their operational efficiency and library managers have been seeking better methods in allocating limited resources among the libraries. This paper employed data envelopment analysis (DEA) technique to assess the performance and resource utilization efficiency of 47 public libraries in Hawaii. Three output measures—circulation, reader visits, and reference transactions and four input categories—collection, library staff, days open, and nonpersonal expenditures were used in the analysis. For fiscal year 1996/97, the estimated technical efficiency scores for Hawaii State public library branches ranged from 0.45 to 1.00, with an average of 0.84. The results showed that 14 of the 47 libraries are technically efficient. The estimated efficiency scores were related to relevant library-specific factors and community characteristics, such as total floor space, size of collection, population density, and location to identify factors influencing library performance. Only floor space and volume of collection did show moderate positive effects on library performance. The resulting information can be mainly useful in improving the performance of inefficient libraries. With special consideration to factors uncontrollable by the libraries the results may also be useful in allocating limited resources among them.

Public libraries in Hawaii have long been concerned with improved performance in terms of the quality of services they provide and efficiency in using limited resources they obtain from the state government. At the same time, the state library agency and legislatures have also been concerned with library accountability and performance in allocating limited resources to the libraries. The current tight economic conditions facing the state have further heightened the importance of these concerns. As the previous methods of assessing the performance of public libraries in Hawaii are found to be inadequate, the state library system has been constantly seeking better methods for deriving meaningful performance measures for public libraries.

A variety of approaches have been used in evaluating library performance. Traditional approaches have been largely concerned with the input base, including the size of staff, volume of collection, operating budget, and so forth (Chen 1997). As noted by Shaughnessy (1993), to own more books, have more staff, and have a larger budget than other libraries was often interpreted as being better. Following the shrinkage of library budgets in recent years, various output measures, such as circulation, the number of users, and reference transactions have been used to assess the performance of public libraries (Van House et al. 1987). In other words, libraries are expected to provide the best possible services given fixed and limited resources. These multiple measures are believed to represent a more complete picture of performance as opposed to a single measure reflecting only one aspect of library activity (Van House, Weil, and McClure 1990). However, multiple measures pose a problem in comparing performance across a cross-section of peer libraries because a library might be doing well in some areas and poorly in others. This problem is partly solved by converting multiple measures to a single measure based on arbitrary weights assigned to different measures as previously suggested for the Hawaii State Public Library System (HSPLS). Assigning uniform weights to all libraries may not be appro-

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priate since each library may have different priorities of services depending on the community needs and the amount of resources it receives. Furthermore, output measures with no regard to the amounts of inputs (volume of collection, library staff, nonpersonal expenditures, etc.) can provide a misleading picture of library performance because the library's performance can be constrained by the availability of resources. Shaughnessy (1993) also points out that utilizing output measures may overlook the input costs and quality of services. These measures are mostly quantitative in nature and accounting for users' perceptions pertaining to the quality of services continues to be the greatest challenge for measuring library performance. Furthermore, there are factors uncontrollable by the libraries such as differences in the demographics of the population served which may have a significant impact on their performance.

In this paper, we argue that data envelopment analysis (DEA) is an appropriate model for assessing the performance of public and nonprofit institutions, including public and university libraries that provide multiple services or outputs to the communities. The most notable feature of DEA is that it is able to generate a single output/input measure to characterize performance (efficiency) of a firm or a decision-making unit (DMU) under multiple-output and multiple-input situations (Charnes, Cooper, and Rhodes 1978). DEA has been widely used in assessing the performance of public sectors utilities as well as various nonprofit institutions (schools, prisons, and so forth). However, except for Chen (1997) and Easun (1994), the application of DEA to measure library performance is limited in the literature. Since DEA can handle qualitative outputs and generate a single output/input performance measure using multiple outputs and multiple inputs, we believe that this technique is superior to previous approaches used in evaluating library performance.

The main objective of this paper is to assess the performance of 47 HSPLS libraries in terms of their technical and scale efficiencies using DEA. This technique not only estimates the current level of performance for each library relative to the most efficient libraries in the state, but it also computes the efficient input and output levels for the inefficient libraries in terms of a linear combination of input and output levels of the efficient libraries. This information can provide valuable insight into the possibilities for augmenting outputs (services) and/or reducing inputs in order for an inefficient library to improve its performance. Furthermore, the information will also be useful for the state library agency in justifying requests for additional library budgets, allocating available resources, tracking the performance of each branch library, and designing new libraries. The effects of various library-specific and community-specific factors on library performance are also investigated.

The Hawaii State Public Library System

The Hawaii State Public Library System (HSPLS) is unique among public library systems in the United States in that it is the only public library system in the country that is administered and funded as a single integrated system by the state government. Private schools and institutes of higher education operate and fund their own libraries.

The HSPLS is directly administered by the state librarian, a position appointed and directed by the State Board of Education. The library system consists of this central administration and 49 public libraries located on the six major islands of the state, including the main state library, the library for the blind and physically handicapped (LBPH), and 12 combined public and school libraries. These combined public and school libraries are operated and staffed by both HSPLS and public school (Department of Education) staffs. A new library is being constructed and a second one is in the design phase. Library patrons may use, borrow from and return books and other material to any library throughout the state.

Resource Availability and Allocation

Hawaii's mainly tourism-based economy has been in a recession since 1992. As a result, beginning fiscal year 1993/1994 state government agencies including the HSPLS have suffered large budget cuts, resulting in personnel layoffs, hiring freezes, and cutbacks in public service programs. The HSPLS operating budget and personnel have decreased in almost every year since FY 1993/94. For example, general fund appropriations and FTE employees have decreased by 23% and 18%, respectively between FY 1992/93 and FY 1997/98.[1] Under these circumstances the HSPLS has been seeking better methods of allocating increasingly scarce resources among the 49 public libraries to accomplish its mission.

Allocating personnel and library materials among the libraries has been of some concern to library managers for a number of years. Since 1987

[1] Source: Management Information Branch, Hawaii State Public Library System, FY 1992/93 to FY 1997/98 Records.

the library system has allocated staff among the libraries mainly as a function of their circulation. A "staffing standard model" was developed to determine the number of professional and technical staffs required for each library according to 22 levels of circulation. Since then attempts have been made to determine staff levels by using weighted measures of circulation, reference questions, and number of users. However, these weighted measures have never been put into practice.[2] Staffing-circulation guidelines continue to be the principal guide to library staffing. To meet declining budgets the HSPLS is now operating with 512 authorized positions, more than 100 fewer than in FY 1992/93. Despite this decline the HSPLS has maintained or increased its hours of operation and has not had to close any libraries. Allocation of library materials, including books, periodicals, and audiovisual items is based on each library's share of total system circulation with adjustments made in consideration of special needs and requirements of each library.[3] The HSPLS administration would ideally wish to allocate library materials to libraries as a function of additional output variables such as reference questions and user counts. Because of its ability to handle multiple outputs and inputs, DEA can provide useful information to allocate resources, especially staff and library materials, thereby enhancing the operational effectiveness of the HSPLS in fulfilling its mission.

DEA Model

Since detailed descriptions of DEA can be readily found elsewhere in the literature, only a general description of this technique and the relevant DEA model used to assess library performance are presented here. DEA is a production frontier approach to efficiency measurement first suggested by Farrell (1957) and later formalized into linear programming (LP) techniques by Seitz (1970, 1971) and Charnes, Cooper, and Rhodes (1978).[4] This is a nonparametric technique for estimating production or "best-practice" frontier such that, for a sample of DMUs, some units lie on the frontier while others lie below the frontier. Those lying on the frontier are considered efficient, while those below it are inefficient. The deviations from the frontier represent inefficiencies. A subset of efficient units (also called reference sets) form the basis for computing the performance as well as efficient output and input levels of the inefficient units.

Consider the situation with n libraries or decision making units (DMUs), each producing s different types of services (outputs) by using m different resources (inputs). The i-th library uses x_{ki} units of the k-th resource in the production of y_{ri} units of the r-th library service. A separate LP problem is solved for each of the n libraries in the sample. Since the library has to provide maximum provision of services from fixed amounts of resources, the output-based DEA model is appropriate in assessing library performance in terms of technical efficiency, which can be obtained by solving the following LP problem:

(1) $$\underset{\phi_i,\ \lambda_j}{\text{Maximize}}\ \phi_i$$

Subject to:

$$\phi_i y_{ri} - \sum_{j=1}^{n} \lambda_j y_{rj} + s_{ri} = 0 \qquad r = 1, \ldots, s \text{ library services}$$

$$x_{ki} - \sum_{j=1}^{n} \lambda_j x_{kj} - e_{ki} = 0 \qquad k = 1, \ldots, m \text{ resources}$$

$$\lambda_j \geq 0,\ s_{ri} \geq 0,\ e_{ki} \geq 0 \qquad i, j = 1, \ldots, n \text{ libraries in the sample}$$

where ϕ is the proportional increase in outputs possible; s_r is the r-th output slack; e_k is the k-th input slack; and λ_j is the weight or intensity variable used to derive all possible linear combinations of the sample observations. When the value of ϕ_i in equation (1) is 1, $\lambda_i = 1$, and $\lambda_i = 0$ for $j \neq i$, the i-th library lies on the frontier and is technically efficient. Furthermore, input and output slacks will always be zeros for the efficient libraries. For the inefficient libraries, $\phi_i > 1$, $\lambda_i = 0$, and $\lambda_j \neq 0$ for $j \neq i$, where j denotes the efficient libraries in the sample. Inefficient libraries may also have some positive output or/and input slacks. The output-based technical efficiency index of the i-th library (TE_i) can be computed as follows:

[2] Personal communications; C. Okinaga, former Administrative Services Officer, Management Information Branch, Hawaii State Public Library System.

[3] Personal communications; C. Spenser, Acting State Librarian, Hawaii Public Library System.

[4] While Seitz (1970, 1971) considered one output and multi-inputs case, Charnes, Cooper, and Rhodes (1978) formalized DEA as a LP model for multi-outputs and multi-inputs situations. As noted by an anonymous reviewer and also cited in Seitz (1970, 1971), J.N. Boles had a paper on the use of LP model in efficiency measurement entitled "Efficiency Squared . . . Efficient Computation of Efficiency Indexes." *Proceedings of the 1966 Meeting of the Western Farm Economics Association:* 137–142. We are thankful to this reviewer for pointing out these earlier studies on application of LP models in frontier analysis, which for some reason are not included in the DEA literature.

(2) $$TE_i = \frac{1}{\phi_i}$$

The projected or frontier production of the r-th service of the i-th library ($\hat{y}_{ri}$) can be computed as follows:

(3) $$\hat{y}_{ri} = \sum_{j=1}^{n} \lambda_j y_{rj} = \phi_i y_{ri} + s_{ri}$$
$$r = 1, \ldots, s \text{ library services}$$

Equation (3) shows that the projected output consists of two components, one representing the proportional increase in all outputs ($\phi_i y_{ri}$) and the other accounting for the nonproportional increase or output slack (s_{ri}). Besides estimating the maximum provision of services from fixed quantities of resources, the output-oriented DEA in equation (1) also estimates the input slacks (excess inputs) that need to be conserved for an inefficient library to be fully efficient. Mathematically, the projected amount of the k-th resource of the i-th library ($\hat{x}_{ki}$) can be expressed as follows:

(4) $$\hat{x}_{ki} = \sum_{j=1}^{n} \lambda_j x_{kj} = x_{ki} - e_{ki}$$
$$k = 1, \ldots, m \text{ resources}$$

It should be noted that the library DEA model given in equation (1) implies the constant returns to scale (CRS) technology. Following Banker, Charnes, and Cooper (1984), the corresponding model under variable returns to scale (VRS) can be obtained by imposing an additional constraint, $\sum_{j=1}^{n} \lambda_j = 1$ on equation (1). The technical efficiency score obtained from the CRS model (TE_{CRS}) is often referred to as "overall" technical efficiency and that obtained from the VRS model is called "pure" technical efficiency (TE_{VRS}).

The VRS frontier is more flexible and envelops the data in a tighter way than the CRS frontier. Under the VRS specification, dominance is weaker in the sense that a scale inefficient library may qualify as a 'best-practice' if it is technically efficient. Consequently, in general, a library will show a poorer performance under the CRS model than in the VRS model (i.e., $TE_{VRS} \geq TE_{CRS} \Leftrightarrow \phi_{CRS} \geq \phi_{VRS}$). This relationship is often used to obtain a measure of scale efficiency (SE) as follows:[5]

(5) $$SE = \frac{TE_{CRS}}{TE_{VRS}} = \frac{\phi_{VRS}}{\phi_{CRS}}$$

where SE = 1 indicates scale efficiency and SE < 1 indicates output-based scale inefficiency. Scale inefficiency is due to the presence of either increasing (IRS) or decreasing returns to scale (DRS), which can be determined by solving a non-increasing returns to scale (NIRS) DEA model which is obtained by substituting the VRS constraint $\sum_{j=1}^{n} \lambda_j = 1$ with $\sum_{j=1}^{n} \lambda_j \leq 1$. Let ϕ_{NIRS} represent the proportional increase in all outputs under the NIRS DEA model. For scale inefficient observations, $\phi_{CRS} = \phi_{NIRS}$ indicates inefficiently small scale or operation in the region of increasing returns to scale and $\phi_{CRS} > \phi_{NIRS}$ indicates inefficiently large scale or decreasing returns to scale (Färe, Grosskopf, and Lovell 1994).

Data and Variables

The data for this study came from a total of 47 public libraries in the State of Hawaii, excluding the main state public library and the LBPH. Following the manual of standardized procedures for output measures for public libraries (Van House et al. 1987), library services are represented in terms of three output measures as follows:[6]

Circulation (y_1) represents the total number of items checked out during the year (in thousands). It should be noted that book circulation does not include in-library materials use simply because of the lack of such data.
Reader visits (y_2) denotes the number of visits to the library during the year (in thousands).
Reference transaction (y_3) is the total number of reference questions asked in a year (in thousands).

Similarly, library resources are summarized in terms of four input categories as follows:[7]

Collection (x_1) denotes the size of holdings (in thousands).
Library staff (x_2) indicates the number of full time employees (FTE) working in the library, excluding janitors, drivers, students and security guards.
Days open (x_3) indicates total annual days open to the public (in 8-hours days).
Other inputs (x_4) represent annual nonpersonal operating expenditures, including supplies, subscriptions, postage, and utilities.

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[5] In other words, this relationship is used to decompose "overall" technical efficiency to its "pure" technical and scale efficiency components.

[6] The output measures defined here are mainly quantitative in nature. Despite the importance of qualitative measures, such as user's satisfaction, no qualitative output measure is considered because of the lack of such information.

[7] Initially, area of library floor space was also considered but was dropped later because of its high correlation with nonpersonal expenditures and volume of collection.

Table 1. Summary Statistics for Output and Input Measures for Hawaii's Public Libraries[a]

	Average	Standard deviation	Minimum value	Maximum value
Outputs				
Book circulation (in thousands)	148.69	115.41	13.99	452.48
Reader visits (in thousands)[b]	117.49	83.15	1.12	415.00
Reference transaction (in thousands)[c]	52.49	39.66	0.52	194.75
Inputs				
Book collection (in thousands)	53.94	38.52	6.56	198.91
Library staff (FTE)	6.10	4.04	1.00	18.00
Days open (in 8-hours days)[d]	262.96	42.82	74.50	334.63
Operating expenses (in thousand dollars)	33.04	26.23	4.31	109.95

[a]The output and input data used in the analysis are for Fiscal Year 1996/1997, i.e., August, 1996 to July, 1997.
[b]Computed as average daily users times total days the library was open to the public during FY 1996/1997.
[c]Computed as average daily reference questions times total days the library was open to the public in FY 1996/1997.
[d]Computed as total annual hours the library was open to the public divided by 8 (i.e. 8-hour days).

These output and input measures are annual totals for FY 1996/1997 and summarized in table 1.

The library performance reflects the performance of both the library and the user. Because much library use is self-service, service outcomes critically depend on people's ability to use the library. Therefore, interpreting the library efficiency results requires a consideration of a number of contextual factors, including the library's resources, user's social, economic and demographic characteristics, and library's roles and objectives. Accordingly, total population of library's service area, size of collection, total floor area, type of operation (combined public and school libraries vs. others), and location (Oahu vs. Neighbor Islands) are related to estimated performance measures to examine their effects on library performance.[8]

Results

"Overall" Technical Efficiency

The DEA models involved in assessing the performance of Hawaii's public libraries were solved using DEAP 2.1 (Coelli 1996). The "overall" technical efficiency score (i.e., technical efficiency relative to the CRS DEA model) for each of the 47 Hawaii's public libraries are presented in table 2. Also presented in the table are the referenced efficient library sets for inefficient libraries as well as frequency with which a particular library appears in the efficient sets of other libraries. The estimated efficiency scores varied from 0.447 to 1.000, with a sample mean of 0.84. Of 47 libraries involved in the analysis, 14 were found to be efficient and 33 were inefficient. About one-fourth of libraries had an "overall" efficiency score of 0.70 or lower and nearly two-fifths of them had 0.90 or higher. Holualoa on Big Island (0.447), Kahuku PS on Oahu (0.461), and Hana PS on Maui (0.472) were some of the least efficient public libraries in Hawaii.

A library which appears frequently in the efficient set of other libraries is regarded as a good example of "best-practice" or "well-rounded performer" (Chen 1997). Among the 14 efficient libraries, Kailua on Oahu appeared most frequently in the efficient sets of inefficient libraries, followed by Mt. View public and school library (Mt. View PS), Bond and Thelma Parker PS from Big Island, and Manoa and Mililani on Oahu. These libraries which appeared more frequently in the efficient sets of other libraries are exemplary operations for inefficient libraries. Those that appear seldom in the efficient sets, such as Kanehoe and Salt Lake on Oahu and Hilo on Big Island are not good examples for inefficient libraries although they are found to be efficient.

To examine the effects of various library-specific and community-specific factors on library performance, the 47 libraries were divided into different groups based on size of collection (3 groups: small, medium, and high), population served (3 groups: low, medium, and high), library floor area (3 groups: small, medium, and high), location (2 groups: Oahu vs. Neighbor Islands), and management style (2 groups: combined public and school vs. public). Among these factors, only size of collection showed a positive and significant (at the 0.10 level) effect on library performance. Floor area also had a moderate positive impact on library

[8] The educational attainment and income level of the population the library serves can also be important, but could not be considered because of the data constraint.

Table 2. Technical Efficiency Scores of Hawaii State Public Libraries Based on CRS DEA Model

ID	Library	TE_{CRS}	Referenced efficient library set (weights)	Frequency[a]
1	Aiea	0.875	11 (0.257), 33 (0.358), 6 (0.465)	0
2	Aina Haina	0.872	6 (0.364), 13 (0.170), 30 (0.508), 15 (0.043)	0
3	Ewa Beach PS	1.000	3 (1.000)	2
4	Hawaii Kai	0.887	11 (0.006), 6 (0.948), 30 (0.043)	0
5	Kahuku PS	0.461	11 (0.417), 22 (0.142), 34 (0.342), 6 (0.001)	0
6	Kailua	1.000	6 (1.000)	24
7	Kaimuki	0.924	14 (0.350), 23 (0.063), 6 (0.534), 9 (0.094)	0
8	Kalihi-Palama	0.914	14 (0.140), 30 (0.705), 6 (0.262)	0
9	Kaneohe	1.000	9 (1.000)	1
10	Liliha	0.776	11 (0.196), 6 (0.660), 34 (0.123)	0
11	Manoa	1.000	11 (1.000)	10
12	McCully	0.858	6 (0.893), 23 (0.131)	0
13	Mililani	1.000	13 (1.000)	9
14	Pearl City	1.000	14 (1.000)	4
15	Salt Lake	1.000	15 (1.000)	2
16	Wahiawa	0.673	30 (0.251), 3 (0.163), 6 (0.402), 33 (0.107)	0
17	Waialua	0.647	6 (0.294), 30 (0.119)	0
18	Waianae	0.783	14 (0.020), 30 (0.600), 6 (0.426)	0
19	Waikiki	0.795	30 (0.245), 15 (0.007), 6 (0.046), 11 (0.520), 13 (0.208)	0
20	Waimanalo PS	0.506	34 (0.130), 22 (0.025), 33 (0.810)	0
21	Waipahu	0.662	6 (0.211), 34 (0.336), 13 (0.396)	0
22	Bond	1.000	22 (1.000)	13
23	Hilo	1.000	23 (1.000)	2
24	Holualoa	0.447	33 (0.050), 13 (0.070)	0
25	Honokaa	0.598	6 (0.048), 30 (0.053), 33 (0.174), 13 (0.074)	0
26	Kailua-Kona	0.995	13 (0.069), 6 (0.440), 30 (0.022), 11 (0.066), 22 (0.310)	0
27	Keaau PS	0.976	11 (0.171), 22 (0.771)	0
28	Kealakekua	0.700	34 (0.465), 22 (0.093), 33 (0.064), 13 (0.064)	0
29	Laupahoehoe PS	0.584	34 (0.134), 22 (0.733)	0
30	Mt. View PS	1.000	30 (1.000)	18
31	Naalehu	0.882	6 (0.020), 13 (0.054), 22 (0.030), 30 (0.037)	0
32	Pahala PS	0.862	34 (0.013), 22 (0.975)	0
33	Pahoa PS	1.000	33 (1.000)	8
34	Thelma Parker PS	1.000	34 (1.000)	10
35	Hana PS	0.472	6 (0.059), 30 (0.202), 33 (0.136), 22 (0.226)	0
36	Kahului	0.973	30 (0.020), 6 (0.882)	0
37	Kihei	1.000	37 (1.000)	0
38	Lahaina	0.624	34 (0.352), 11 (0.095), 22 (0.417)	0
39	Lanai PS	0.858	34 (0.444), 22 (0.612)	0
40	Makawao	0.719	11 (0.081), 13 (0.051), 33 (0.560), 6 (0.202), 34 (0.058)	0
41	Molokai	0.776	22 (0.506), 11 (0.109), 30 (0.359), 6 (0.004)	0
42	Wailuku	0.838	14 (0.145), 3 (0.191), 30 (0.624)	0
43	Hanapepe	0.986	6 (0.068), 30 (0.795)	0
44	Kapaa	0.867	30 (0.153), 6 (0.393)	0
45	Koloa PS	1.000	45 (1.000)	0
46	Lihue	0.654	6 (0.975), 30 (0.076)	0
47	Waimea	0.882	6 (0.080), 22 (0.080), 30 (0.374)	0

[a]Frequency represents the number of times that a library appears in the efficient sets of other libraries.

performance. This information can be useful in adding a new library.

"Pure" Technical and Scale Efficiencies

As mentioned above, 14 libraries were efficient and 33 libraries were inefficient in terms of "overall" technical efficiency. Table 3 shows the decomposition of "overall" technical efficiency to its "pure" technical and scale efficiency components and sources of inefficiencies among the 33 inefficient libraries. As indicated by a relatively higher measure of scale efficiency compared to "pure" technical efficiency, for almost all the inefficient libraries, the "overall" inefficiency is primarily due to technical inefficiency. Scale efficiency scores for inefficient libraries ranged from 0.447 to 0.999, with an average of 0.957, while "pure" technical efficiency varied from 0.474 to 1.000, with a mean of 0.805. Five libraries, namely Holualoa, Kailua-

Table 3. Scale Efficiencies and Returns to Scale for Inefficient Libraries

ID	Library	"Overall" technical efficiency (TE_{CRS})	"Pure" technical efficiency (TE_{VRS})	Scale efficiency (TE_{CRS}/TE_{VRS})	Returns to scale
1	Aiea	0.875	0.897	0.975	DRS
2	Aina Haina	0.872	0.877	0.995	DRS
4	Hawaii Kai	0.887	0.888	0.999	IRS
5	Kahuku PS	0.461	0.474	0.973	IRS
7	Kaimuki	0.924	0.939	0.984	DRS
8	Kalihi-Palama	0.914	0.948	0.964	DRS
10	Liliha	0.776	0.779	0.996	IRS
12	McCully	0.858	0.868	0.988	DRS
16	Wahiawa	0.673	0.686	0.981	IRS
17	Waialua	0.647	0.700	0.925	IRS
18	Waianae	0.783	0.795	0.985	DRS
19	Waikiki	0.795	0.798	0.996	DRS
20	Waimanalo PS	0.506	0.509	0.994	IRS
21	Waipahu	0.662	0.663	0.999	IRS
24	Holualoa	0.447	1.000	0.447	IRS
25	Honokaa	0.598	0.639	0.936	IRS
26	Kailua-Kona	0.995	1.000	0.995	IRS
27	Keaau PS	0.976	1.000	0.976	IRS
28	Kealakekua	0.700	0.712	0.983	IRS
29	Laupahoehoe PS	0.584	0.605	0.965	IRS
31	Naalehu	0.882	1.000	0.882	IRS
32	Pahala PS	0.862	0.869	0.992	IRS
35	Hana PS	0.472	0.514	0.919	IRS
36	Kahului	0.973	0.977	0.995	IRS
38	Lahaina	0.624	0.664	0.940	IRS
39	Lanai PS	0.858	0.862	0.995	DRS
40	Makawao	0.719	0.726	0.991	IRS
41	Molokai	0.776	0.784	0.991	IRS
42	Wailuku	0.838	0.850	0.985	IRS
43	Hanapepe	0.986	1.000	0.986	IRS
44	Kapaa	0.867	0.906	0.957	IRS
46	Lihue	0.654	0.660	0.990	DRS
47	Waimea	0.882	0.971	0.909	IRS
	Average	0.767	0.805	0.957	–

Kona, Keaau PS, and Naalehu on Big Island and Hanapeppe in Kauai were found to be efficient in terms of "pure" technical efficiency although they were inefficient in terms of "overall" technical efficiency. Among the 33 inefficient libraries, 9 demonstrated inefficiently large scale or decreasing returns to scale (DRS), while 24 demonstrated inefficiently small scale or increasing returns to scale (IRS). Holualoa showed the lowest scale efficiency (0.447), followed by Naalehu (0.882). Both of these libraries had the smallest collection (<7,000) and, as expected, showed increasing returns to scale. The rest of the libraries were doing quite well in terms of the scale of operation.

Output and Input Slacks

As mentioned earlier, incremental outputs of inefficient libraries come through two sources, namely proportional increase in all outputs and residual increase in some of the outputs after the maximum proportional increase is accomplished. This residual increase in output is also called the output slack. Under the output-oriented DEA model, inefficient libraries may have potential for increasing outputs while reducing their inputs. The amount of input that can be reduced is referred to as excess input or input slack. Because the efficiency is defined in terms of proportional increase in outputs, it is important to consider both input and output slacks in estimating potential output and input level for inefficient libraries. The summary of output and input slacks is presented in table 4.

For outputs, 9 libraries showed positive slacks on circulation and 13 libraries on both reader visits and reference transactions, indicating that the output increment for the majority of inefficient libraries come from the proportional increase in outputs. On average, these slacks respectively accounted for 16.7%, 26.1%, and 45.8% of potential levels of circulation, reader visits, and reference transactions of these libraries. Information on output

Table 4. Summary of Output and Input Slacks for Inefficient Libraries

	Number[a]	Average	Standard deviation	Minimum value	Maximum value
Output slacks					
Circulation (thousands)	9	26.015	26.500	3.602	84.609
Reader visits (thousands)	13	32.627	28.401	3.765	100.592
Reference transactions (thousands)	13	13.984	14.650	0.306	51.211
Input slacks					
Collection (in thousands)	21	9.025	6.230	0.013	20.892
Library staff (FTE)	7	0.583	0.516	0.016	1.289
Days open (8-hour days)	13	75.143	51.221	7.130	154.922
Operating expenses ($ thousands)	19	10.528	9.934	0.228	35.910

[a]Number denotes the number of inefficient libraries with positive output and input slacks.

slacks can be useful for library managers in identifying important areas for the improvement.

Among the inputs, the largest number of slacks was observed for collection (21), followed by operating expenses (19), days open (13), and staff (7). These slacks respectively accounted for 18.6%, 31.5%, 31.9%, and 7.8% of existing collection, operating costs, days open, and library staff of the inefficient libraries involved. As shown by a small number of slacks for staff and their small magnitude relative to existing staffing, most libraries are doing quite well in using their personnel. Information on excess collection can be useful for library managers in distributing new materials among the libraries as well as upgrading the collection quality by culling old materials. Because of the nature of library service, it would not be easy to deal with excess days open, except for limiting hours to critical times, such as evenings or weekends when patrons are more likely to visit the libraries. A sizable proportion of inefficient libraries showed potential for conserving operating expenses relative to their efficient counterparts. The library managers may use this information in allocating operating budgets among the libraries, but regardless of performance each library must be able to pay its utilities, which is the largest component of operating expenditures.

Conclusions

In light of an increasing need for better methods for assessing performance or resource utilization efficiency of public libraries in Hawaii, data envelopment analysis (DEA) model is proposed to estimate the performance of 47 library branches of Hawaii State Public Library System (HSPLS) in terms of their technical and scale efficiencies. A library production frontier is defined in terms of 3 outputs measures: circulation, reader visits, and reference transactions and 4 resource inputs: collection, staff, hours of operation, and nonpersonal operating expenditures. The estimated efficiencies are related to relevant library-specific and community-specific factors to examine their influence on library performance.

For FY 1996/97, the "overall" technical efficiency scores range from 0.447 to 1.000, with a sample average of 0.837. The results show that 14 libraries are efficient and there are substantial inefficiencies among the rest of the libraries. "Overall" inefficiency is primarily due to technical inefficiency rather than scale inefficiency. Among the various library-specific and community-specific variables considered, only the size of collection has a positive and significant effect on library performance.

The DEA results can be useful for both individual libraries as well as for the state library agency. The library may find this information valuable in comparing its performance with peer libraries and identifying areas where improvement is needed, while the state library agency may use these results in monitoring existing libraries, planning new libraries, and allocating scarce resources among the libraries. The DEA results may also serve as a valuable benchmarking tool to identify library's best practices for superior performance and, if done periodically, to assess the improvement in library's performance over time. However, caution is needed in both interpreting and using the DEA results for policy purposes for several reasons. First, since DEA is deterministic any deviation from the "best-practice" frontier is attributed to inefficiency. In other words, no account is made for measurement error and other stochastic noise in the data. Second, the results presented in this paper are based solely on quantitative aspects of library activity. Third, and perhaps most importantly, library performance is a complex function of several user's and community characteristics, which are beyond the library control. In view of these limitations, we feel that the results are more appropriate for comparing the performance of individual libraries and identifying the areas of improvement among the inefficient libraries rather than using them as yardsticks for resource allocation unless various non-discretionary factors related to socioeconomic and demographic characteristics of the population served and an appropriate measure of users' satisfaction are formally included in the model. A similar study on the changes in performance of the sample libraries based on historical data may provide further insights on possible impacts of resource availability and policy changes on their performance.

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