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Assessing social efficiency of libraries from a dynamic perspective: The Peruvian municipal library system

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ABSTRACT

Municipal libraries are one of the most important cultural institutions, especially in developing countries, where they help build social capital, improve quality of life, and reduce inequalities. As publicly funded entities, their contribution to welfare should be evaluated for them to gain accreditation, especially when technological changes have altered user interest and access to certain traditional functions. A dynamic Data Envelopment Analysis (DEA) model is used to evaluate performance and to estimate the productivity of a group of libraries in Peru, taking the mission of social impact as a benchmark. Starting from low efficiency values, results show substantial progress, with differences, depending on geographical areas, and a trade-off is seen between efficiency and poverty indicators. Human capital, other cultural facilities and accessibility emerge as external drivers of efficiency. Cultural policy implications are provided, and the study may serve to approach social impact evaluation for cultural institutions, especially in emerging economies.

1. Introduction

The transformation of public libraries from their original functions which focused on the preservation, custody, and lending of materials, to new models as civic agents for participation and the transformation of societies is now commonplace (Scott, 2011; Smith, 2019; Willingham, 2008). The technical change that led to lending becoming a less attractive function (Aabø, 2005b; Barclay, 2017; Kann-Rasmussen & Rasmussen, 2021) generated the need to look for new forms of service that could socially accredit the work carried out by libraries through their impact on people's quality of life (Fujiwara, Lawton, & Mourato, 2019). This momentum has defined the key missions of libraries and now involve providing access to information, education, inclusion, civic participation, and culture (IFLA, 2022), thereby broadening their repertoire of activities towards building social and cultural capital (Glorieux, Kuppens, & Vandebroeck, 2007; Wojciechowska, 2021). Each library balances its functions and activities by taking into account the environment in which it operates and by valuing its contribution to the well-being of society.

As public entities and consumers of collective resources, libraries must also be subject to evaluation that will gauge the extent to which they align with and fulfil the objectives for which they are created; namely, to achieve social impact that will enhance citizens' well-being. This evaluation ultimately seeks to serve the general interest, boost transparency, help create reputational value and, ultimately, contribute to its accreditation (Vermeulen & Maas, 2021). This evaluation can be approached in terms of outputs or outcomes or, in other words, services provided or the social impact generated. The second option is undoubtedly more complex (Bille & Olsen, 2018; Kann-Rasmussen & Rasmussen, 2021) given the impossibility of knowing the counterfactual situation, and the need to resort to subjective assessments that reflect changes in well-being (Fujiwara, Lawton & Mourato, 2017; Wheatley & Bickerton, 2017). Whatever the case, any change in individual and collective utility requires the concurrence of users in the consumption of the wide range of services that libraries are providing in an increasingly diverse manner, and which include educational, cultural, social interaction services, etc. The approach to the social efficiency of libraries adopted here relates the resources consumed with the impact generated in user consumption of different services. To this end, a Data Envelopment Analysis (DEA) model is applied in its dynamic slack-based measure (SBM) version to evaluate a production function that considers input variables measured in terms of labour and capital, and the large array of services provided as a complex output variable. This composite output variable offers an approximation of the social impact generated, insofar as the services provided are represented as the "treatment" prior to achieving this impact and which can finally become a driver to reduce

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inequalities, promote civic attitudes, prevent social exclusion and contribute to local identity. (Wojciechowska, 2021), as well as offer other health and economic benefits (Fujiwara et al., 2017). Although information technology has blurred face-to-face presence in other areas, libraries continue to be physical spaces and meeting points for sharing cultural and social activities (Aabø & Audunson, 2012). Innovations such as makerspaces promote informal and collaborative learning, creation, participation and inclusion (Bowler & Champagne, 2016; Koh, Abbas & Willett, 2018), and contribute to well-being and, consequently, the social efficiency of these institutions.

2. Problem statement

Considering that welfare contributions materialize in the long run, this work seeks to assess the social efficiency of a public library system over a long period, comparing the resources consumed and the impact generated through the use of the different services provided by libraries for citizens. The aim here is not to specifically evaluate management, but to consider a basic production function where certain capital resources act as carry-overs over time (mainly the library collection). The number of users served in the different services provided by the libraries is taken as a proxy variable for measuring social impact. This is based on the idea that cultural consumption and the degree of training constitute a lever of social transformation, and that the impact in terms of contribution to well-being is directly related to the number of services provided; in other words, the greater the number of users served, the greater the possibility of reducing inequalities, creating social networks, preventing exclusion, and improving health, etc. While most works in this field propose case studies involving library systems in countries with high levels of development (Guccio, Mignosa & Rizzo, 2018; Hammond, 2002; Stroobants & Bouckaert, 2014; Vitaliano, 1998; De Witte & Geys, 2011; Worthington, 1999), this case study looks at the municipal library system of Peru, a country with structural limitations that affect levels of poverty and inequality, and which faces the challenge of improving the quality of its public service and for which an efficient library system constitutes a highly useful tool for promoting social capital, reducing inequalities, and favouring cohesion. The goal here is also to calculate Malmquist productivity indices and their decomposition to understand the extent to which the system is affected by technical changes. In addition, the model is completed with a second-stage analysis that gauges the extent to which efficiency results are affected by the socio-economic variables that define the environment. Given the peculiarities of this developing country, all analyses of efficiency and productivity computation are conducted on a regional basis so as to take into account the geographical diversity of the country and considering the size of the municipalities where the libraries are located in order to address the scale of their services. To the best of the authors' knowledge, there are no efficiency studies on the Peruvian public library system, at least with this three-fold approach that considers social impact, dynamic evolution over time, and geographical analysis of environmental variables. Consequently, the authors' work makes a methodological proposal that offers useful results for library managers, who can gain insights into the determinants of the efficiency of their institutions, and for those responsible for cultural policy, who can become aware of the situation of regional inequalities and their causes.

3. Literature review

The way in which the relationship between cultural organizations and their institutional environment has evolved as a result of the New Public Governance paradigm (Osborne, 2007; Torfing & Triantafillou, 2013) has led other studies addressing the performance of cultural organizations to gauge their social impact as a means of accreditation (Kann-Rasmussen & Rasmussen, 2021). Measures of social impact estimate the value generated by cultural institutions through techniques such as calculating social return on investment (SROI), contingent valuation (CV), and well-being valuation (WV). Works in this field include Aabø (2005a) for the evaluation of the library system in Norway, Hájek and Stejskal (2014) for the evaluation of the Prague City Library, Fujiwara et al. (2017, 2019) for the evaluation of the library service in England, or Gómez-Zapata and del Barrio-Tellado (2023) for the evaluation of the public library system in the city of Medellin, Colombia.

A different perspective is adopted in this work and is one inspired again by the New Public Management paradigm that proposes evaluation aimed at measuring efficiency by observing the relationship between resources employed and services provided (Belfiore, 2004; Kann-Rasmussen, 2023). Some of the works in this area propose constructing tables of indicators to assess effectiveness in achieving objectives and efficiency in the provision of services (Lloyd, 2006; de la Mano & Creaser, 2014; Poll, 2002). This tool is useful for internal management and for external communication, but complicates comparisons between entities. Obtaining a summary indicator for all units can be achieved by applying non-parametric frontier models,–in particular Data Envelopment Analyses (DEA), which can then provide an efficiency value between zero and one for a set of entities, where a value of one describes the most efficient units, and lower values show the distance of these units from the optimal position.[1]

Some works have applied DEA to evaluate the performance of different library systems. Chen (1997) evaluates the technical efficiency of 23 university libraries in Taipei. Vitaliano (1998) analyses the performance of 184 public libraries in the state of New York, and Miidla and Kikas (2009) propose an equivalent study for the central public library system in Estonia. Some works (De Witte & Geys, 2011; Del Barrio-Tellado et al. 2021; Vitaliano, 1998; Worthington, 1999) also introduce a second-stage study to identify possible effects of environmental variables on efficiency outcomes. DEA is suited to studying libraries as it does not require an explicit formulation of the production function. However, some authors have tried to clarify the structure of this production function by identifying different stages in the provision of library services. The first stage focuses on establishing the institution's cultural offer and allows management efficiency to be assessed, while the second stage shows the institution's capacity to attract users. Following this idea, Hammond (2002) designed a two-stage model where the first stage shows the consumption of labor and capital resources for generating service potential, while the second stage shows services provided to users. A similar approach is found in Simon, Simon, and Arias (2011), although this time with an additional stage aimed at measuring the final impact of a group of university libraries. Stage models are refined by introducing network-DEA methods that allow the efficiency results in the different stages of the production function to be obtained, as well as the overall efficiency results, considering the links that exist between the stages involved in the production function (Guccio et al., 2018).

One key issue when appraising library performance is the time dimension. Efficiency studies usually compare resources consumed with services provided in each period. However, in the case of libraries the collection must be considered as a permanent resource that is not extinguished in each period of analysis, and which therefore differs from the other resources available for service provision. Some works have tried to introduce a time dimension when studying library performance without considering this conceptual precision, by simply applying DEA models over consecutive time periods (Jorge, Jorge, Russo, & Oliveira de Sá, 2012Carvalho et al., 2012; Miidla & Kikas, 2009; Stroobants & Bouckaert, 2014). In other cases, this has been done by calculating Malmquist productivity indices and their decomposition (Simon et al., 2011; Vrabková, 2019). Other subsequent works apply dynamic-DEA models to study the time evolution of performance with greater

[1] There are other parametric methods for calculating efficiency, such as stochastic frontier methods. However, the DEA methodology is the most frequently used in cultural institutions due to its flexibility in terms of not requiring the explicit formulation of the production function.

precision, as they allow for a discrimination between inputs consumed and maintained over time (Del Barrio-Tellado et al., 2021). Furthermore, some studies have introduced new methodological details, such as Bernardo et al. (2020), where a zero-sum gain DEA model is applied for the optimal distribution of resources within a university library system, or Del Barrio-Tellado, Gómez-Vega, and Herrero-Prieto (2023), where a time dimension is incorporated into the analysis of cultural entities from a regional perspective.

Finally, some works consider that efficiency results are affected by the context in which the libraries' work and so analyse the effect of environmental variables. This second stage of the efficiency evaluation is usually carried out by means of a regression model through different alternatives (lineal, tobit, truncated), the most widespread being the one proposed by Simar and Wilson (2007). However, this model is based on two highly restrictive basic assumptions: the fulfilment of the separability condition that allows the environmental variables to affect the efficiency results, but not the frontier; and the assumption that the efficiency values follow a truncated normal distribution. In an attempt to overcome these limitations, the use of fractional regression models (FRM) is proposed, in line with the work of Papke and Wooldridge (1996) and Ramalho, Ramalho, and Henriques (2010), which allows bounded response variables to be modelled, evaluating the adequacy of the model specification, and which is conveniently adapted to the possible values of the dependent variable. In this study, efficiency indices are taken as descriptive measures of the relative performance of libraries and distributed in the interval (0,1]. This approach has been considered in some cases in the cultural sector, specifically when studying cultural entities such as museums (Del Barrio-Tellado & Herrero-Prieto, 2019), archives (Guccio et al., 2020), and libraries (Del Barrio-Tellado et al., 2021).

4. Methodology and case study

4.1. Methodology

As noted above, an SBM (slacks-based-measure) dynamic-DEA model is proposed, based on the work of Tone and Tsutsui (2010) to assess how efficient a public library system is at achieving its objectives. The model is well suited to the present case study in that it does not require proportional changes in inputs and outputs, as is to be expected for an activity such as that carried out by libraries. Furthermore, it is a dynamic model that considers the existence of consumed inputs in each period, unconsumed inputs or carry-overs, and outputs. Carry-overs allow for the connection between the activities of two consecutive periods and, in the case of cultural entities such as museums and libraries, it is easy to identify them with the main resource available, i.e. the art and library collection, respectively.

This case commences from a general non-oriented dynamic model that considers both possible reductions in inputs and possible increases in outputs, in line with the following formulation:

$$\rho_0^* = min \frac{\frac{1}{T}\sum_{t=1}^{T} W^t \left[1 - \frac{1}{m+nbad}\left(\sum_{i=1}^{m} \frac{w_i^- s_{it}^-}{x_{iot}} + \sum_{i=1}^{nbad} \frac{s_{it}^{bad}}{z_{iot}^{bad}}\right)\right]}{\frac{1}{T}\sum_{t=1}^{T} W^t \left[1 + \frac{1}{s+ngood}\left(\sum_{i=1}^{s} \frac{w_i^+ s_{it}^+}{y_{iot}} + \sum_{i=1}^{ngood} \frac{s_{it}^{good}}{z_{iot}^{good}}\right)\right]}$$

subject to:

$$\sum_{j=1}^{n} z_{ijt}^{\alpha} \lambda_j^t = \sum_{j=1}^{n} z_{ijt}^{\alpha} \lambda_j^{t+1} \ (\forall i; t = 1, \ldots, T-1),$$

$$x_{iot} = \sum_{j=1}^{n} x_{ijt} \lambda_j^t + s_{it}^- \ (i = 1, \ldots, m; t = 1, \ldots, T)$$

$$x_{iot}^{fix} = \sum_{j=1}^{n} x_{ijt}^{fix} \lambda_j^t \ (i = 1, \ldots, p; t = 1, \ldots, T)$$

$$y_{iot} = \sum_{j=1}^{n} y_{ijt} \lambda_j^t - s_{it}^+ \ (i = 1, \ldots, s; t = 1, \ldots, T)$$

$$y_{iot}^{fix} = \sum_{j=1}^{n} y_{ijt}^{fix} \lambda_j^t \ (i = 1, \ldots, r; t = 1, \ldots, T)$$

$$z_{iot}^{good} = \sum_{j=1}^{n} z_{ijt}^{good} \lambda_j^t - s_{it}^{good} \ (i = 1, \ldots, ngood; t = 1, \ldots, T)$$

$$z_{iot}^{bad} = \sum_{j=1}^{n} z_{ijt}^{bad} \lambda_j^t + s_{it}^{bad} \ (i = 1, \ldots, nbad; t = 1, \ldots, T)$$

$$z_{iot}^{free} = \sum_{j=1}^{n} z_{ijt}^{free} \lambda_j^t + s_{it}^{free} \ (i = 1, \ldots, nfree; t = 1, \ldots, T)$$

$$z_{iot}^{fix} = \sum_{j=1}^{n} z_{ijt}^{fix} \lambda_j^t \ (i = 1, \ldots, nfix; t = 1, \ldots, T)$$

$$\sum_{j=1}^{n} \lambda_j^t = 1 \ (t = 1, \ldots, T)$$

$$\lambda_j^t \geq 0, s_{it}^- \geq 0, s_{it}^+ \geq 0, s_{it}^{good} \geq 0, s_{it}^{bad} \geq 0 \ and \ s_{it}^{free} : free(\forall i, t),$$

where x_{ijt} $(i = 1, \ldots m)$ and x_{ijt}^{fix} $(i = 1, \ldots p)$ represent the discretionary and non-discretionary inputs i consumed by library j $(j = 1, \ldots n)$ in period t $(t = 1, \ldots T)$, while y_{ijt} $(i = 1, \ldots s)$ and y_{ijt}^{fix} $(i = 1, \ldots r)$ represent the discretionary and non-discretionary outputs i produced by library j in period t. In addition, z_{ijt}^{good} $(i = 1, \ldots ngood)$, z_{ijt}^{bad} $(i = 1, \ldots nbad)$, z_{ijt}^{free} $(i = 1, \ldots nfree)$ and z_{ijt}^{fix} $(i = 1, \ldots nfix)$ carry-overs i are denoted, which serve as links between t periods for each library j, taking into account the different possible categories of links, i.e. desirable or good, undesirable or bad, freely available to the institution or free, and non-discretionary or fixed. Finally, $s_{it}^-, s_{it}^+, s_{it}^{good}, s_{it}^{bad}$ and s_{it}^{free} represent the slack variables for input excess, output shortfall, link shortfall, link excess, and link deviation. For each library j, the proposed model provides an overall efficiency indicator $\left(\rho_j^*\right)$ for the full-time interval as well as an efficiency indicator for each of the t periods $\left(\rho_{jt}^*\right)$. This indicator takes a value of one for efficient libraries and a value of less than one for inefficient entities.

To complete the study, the dynamic Malmquist indices (Caves, Christensen, & Diewert, 1982) are calculated from the dynamic efficiency indices (Färe et al.,1994; Tone & Tsutsui, 2017). Decomposing the Malmquist index $\left(\mu_j\right)$ will provide an insight into the effort deployed by each entity j in improving its efficiency (catch-up term) $\left(\gamma_j^{t \to t+1}\right)$, and the extent to which technological evolution causes shifts in the efficient frontier (frontier-shift term) $\left(\varphi_j^{t \to t+1}\right)$ for each entity. The following expression relates both components when calculating the dynamic Malmquist index:

$$\mu_j^{t \to t+1} = \gamma_j^{t \to t+1} . \varphi_j^{t \to t+1} \ (t = 1, \ldots T)$$

The part of the index reflecting the dynamic evolution of the efficiency between two time periods can be calculated as the ratio between the efficiencies of periods t + 1 and t:

$$\gamma_j^{t \to t+1} = \frac{\rho_0^{t+1*}}{\rho_0^{t*}}$$

The part of the index that reflects the displacement of the technological frontier between two points in time can also be calculated:

$$\varphi_j^{t \to t+1} = \left[\frac{\rho_0^{t*}}{\rho_0^{t\,(t+1)*}} . \frac{\rho_0^{t+1(t)*}}{\rho_0^{t+1*}}\right]^{1/2}$$

where $\rho_0^{t\,(t+1)*}$ represents the efficiency ratio of entity o at time t with respect to the frontier at t + 1, and $\rho_0^{t+1(t)*}$ the efficiency ratio of entity o

at time t + 1 with respect to the frontier at t. A value greater than one in the catch-up term $\left(\gamma_j^{t\to t+1}\right)$ indicates improvements in efficiency, while a value below 1 indicates regression. Likewise, a value greater than one in the frontier-shift term $\left(\varphi_j^{t\to t+1}\right)$ represents improvements associated with technological change. Conversely, a value of less than one represents a reversal in technological conditions.

From the dynamic Malmquist indices described above, it is possible to calculate an overall dynamic index as the geometric mean of the dynamic Malmquist indices, and a cumulative dynamic Malmquist index. $\left(\widetilde{\mu}_o^{1\to t}\right)$ which, starting from the initial period, shows the cumulative development up to periods 2, …,T (Tone & Tsutsui, 2017):

$$\widetilde{\mu}_o^{1\to t} = \prod_{t=1}^{t} \mu_0^{t\to t+1} \ (t = 1, \ldots, T-1)$$

Again, this cumulative index can be decomposed into two terms showing the cumulative efficiency improvements $\left(\widetilde{\gamma}_0^{1\to t}\right)$ and the cumulative shifts of the frontier $\left(\widetilde{\varphi}_0^{1\to t}\right)$, respectively (Tone & Tsutsui, 2017):

$$\widetilde{\mu}_o^{1\to t} = \prod_{t=1}^{t} \gamma_0^{t\to t+1}.\varphi_0^{t\to t+1} = \widetilde{\gamma}_0^{1\to t}.\widetilde{\varphi}_0^{1\to t} (t = 1, \ldots, T-1)$$

The work is completed with a second-stage study to analyse whether efficiency results are affected by the variables that define the environment in which the institutions in the sample operate. The following expression describes the model:

$E(\rho_0/z_i) = G(z_i\vartheta)\ i = 0\ 1,\ 2,\ \ldots,$n.

where ρ_0 represents the measure of efficiency; z_i is the vector of contextual variables for each entity i; G(.) represents a non-linear function satisfying condition $0 \le G(.) \le 1$ for which different specifications –logit, probit, loglog, and clogloglog– are assumed, and where ϑ represents the vector of parameters to be determined.

4.2. Case study: Peru's municipal libraries

Having defined the model for the dynamic evaluation of efficiency, the Peruvian municipal library system is taken as a case study. As for other countries that face important developmental challenges, libraries in our case study are a useful tool in promoting social capital since they facilitate access to information and education as well as offering social inclusion, and because they improve the quality of life of citizens and promote more equitable development. According to data from the country's National Institute of Statistics and Informatics (INEI), through the 2020 National Registry of Municipalities (RENAMU), the group is initially formed by 474 libraries, distributed unequally among the country's 1874 municipalities in terms of spatial dimension, since only 25% of the municipalities have a public library. Municipal libraries are managed by local governments, with supervision by the national government. The objectives of these libraries are linked to accessibility to information and to promoting reading, optimal management of resources, social, cultural and economic impact by expanding the number of users, with particular attention focusing on vulnerable groups.

The period 2014 to 2019 is taken as the reference. This period offers the most recent data available, added to which the interval includes a period wherein different projects were launched to implement standards of quality, effectiveness, and efficiency in the provision of library services. From the data corresponding to the total population in the reference period, the sample was filtered by eliminating units whose start-up proved to be merely nominal, as they showed hardly any activity and were very poorly staffed. In addition, libraries that did not show constant activity during the period from 2014 to 2019 were removed from the sample. Some libraries with inconsistent data were also excluded. Finally, to maintain the homogeneity required by DEA, libraries that did not exceed certain minimum size thresholds were excluded from the sample. These thresholds involved maintaining collections of over 500 items, having a minimum surface area of 35 m^2 by the end of the period analysed, and receiving over 100 visitors per year. As a result of this process, there is a final sample of 167 libraries that are representative of the institutions operating in Peru in the reference period.

Taking the main objective of these entities to be that of generating a positive social impact on the inhabitants of the areas in which they operate, a production function is defined as shown in Fig. 1. Starting from this production function, a non-oriented dynamic SBM model is applied that considers possible reductions in inputs and increases in outputs. Furthermore, considering the differences in size of the units evaluated, a model with variable returns to scale is assumed. STAFF, SURFACE, and FACILITIES are taken as input variables indicating the available resources. The STAFF variable represents the labour resources available to the libraries to provide the services entrusted to them and is measured as the number of people working full time. The SURFACE and FACILITIES variables refer to the capital endowments available to the institutions to conduct their work. The former refers to the useful surface area they have –measured in square metres, while the latter represents facilities such as reading rooms, children's rooms, newspaper libraries, internet booths, etc., which have been measured in units. In both cases, these variables are deemed to generate consumption (amortization, maintenance, other expenses) in each period of activity. An additional resource available to the institutions is the collection, represented by the variable BIBLIOGRAPHIC FUNDS. In line with previous work (Del Barrio-Tellado et al., 2021), the collection is considered to be a link between periods, as it is a productive resource that is maintained over time and is therefore incorporated into the production function as a carry-over from the non-discretionary category, since libraries cannot freely dispose of this resource, given their function of custody and conservation of the funds entrusted to them. All these resources are allocated to the provision of services that have a positive impact on the population's well-being. Considering that generating this impact requires the prior provision of the service, as a proxy variable for this impact an output variable called USERS is used, which measures the number of services provided, whether by circulating materials, consultation in the reading room, or participation in cultural activities. All these services help generate a positive impact on citizens' well-being (Fujiwara et al., 2019) that has been described in numerous works in terms of helping to create social capital (Wojciechowska, 2021), the capacity to act as civic agents to transform communities (Ferreira, Nowicki, & Shakya, 2023; Willingham, 2008), and constituting a meeting point for access to information and cultural development (Glorieux et al., 2007).

In addition to the variables representing inputs and outputs, there is a set of variables that characterize the environment in which the libraries operate. For all the descriptive variables of the environment, the data were taken from the National Institute of Statistics and Informatics of Peru and were disaggregated at the municipal level. These variables try to show the cultural and economic level of the population, as well as the cultural endowments of each municipality. Among the former, the variable HUMAN CAPITAL is used, which indicates the percentage of the population with university studies in each municipality; INTERNET, which shows the percentage of the population that usually uses the Internet to access information; ILLITERATE, which indicates the percentage of the population who cannot read; and EXTREME POVERTY, which measures the percentage of people living in extreme poverty and which thus acts as a proxy for the level of income in the opposite direction. The second group of variables contains data on the number of cultural centers in the municipality (CULTURAL CENTRES) and the number of travel agencies in each municipality (TRAVEL AGENCIES) as an indicator of accessibility, in the absence of other data related to

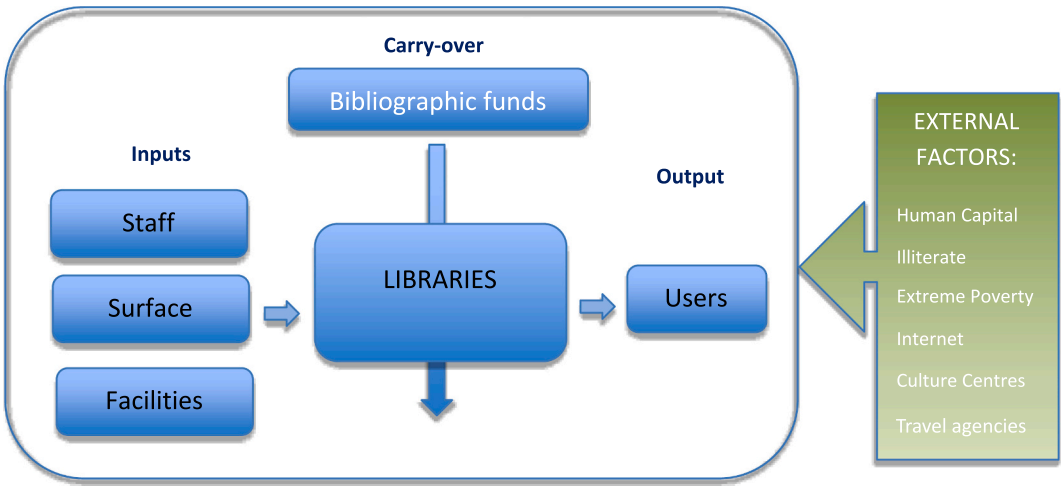

Fig. 1. Production function of municipal libraries.

infrastructure that facilitates travel. Table 1 shows the descriptive statistics for all the variables. All calculations were performed with the DEA-Solver-Pro and Stata software packages.

5. Findings

Table 2 shows the descriptive statistics of the dynamic efficiency indicators of the sample of libraries for each period evaluated, and for the period between 2014 and 2019. As can be seen, the average efficiency index for the total period is low (0.3587), although between 2014 and 2019 it does show sustained improvement, reaching an average value of 0.5049 in 2019.

Of the 167 libraries included in the study, 11 obtain the maximum value for the overall index for the period (2014 to 2019). Three of these libraries are located in the city of Lima and the rest are mostly located in small rural municipalities. In view of these data, differences in the efficiency results were compared depending on the type of municipality served by the libraries. To do this, the classification of municipalities as established in the rules governing the operation of municipal libraries in Peru (BNP, 2019) was taken. This includes four categories of municipalities in terms of population: A, for municipalities with over 100,000 inhabitants; B, for municipalities with between 50,000 and 99,999 inhabitants; C, for municipalities with between 10,000 and 49,999 inhabitants; and D for municipalities with less than 10,000 inhabitants.

Table B.1 and Fig. A.1 (see Appendix) show the dynamic efficiency indices by library type (depending on the size of the municipality) and year. Tests were conducted for significant differences in the efficiency results between the different groups of libraries using the Kwallis and Levene tests. In both cases, differences in efficiency distribution were found to be significant. The average dynamic efficiency ratios by region were also calculated to determine whether there are any significant geographical differences. Table B.2 (see Appendix) shows the average dynamic efficiency indices for the period 2014–2019 by region, which is also shown together with the distribution of libraries according to the size of the municipality in the map of Fig. 2. As can be seen, there are notable differences in efficiency between regions, ranging from 0.707 for the Huancavelica region to 0.115 for Ucayali. In the first case, this region concentrates type B and C libraries, located in the highlands. At the other extreme, the region of Ucayali, which is located in the rainforest, has type A and B libraries, and serves an area of considerable size with a small and disperse population.

The efficiency results of the libraries in the sample were also grouped according to the three natural regions of Peru; coast, highlands, and rainforest. Given the different conditions that characterize these (reflected in small and dispersed populations with a tendency towards depopulation in the jungle, small and medium-sized populations, but with tourist activity in the mountains, and larger populations on the coast), differences in efficiency results can also be expected for each region. Using this classification as a reference, tests for differences in distributions were carried out using the Kwallis, and Levene, with significant differences emerging in both cases. Table B.3 (see Appendix) shows the statistics of the efficiency indicators for each of these three categories. As can be seen in Fig. 2, the highest efficiency values

Table 1
Descriptive statistics.

Variable	Description	Average	Min	Max	St Dev.
STAFF	number of employees	3.445	1	33	4.036
SURFACE	surface area (m^2)	303.566	39	2671	354.722
FACILITIES	number of facilities (reading rooms, children's rooms, newspaper and periodicals libraries, internet booths, etc.)	2.713	1	7	1.254
BIBLIOGRAPHIC FUNDS	number of bibliographic resources	7585.948	620	99,286	9906.038
USERS	number of services provided	5819.854	100	80,140	10,185.41
HUMAN CAPITAL	% of population with university education	7.598	0	50	8.067
INTERNET	% of population using the Internet to obtain information	87.021	0	100	14.321
CULTURE CENTRES	number of cultural centres per municipality	0.296	0	6	0.630
TRAVEL AGENCIES	number of travel agencies	21.432	0	806	70.565
ILLITERATE	% of population unable to read	13.254	0	63.16	8.966
EXTREME POVERTY	% of population living in extreme poverty	0.296	0	6	0.630

Table 2
Dynamic efficiency indicators (2014–2019).

	2014	2015	2016	2017	2018	2019	Overall
Mean	0.3165	0.4809	0.4844	0.4606	0.4857	0.5049	0.3587
Min	0.0009	0.0170	0.0122	0.0126	0.0162	0.0097	0.0149
Max	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
St. Dev.	0.3256	0.3887	0.3859	0.3806	0.3662	0.3954	0.3108

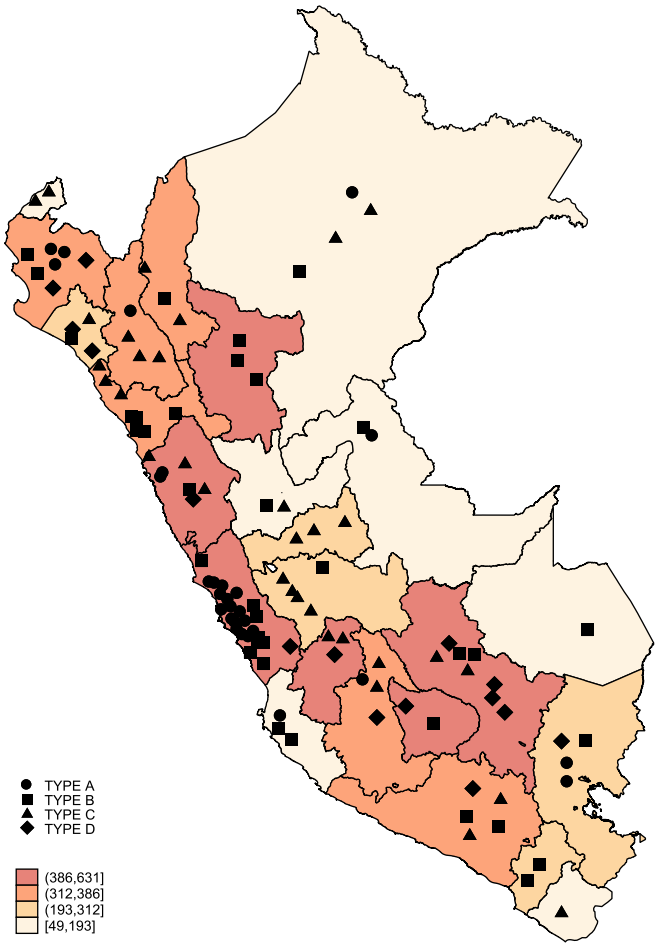

Fig. 2. Library efficiency map by region and distribution of libraries by type of district.

correspond to the highland area, where smaller libraries tend to operate with fewer resources than on the coast, serving a population with lower average levels of education. The next group in terms of efficiency levels corresponds to the coast, where the highest population density with higher levels of education is concentrated in larger urban centres. Finally, the lowest efficiency values correspond to libraries in the rainforest, which are located in smaller population centres and which serve large areas.

To complete the study of the temporal evolution of library impact, Malmquist dynamic productivity indices were calculated. These show how productivity between two points evolves over time based on dynamic SBM efficiency indices and their decomposition into two factors that show the changes triggered by improvements in efficiency (catch-up) as well as those derived from displacements of the frontier as a result of technological developments (frontier shift). Table 3 shows the average results for the group of libraries. A cumulative average increase in productivity for the period 2014–2019 of 425% can be seen. This is due almost entirely to efficiency gains over the period, given that the frontier shift resulting from technological progress is hardly noticeable. The temporal distribution of productivity gains is reflected in Table B.4 (see Appendix) and shows that the most significant jumps correspond to the periods 2014 → 2015 and 2018 → 2019.

As was done for the efficiency indicators, possible differences were sought in productivity depending on library classification in terms of the population in the municipality where the libraries are located. Table B.5 (see Appendix) shows the productivity results according to this classification. In this case, only Levene's test confirms a relationship between population type and productivity results. Average productivity changes by region were also calculated, resulting in the data shown in Table B.6 (see Appendix). The regions with the highest productivity improvements are Ica, Lambayeque, and Arequipa, all of which are located in the coastal area, and which have medium/high levels of efficiency. At the opposite extreme are the regions of Ucayali and Cusco, located in the rainforest and highland regions, respectively, and which initially obtained very different efficiency results (low in the case of Ucayali and high for the Cusco region). In general, it can be said that the regions with the highest productivity gains have average population densities and average levels of wealth. As was done before, results were grouped according to the three natural regions of Peru. The results are shown in Table B.7 (see Appendix). Different tests (Kwallis and Levene) were conducted to ascertain possible differences in the distributions, and these confirmed the existence of significant differences only in the Levene test. In this case, the highest productivity increases correspond to the coastal area, followed by the highlands and the rainforest.

In view of these previous results, a test was conducted to ascertain whether efficiency values are conditioned by environmental variables in the areas in which each library operates. Although the availability of information is limited, as indicated above, the variables used aim to describe the economic and cultural environment of the population (human capital, internet access, population living in extreme poverty, and degree of illiteracy), as well as the level of endowment of the municipality in which the libraries operate (cultural centres, number of travel agencies). Following the work of Papke and Wooldridge (1996), Ramalho et al. (2010) and Ramalho, Ramalho, and Murteira (2011), a fractional regression model was proposed, taking library indicators of dynamic efficiency as the dependent variable, and those that characterize the environment as independent variables. Different specifications were considered for the model; logit, probit, loglog and cloglog. A one-part model was initially proposed on the understanding that the extreme and intermediate values of the dependent variable do not derive from separate decisions but are a result of how the institution approaches service provision (Ramalho et al., 2011). Nevertheless, the appropriateness of this choice versus a two-part model was confirmed by means of a P-test for all four functional specifications. The results are shown in Table 4, where the one-part model is the correct specification in all cases, except for the loglog function, where the two-part specification is not acceptable either. Taking a one-part model, a RESET test was next proposed that allows the functional form to be defined that best fits the present case. The results confirm the impossibility of opting for the loglog specification, while the logit, probit and cloglog specifications show similar results in terms of sign and significance and are acceptable in all cases.

As seen in Table 4, there is a significant and positive relationship between the population's level of education, measured through the HUMAN CAPITAL variable, and efficiency results. A positive and significant relationship was also found between illiteracy level and

Table 3
Cumulative and overall Dynamic Malmquist index.

	Malmquist		Catch-up		Frontier-shift	
	Overall	Cumulative	Overall	Cumulative	Overall	Cumulative
Mean	1.1098	4.2520	1.1431	4.0470	0.9709	1.0410
Min	2.5661	0.0597	2.5654	0.1170	1.7629	0.0590
Max	0.5692	111.2594	0.6507	111.2594	0.5692	17.0260
St Dev	0.3157	11.5848	0.2844	10.39053	0.1203	1.3912

Table 4
Regression analysis between efficiency indicators and external variables.

Fractional Regression Model	Logit		Probit		Loglog		Cloglog	
	Coef.	P > z	Coef.	P > z	Coef.	P > z	Coef.	P > z
HUMAN CAPITAL	0.0213	0.012 *	0.0133	0.009 **	0.0145	0.013 *	0.0159	0.005 **
ILLITERATE	0.0336	0.000 **	0.0203	0.000 **	0.0223	0.000**	0.0228	0.000 **
EXTREME POVERTY	−0.0209	0.041 *	−0.0123	0.039 *	−0.0123	0.027 *	−0.0140	0.062
INTERNET	−0.0028	0.378	−0.0017	0.378	−0.0019	0.396	−0.0021	0.370
CULTURE CENTRES	0.2295	0.004 **	0.1453	0.003 **	0.1561	0.009**	0.1749	0.001 **
TRAVEL AGENCIES	0.0046	0.000 **	0.0027	0.000 **	0.0034	0.000**	0.0027	0.000 **
Constant	−0.6589	0.033	−0.4039	0.035	−0.0777	0.717	−0.8316	0.000
R^2	0.0720	0.0719			0.0695	0.0733		
Ptest								
H1: One part FRM	0.0002**		0.0005**		0.0002**		0.0212*	
H1: Two-part FRM	0.0945		0.1545		0.0062**		0.8744	
RESET LM TEST (Lagrange Multiplier)	0.0830		0.1722		0.0043**		0.9696	

Level of significance: *p-value<0.05, ** p-value<0.01.

efficiency. As regards the variable that reflects the level of poverty (EXTREME POVERTY), a negative and significant relationship with the efficiency results is evident, indicating that participation in cultural activities first requires basic needs to be satisfied. Regarding the percentage of people using the Internet as a source of information and the level of efficiency of libraries, no significant relationship was found. Finally, the variables related to cultural endowments and accessibility (CULTURE CENTRES and TRAVEL AGENCIES) show a positive and significant relationship with efficiency levels. The percentage change in efficiency for a 1% change in the external covariate was computed through elasticities. All specifications show similar size effects, with the variables referring to population formation showing the largest size effect on efficiency outcomes.

6. Discussion

Some of the measures implemented in the Peruvian municipal library system in the period under review, such as public management performance awards, integration in the Iberbibliotecas system,[2] or public awareness campaigns, may have contributed to the favorable evolution of efficiency indicators. The results seem to indicate that it is the most populated and smallest municipalities that obtain the best efficiency results for the period evaluated. This might be explained by them serving a bigger population in the case of the larger municipalities, and by the limited cultural offer available in the smaller municipalities, which leads users to focus their interest on libraries, given the scarcity of alternatives for culture and leisure, with all that this implies in terms of the social impact generated by libraries in this type of municipality. The spatial analysis of efficiency results would point to the importance of rethinking the size and location of libraries in the area as a means of extending their impact, by adapting them more to the area and population they serve.

The values of the Malmquist productivity indices show that while demand for libraries has been significantly affected by technical developments and widespread access to information and communication technologies, their service-oriented productive activity shows a certain imperviousness to technological advances. Some actions implemented in libraries, such as the publication of the standard governing library operation in 2015 or incorporation into the Ibero-American Programme of public libraries (Iberbibliotecas) as of 2017, could explain the most significant gains in productivity. The correlation analysis between efficiency and productivity shows a trade-off between the two variables, suggesting that the highest productivity gains in the period correspond to libraries with low overall efficiency levels, which might reflect the effort made by these institutions to adapt to minimum performance standards during this period. The combined analysis of efficiency and productivity indicators by geographical area seems to indicate a tendency towards uniformity in libraries in coastal and highland areas. In contrast, libraries located in the jungle area, which have lower efficiency values and lower productivity improvements, tend to move away from the rest of the libraries in the area.

The results of the second-stage analysis are in line with results obtained in previous studies. As far as human capital is concerned, equivalent results are observed in Sin and Kim (2008) for the United States, Glorieux et al. (2007) for the Flemish public library system (Belgium), and in Japzon and Gong (2005) for a group of public libraries in New York City. Previously noted are the good efficiency results of libraries located in smaller populations. It is common in these communities to implement library programs to eradicate illiteracy, which may explain the results obtained. In addition, Aabo (2012) points out the role that libraries play as a meeting point for people with low levels of education and how libraries contribute towards community cohesion.

The negative relationship between poverty and the use of library services is documented in works such as Glorieux et al. (2007), where a significant and negative relationship is shown between the percentage of households lacking basic comfort (as a measure of poverty) and the number of registered library users. Japzon and Gong (2005) obtain equivalent results by finding a negative and significant relationship between circulation of materials and low-income levels.

No relationship was found between the degree of use of the Internet

[2] Iberbibliotecas is a programme that supports the development of networks or systems of public libraries in Latin-America. It seeks to demonstrate their impact on the construction of the social fabric and development of democratic societies through support programmes for library projects, training courses for people linked to libraries, as well as scholarship and internship programmes.

as a source of information and the level of efficiency. This might be because, although libraries initially made internet access possible for some users, universal access to the Internet has now changed the role of libraries as providers of this service, such that new services like guides for the creative use of these resources have now been incorporated (Wojciechowska, 2021).

The relationship between efficiency and cultural endowments and accessibility is in line with that obtained by Barrio-Tellado et al. (2023), and shows a positive relationship between library efficiency and domestic tourism and public spending on culture.

Although libraries do emerge as a useful tool for improving education and for promoting inclusion, the results show how it is necessary to remember that uniform management thereof is not possible, given the differences between areas, with particular attention needing to be focused on libraries located in rural areas that have fewer resources, infrastructure, and cultural offerings.

Finally, it should be noted that this way of measuring the impact of libraries is based on quantitative data relating to the number of users served. However, the contribution to the well-being of communities, although depending directly on the number of users served, is also conditioned by the quality of the services provided and their orientation to social needs. Consequently, it is necessary to measure the impact generated by libraries on issues such as social cohesion, civic sense, health, identity or inequalities. As a result, new studies that consider measures of quality and user satisfaction could help to enrich the analysis. It is also worth studying how participation and collaboration with other local institutions might affect library efficiency.

7. Conclusions

As entities that consume public resources, libraries must be subject to evaluation processes that assess the extent to which the resources allocated to them have helped to create well-being for society. The authors propose an evaluation model that relates the resources consumed to the social impact generated, measured through the number of visitors to libraries for any of the activities that make up their range of services; not only the traditional ones of consultation and lending, but also cultural as well as entertainment activities. This choice is justified by previous literature that recognizes the value and impact generated by these institutions through a range of services geared towards education and leisure and aimed at a wide range of users that include children and adults, the elderly, schools, companies, etc. For all of these users, libraries represent a physical space for cultural and social encounters, whether in relation to study, training or leisure.

Libraries are now adapting to the technological changes imposed by the environment, and our work also evaluates to what extent libraries are permeable to technical change and whether this has affected their productivity levels. Finally, the spatial environment also proves decisive in the success of libraries, and we show that level of education, accessibility and poverty rates act as drivers of library efficiency in Peru.

The results of this work is relevant for the design of public policies, especially in developing countries, which seek to improve the welfare conditions of their citizens as well as the quality of the public services made available. Libraries can contribute to this objective by promoting the creation of cultural capital as a factor of development.

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CRediT authorship contribution statement

María José del Barrio-Tellado: Writing – review & editing, Writing – original draft, Supervision, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Angela Milagros Reyes-Gutierrez:** Writing – original draft, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

No potential conflict of interest was reported by the authors.

Appendix A. Supplementary data

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