Evaluation of the Efficiency of Public Historical Archives

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Abstract

In the economic literature increasing attention is paid to the efficiency evaluation in the cultural sector. However, so far, the performance of archives is rarely investigated, notwithstanding their cultural and historical relevance. Indeed, the analysis of archives raises interesting theoretical issues because of the economic features of their outputs, ranging from public goods to divisible services. Moreover, similar services are usually provided in a decentralized way and, therefore, there is room for interesting benchmarking analysis and for policy implications. In this paper we investigate the efficiency of public historical archives in Italy over the period 2011-2012. The efficiency frontier is estimated using Data Envelopment Analysis (DEA) implementing several procedure that allows us to better investigate the performance. The efficiency analysis provides insights for policy implication.

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1. Introduction

The economic investigation on the efficiency and, more in general, on the performance of cultural services and activities is longstanding, though much less widespread if compared with other sectors such as health or education. It has developed using different methodologies and approaches - both parametric and non- parametric approaches - and it has been applied to several fields such as museums, theatres, libraries, heritage authorities. Several issues still deserve closer investigation since the peculiar nature of cultural activities raises severe measurement and evaluation problems and there are difficulties in collecting reliable data suitable to represent the complex activity of cultural institutions.

In the cultural economics literature, so far, to our knowledge, no attention has been devoted to Public Historical Archives (PHA), though these organizations play a relevant cultural role because they are a primary source for historical research and their activities exhibit quite interesting features from an economic point of view.

By PHA we refer to public institutions conserving public records and other documents of various types which are preserved because of their permanent cultural, historical, or evidentiary value. Archival records are in most cases unique and, from this perspective, archives function is quite distinct from the one performed by libraries.

Indeed, such a conservation function helps to conserve the records of the past for future generations; in fact, historians process information and data collected through archival records in order to reconstruct the history of societies and/or of specific individuals, groups or organizations. The conservation function of archives, therefore, generates a 'public good', with its well-known economic implications.

Still, archives are not only aimed at ensuring permanent or long-term conservation of their collection but also at making it available to the public for various purposes, such as, for instance, study, research or entertainment, depending on the characteristics of the records. In so doing also divisible benefits are produced, depending on the individual 'consumption'.

Archives, therefore, as many other cultural organizations, can be considered a multi-product organization and, therefore, in investigating their performance, such a feature has to be taken into account. The combination of private and public benefits is rather peculiar of PHA and it differs from other cultural organizations, even from libraries, which are usually considered the most similar ones. Indeed, the 'public' component of benefits seems to have more weight than the 'private' one, raising theoretical and empirical issues.

This paper aims at investigating the efficiency of PHA, The analysis of the efficiency of PHA will be carried out, using Italy as a case study and employing an official detailed data set on Italian PHA provided by the Italian Ministry for Cultural Goods and Activities and Tourism (MIBACT). To address such an issue a nonparametric approach (DEA-Data Envelopment Analysis) is used to measure the relative efficiency in the production of archival services.

The analysis develops as it follows: in section 2 a short review of the existing literature on the efficiency measurement of cultural institutions is offered. Section 3 analyses the main features of our case study, Italian PHAs and section 4 describes the methodology and the data used. Section 5 provides technical efficiency estimates and section 6 offers some concluding remarks.

2. Efficiency of cultural institutions: a literature review

The measurement of efficiency of cultural institutions is part of a more general work, related to the analysis of performance. The use of performance indicators in the cultural field is quite widespread nowadays. The basic reason for the development of this practice is that the scope for commercial profit-oriented activity is very limited in most sectors of cultural production, and the size of public and private contributions can be large. The different stakeholders cannot refer to any market signal, however imperfect it may be, to evaluate different aspects of cultural production. Therefore there is a need to define ‘virtual’ measures of cultural institutions’ performance so as to provide some empirical support to the judgment on the value of cultural production.

Generally speaking, it is possible to find many measures of very different elements of the performance of organizations and sectors. Efficiency is one of the

aspects of performance, which has been mostly explored. One of the notions that has been used to analyse and to measure efficiency is cost minimisation. Heilbrun and Gray (1993) develop their analysis of art museums in the US by focusing on the financial aspects of their management. Cost minimisation is an important dimension to be considered when evaluating the efficiency of cultural institutions, but there must be serious doubts as to whether it properly measures their performance. Cost minimisation is related to the optimal choice of inputs and, therefore, it implies that the institutions' managers should be able to control the main inputs used in the different activities in which an institution is involved. This is not always true for every institution, particularly in those countries where most cultural institutions belong to the public sector, and operate within a set of, more or less, tight constraints. For this reason, therefore, several studies have considered, in their analysis of cultural institutions' efficiency, at the technical efficiency dimension. Technical efficiency occurs when an organisation produces the maximum output given the available inputs. Perelman and Pestieau (1988) think of technical efficiency as a "natural" objective of any organisation, both public and private. "The only objective for which no extenuating circumstances can be invoked is that of technical efficiency (for a given input pattern, more of any outputs cannot be produced). This objective is thus compatible with all the other objectives. In other words, there are no good justifications of any sort for not producing more with the available inputs" (Perelman and Pestieau, 1988, p. 433).

The measurement of efficiency has initially developed through the use of productivity indicators. This type of indicators provides information on single aspects of arts production and consumption. However, when we consider, for instance, the output of many cultural institutions, we can observe that their production process is generally multidimensional, both from the input and the output side. A general evaluation of the efficiency of production can, then, be obtained only through a multiplicity of indicators, which does not allow a clear-cut evaluation of the efficiency of an organization. Moreover, when comparing the values of the same indicator for different organizations, the relevance of the comparison is limited by the fact that quantities of output, multiples or

submultiples of that achieved by any given organization, are not necessarily technically attainable employing multiples or sub-multiples of the inputs used by that organization. There is a need, therefore, to use more advanced techniques that take into account the multidimensional nature of arts production and consumption. There have been now several attempts (Pignataro, 2002; Mairesse and Vanden Eeckaut, 2002; Bishop and Brand, 2003; Basso and Funari, 2004; Finocchiaro Castro, Guccio and Rizzo, 2011; Finocchiaro Castro and Rizzo, 2009; Del Barrio, Herrero and Sanz, 2009; Last and Wetzd, 2010; Del Barrio and Herrero, 2013; Zieba, 2011; for recent surveys of the use of these techniques see Pignataro, 2011, and Fernadez-Blanco, Herrero and Prieto-Rodriguez, 2013), dealing with the efficiency of museums and other cultural institutions, to employ the method of efficiency frontiers. Efficiency frontiers or, as sometimes they are called, best practice frontiers, are the sets of the best production units. The particular advantages of this methodology, with respect to simple productivity indicators, are of different nature. First, by benchmarking the performance of different institutions, it allows to establish a sort of 'best' reference, those institutions which are on the efficiency frontier (that is, they are 100 per cent efficient), so as to compute a single efficiency index, which is the 'distance' of each observation from the frontier. In such a way, it is possible to move from the measure of productivity to that of relative efficiency. Second, this methodology takes simultaneously into account all the relevant inputs and outputs of the production process, developing one single measure of efficiency. Finally, it proves to be very useful in several contexts, where comparison of performance is required, for management or financing purposes.

Among the natural candidate methodologies for the task of employing the method of efficiency frontiers, there are the non-parametric frontier techniques. Free Disposal Hull (FDH) and Data Envelopment Analysis (DEA) are among the most known and applied nonparametric techniques for the measurement of efficiency. DEA is a nonparametric technique, generally used to estimate a production function with minimal assumptions, and it can easily handle multiple inputs/outputs situations. By constructing envelopment unitary isoquants corresponding to comparable observation units across different situations, DEA

identifies as productive benchmarks those units that exhibit the lowest technical coefficients, i.e. lowest input amount to produce one unit of output. In so doing, DEA allows for the identification of best practices and for the comparison of each unit with the best possible performance among the peers, rather than just with the average. Despite the complexity of the techniques, the most challenging task for their application is the identification of the production process, that is the relation between the inputs used in the process and the output(s) eventually attained. The main problem encountered here is connected with a clear identification of what constitutes the output(s) of cultural institutions. This problem, as revealed in most works, is crucial for the results of the efficiency measurement and for their interpretation.

3. Italian public historical archives: activities and organization

In Italy, archival functions pertains to the MIBACT through the Archives General Directorate and are performed by its peripheral structures, State Archives (PHAs). The close analysis of the ministerial administrative organization is outside the scope of this paper[1]: however, it is useful to outline that the General Directorate, among the other functions, coordinates, from a technical and scientific point of view, the activities of PHAs.

Italian PHAs are 101, mainly located in provincial capital towns and, usually, in important historical buildings. PHAs pursue the objective of conserving pre-unitary archival documents of central and local administrations as well as those produced by local administrations of the unitary State[2]. PHAs also oversight on the management of state archives which are still in use and on the discarding of documents of no historical interest.[3]

Some PHAs also have Sections[4] which are located in minor cities, and are established because of the high cultural relevance of the documents existing within the specific area in which they operate.

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[1] A detailed description can be found at http://www.archivi.beniculturali.it/

2 These documents become part of the collection of PHA after 40 years the end of the procedure.

3 The protection of private documents pertains to 19 Archivistic *Soprintendenze* which issue 'declarations of cultural interests.

4 Sections are overall 35.

PHAs collections contains several types of records ranging from paper documents, parchments and seals to photos, sound recording, films, drawings, musical scores, etc.

The 'consumption' of archival records can be done in various ways ranging from the traditional ones, such as visiting the archive building and consulting the required material, to more technological ones, such as browsing the archive website and access digitized documents and records. The process for opening PHAs collections, *e.g.* to make them shared and accessible is under way: 90 PHAs have adopted the Informative System for State Archives (SIAS)[5] and 88 PHAs are accessible through web.

4. Methods and data

4.1 Methodological framework

In this study, we focus on technical efficiency of Italian PHA (our Decision Making Units - DMUs), which involves the comparison between the actual performance of each DMU and the optimal performance of DMUs located on the relevant frontier (the best practice frontier). This approach is based on the efficiency measures proposed by Koopmans (1951) and Debreu (1951) and empirically applied by Farrell (1957). Two main analytical approaches are available to estimate efficiency frontiers: parametric and non-parametric.[6]

More in detail, we apply the non-parametric frontier method developed by Charnes et al. (1978) that generalized Farrell's single input/output measure into a multiple-input/multiple-output technique. The aim of this approach is to measure productive efficiency through the estimation of a frontier envelopment surface for all DMUs by using linear programming techniques. By constructing envelopment unitary isoquants corresponding to comparable DMUs across different situations, DEA identifies as productive benchmarks those DMUs that exhibit the lowest

5 SIAS is ITC tool which is used to preserve and enhance PHAs collections, allowing each PHA to manage all the steps related to the conservation and use - on site and through web - of PHAs collections. Up to now SIAS figures are: 573.487 inventory cards, 80.999 parchments and seals, and 164.671 images. For details, see http://www.archivi.beniculturali.it/index.php/archivi-nel-web/sias-sistema-informativo-degli-archivi-di-stato

6 For a more extensive discussion, see Cooper et al. (2007) and Fried et al. (2008).

technical coefficients, *i.e.* the lowest amount of inputs to produce one unit of output. In so doing, DEA allows for the identification of best practices and for the comparison of each DMU with the best possible performance among the peers, rather than just with the average. Once the reference frontiers have been defined, it is possible to assess the potential efficiency improvements available to inefficient DMUs if they were producing according to the best practice of their benchmark peers. From an equivalent perspective, these estimates identify the necessary changes that each DMU needs to undertake in order to reach the efficiency level of the most successful DMU. Following the literature reviewed in the previous section we employ an input-oriented approach[7]

In order to help the interpretation of the results in the next sections, it is useful to recall that in the input-oriented DEA model, considering n DMUs to be evaluated, an efficiency score θ_i is calculated for each DMU solving the following program, for $i=1,\ldots, n$, in the case of constant returns to scale (CRS):

$$\begin{aligned} &\text{Min}_{\lambda,\theta_i} \quad \theta_i \\ &\text{subject to } Y\lambda - y_i \geq 0 \\ &\qquad\qquad \theta_i x_i - X\lambda \geq 0 \\ &\qquad\qquad \lambda \geq 0 \end{aligned} \qquad [1]$$

where x_i and y_i are respectively the input and output of *i-th* DMU; X is the matrix of inputs and Y is the matrix of outputs of the sample, λ is a $n\times1$ vector of weights which allows to obtain a convex combination between inputs and outputs. Solving [1], DMUs with an efficiency score equal to one are located on the frontier and, therefore, their inputs cannot be further reduced without a corresponding decrease in outputs[8]. A subsequent paper in 1984 by Banker, Charnes and Cooper extended the model [1] to assume variable returns to scale (VRS) which allow to distinguish between Technical Efficiency (TE) and Scale Efficiency (SE).

The literature investigating the efficiency of cultural heritage institutions, reviewed in section 2, is on a one-stage-production model. Under this approach, it

[7] From an input-oriented perspective efficiency is defined as the ratio of a DMU's observed input to the minimum input which could be achieved given its output levels (Farrell, 1957).

[8] We assume a Farrell (1957) distance function definition.

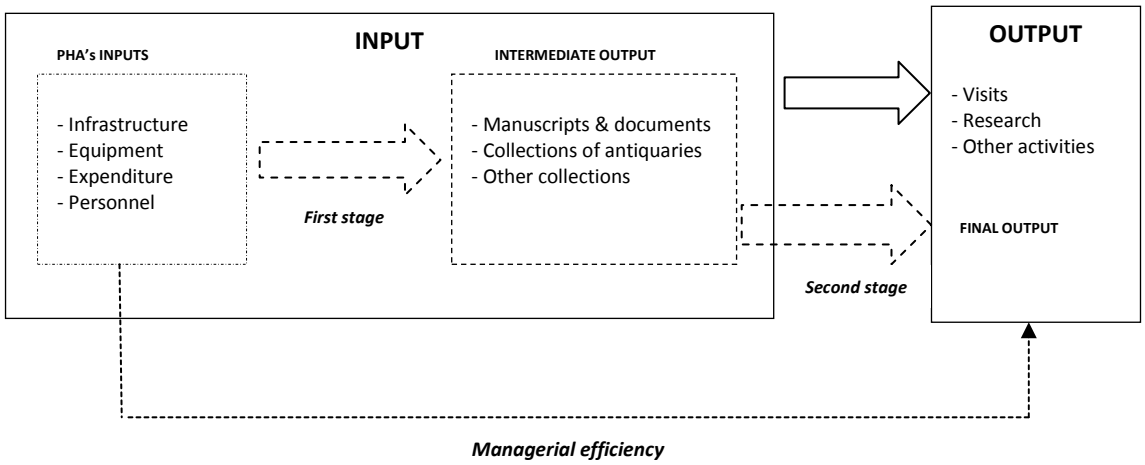
is assumed that the cultural heritage institution disposes of a set of resources (e.g. staff, equipment, physical space, expenditure, collections, etc.) used exclusively to provide services (such as visits, research, education, etc.) to the users. Since the institution's cultural relevance cannot be confined to the number of pieces in the collection, in some cases the efficiency analysis is confined to managerial aspects, excluding variables connected to heritage magnitude and relevance. However, within the same approach the institution's cultural value could be treated at least as uncontrollable variables. In fact, the one-stage model might directly include uncontrollable variables in its linear functions, along with traditional inputs and outputs use of the capability of DEA to accommodate multiple variables (Banker and Morey, 1986). From this approach, the management can decide on some controllable factors internal to production activities, while the impact of the uncontrollable factors is out of the control of the management. Conversely studies which have constructed models using controllable factors only, implicitly assume that all the inefficiencies of DMUs are caused by bad management and underestimate the evaluation of those DMUs.

A different prospective is given by the two-stage-production structures of DEA efficiency analysis proposed by Färe and Grosskopf (1996). In fact, this production structure permits the examination of a sequence of production technologies, where inputs in a first stage produce intermediate outputs, which then become inputs for the second stage where the final outputs are produced[9]. More specifically, in the production structure we assume that at stage one, managers combine the basic resources of the PHA (infrastructure, equipment, expenditure, personnel, etc.), available for the performance of a set of internal operations, in order to generate a set of "intermediate outputs" aimed at increasing and improving the infrastructure and the PHA resources to be made available to users. At stage two, these 'intermediate outputs' are used for the delivery and consumption of PHA services 'final outputs'.

The figure 1 shows the PHA different production models, structured in one (with and without heritage) and in two stages.

[9] The production structure could be also structured in three or four stages to take into account the network production process or the measure of the outcome. Moreover, it is also possible employ the regression two-stage approach.

Figure 1 – PHA's production models.



Source: our elaboration

In what follows, this production structure has been considered, since it allows for the potential identification of sub-process efficiencies in the production system. The resulting information can then be used to determine the reasons of poor performances[10].

As mentioned above, the deterministic nature of non-parametric methods has caused the traditional literature to describe them as non-statistical methods. Moreover, DEA estimators have received some criticisms because they rely on extreme points and may be very sensitive to data selection, aggregation, model specification, and data errors. However, a series of recent developments made it possible to determine statistical properties of non-parametric frontier estimators in a statistical model (Simar and Wilson, 2008). Nowadays, statistical inference based on non-parametric frontier approaches in measuring the economic efficiency is available basically by using asymptotic sampling distributions or by using bootstrap (Simar and Wilson, 2008). To account for DEA traditional limitations, which do not allow for any statistical inference and measurement

[10] The two-stage model starts with a standard DEA model based on traditional inputs and outputs in the first stage, and regresses the efficiency scores of the first stage against a set of selected uncontrollable variables in the second stage. When running the two-stage approach, researchers usually adopt censored regression techniques (Tobit) or, in a few cases, OLS estimates to take into account the censored nature of dependent variable. However, Simar and Wilson (2007) show that in these case the estimates are biased because of serial correlation of efficiency scores and suggests to apply semi-parametric two-stage techniques.

error, Simar and Wilson (1998, 2000) introduced a bootstrapping methodology to determine the statistical properties of DEA estimators. The idea underlying the bootstrap procedure is to approximate the sampling distributions of efficiency scores by simulating their Data Generating Process - DGP (Simar and Wilson, 2008) [11].

The model that is applied in determining the DEA production frontier in this paper is the one outlined by Simar and Wilson, (1998, 2000). This enable us, to overcome some traditional DEA limitations and to provide a robustness check of our findings. More in particular, we employ a consistent bootstrap estimation procedure (Simar and Wilson, 1998), to obtain the sampling distribution of the efficiency scores and derive bias corrected scores.

4.2 Data

The data we use are drawn from the Italian MIBACT database that includes data on each PHA collected on yearly basis by MIBACT Statistical office (*Ufficio di statistica - Ministero dei Beni e delle Attività Culturali e del Turismo*). The final sample comprises 99 PHAs that are similar in nature - since data have been analysed for reporting errors, outliers and missing values - and refers to the years 2011-2012. Therefore, the resulting dataset consists of a sample of cross-sectional and time series observation for 98 Italian PHAs for 2 years, thus resulting in 198 observations.

The PHAs production process is considered to be represented by the use of multiple inputs to produce several outputs. Inputs are generally provided by the collections available, and the technologies adopted for their conservation and fruition, as well as buildings, rooms, deposits and personnel. Regarding the outputs, PHAs provide services in terms of conservation, storage, and access to their collections. We make a description of the employed variables for our sample

[11] Some major issues remain regarding the use of asymptotic results and bootstrap: first, the high sensitivity of non-parametric approaches to extreme value and outliers and, second, the way to allow stochastic noises in a non-parametric frontiers. Alternative approaches provide robust measures of efficiency at extreme data points based on partial frontiers and the resulting partial efficiency scores. A detailed survey of these approaches can be found in Simar and Wilson (2008). See also Wilson (2012) for a discussion on these approaches and for a proposed extension of *order-m* estimator obtained by Cazals et al. (2002).

of PHAs that we believe are representative of all the inputs and outputs linked to the production function of a PHA[12]. As for the inputs, we distinguish between current and capital resources. The capital resources are measured by two variables: the total surface area (SURFACE) in square metres is used as an indirect measure of the infra-structure, since most of the space in the PHA will be used for storing the collection and, moreover, this measure gives a rough idea of the scale and importance of the building housing the PHA's collection; and the total shelf's dimension (SHELF) in linear metres as indicator for the equipment and services which are deemed essential for the PHA to undertake many of its mainly activities.

Current inputs should be well reflected by the number of personnel (PERS) and current PHA expenditure (EXP), excluding current labour costs. We furthermore use three measures of the cultural heritage managed by the PHA: manuscripts and documents (M&D); collections of antiquaries (ANTIQUARIES) and other collections (O_COLLECTION).

Both current and capital inputs are used to fulfil two main tasks of the PHA: the utilisation function (i.e. exposition, research and education) and the conservation function. The utilisation function and archival function whereby the most basic expression of demand to the number of visitors (VISIT). Furthermore we use the total number of requests processed by PHA for both scientific and non-scientific purposes (RESEARCH), the total number of document inspected in the requests processed (D_RESEARCH). Moreover, to provide a rough measure of the cultural relevance of the collection managed by PHA we use the ratio of the requests processed via postal service delivery on total requests (PD_RES). Such a variable, therefore, can be considered a proxy for the conservation output produced by PHAs. Table 1 provides an illustration of inputs, outputs and models employed whereas table 2 shows the descriptive statistics of the variables in our sample. Notice that first two columns refer both to one-stage approach (i.e. the managerial model and the one with cultural heritage included as an uncontrollable

[12] However some production dimensions may not be easily quantified and it is often impractical to include all identifiable inputs and outputs, due to the limited number of observations available for each PHA. Moreover, no data are available to measure the output provided through web.

input) and two stage approach in which cultural heritage is a "intermediate output" in PHAs' production process.

Table 1 – The estimated models.

Variable	Mod_1	Mod_2
Input		
SURFACE	♦	♦
SHELF	♦	♦
PERS	♦	♦
EXP	♦	♦
Uncontrollable input (Intermediate output)		
M&D		♦
ANTIQUARIES		♦
O_COLLECTION		♦
Final output		
VISIT	♦	♦
RESEARCH	♦	♦
D_RESEARCH	♦	♦
PD_RES	♦	♦

Source: our elaboration

Table 2 – Descriptive statistics of employed variables

Variables	Obs.	Mean	St. Dev.	Min	Max
SURFACE	198	5380.89	6177.63	340.00	36141.00
SHELF	198	15187.05	16957.75	0.00	90000.00
PERS	198	25.87	19.83	3.00	98.00
EXP	198	192103.80	240869.50	15465.00	2206594.00
M&D	198	128458.10	135121.90	12117.00	947909.00
ANTIQUARIES	198	22095.72	43525.97	147.00	315623.00
O_COLLECTION	198	74973.65	357614.90	0.00	3350724.00
VISIT	198	2775.66	3361.18	0.00	22224.00
RESEARCH	198	1266.59	2363.60	0.00	24684.00
D_RESEARCH	198	8803.84	8958.19	0.00	49085.00
PD_RES	198	0.31	0.17	0.00	1.00

Source: our elaboration on data provided by MIBACT Statistical office

5. Efficiency results and discussion

Before presenting the outcomes of the two-stage network performance model (as discussed in the previous section 4.1), we outline the findings for the one-stage input DEA-models reported in Table 1 for the whole sample of PHAs. The descriptive statistics of outcomes of those two models (i.e., the managerial model and the model with uncontrollable input) are listed in Table 3.

Table 3 - The descriptive statistics of the model outcomes (one-step)

Sample	CRS				VRS			
	Average (%)	St. dev. (%)	Min (%)	Max (%)	Average (%)	St. dev. (%)	Min (%)	Max (%)
Managerial efficiency model								
All sample	**51.94**	**25.58**	**11.82**	**100.00**	**60.73**	**25.77**	**14.78**	**100.00**
Year 2011	52.43	25.17	15.61	100.00	60.52	25.77	16.82	100.00
Year 2012	51.44	26.10	11.82	100.00	60.93	25.90	14.78	100.00
With sub-section	50.68	23.29	19.34	100.00	57.94	23.40	23.06	100.00
With school	40.58	17.64	14.68	90.00	54.29	28.41	14.78	100.00
North	56.70	23.41	15.61	100.00	65.02	23.52	23.77	100.00
Centre	47.26	26.30	11.82	100.00	59.40	27.06	21.04	100.00
South	49.16	26.99	14.68	100.00	56.41	27.05	14.78	100.00
Model with uncontrollable input								
All sample	**59.03**	**28.32**	**11.82**	**100.00**	**69.19**	**26.50**	**14.78**	**100.00**
Year 2011	59.82	27.56	15.61	100.00	69.88	26.56	16.82	100.00
Year 2012	58.23	29.18	11.82	100.00	68.50	26.57	14.78	100.00
With sub-section	60.78	27.62	19.34	100.00	68.86	25.52	27.39	100.00
With school	48.09	26.48	14.68	100.00	58.68	30.80	14.78	100.00
North	59.64	24.63	15.61	100.00	68.02	24.21	23.77	100.00
Centre	55.91	31.20	11.82	100.00	66.87	29.03	21.13	100.00
South	60.25	30.75	14.68	100.00	72.05	27.60	14.78	100.00

Source: our elaboration on data provided by MIBACT Statistical office

The average aggregate technical efficiency score of 51.94%, in the managerial model with constant returns to scale (CCR), indicates that the PHAs are, in general, quite technical inefficient in fruition and archival services. The large standard deviation as well as the large difference between the minimum and maximum cost efficiency indicates, however, that there are considerable differences in the aggregate technical efficiency of Italian PHAs. Table 3 also shows the efficiency scores for sub-sample. The subsample of PHAs having a school for archivists show minor differences that, however, turn out to be significant in all estimates, indicating that educational services absorb an

important share of resources. Marginal differences among PHAs exist also in relation with the geographical macro areas (North, Centre and South). Table 3 includes also estimates for the case of variable returns to scale (VRS), which show results generally overlapping with those under constant returns to scale (CRS). In the lower part of Table 3, we show estimates for the model with uncontrollable input, where cultural heritage is considered an input external to managerial control that nonetheless affects technical efficiency. As expected, average levels of efficiency of PHAs in our sample increase when we consider such an input, reaching efficiency scores of 59.03%. Observation of the score distribution in subsamples reveal regularities with respect to the previous model. This is not the case, however, of the efficiency score distribution for geographical areas. Remarkably, the distribution is significantly different from what previously seen and suggests that cultural heritage of PHAs is relevant to perform a correct evaluation of efficiency, especially for those DMUs located in the Centre and South.

As previously described, the one-stage approach takes the production process as a black-box that does not allow for an examination of the reasons behind different performances of DMUs. We, therefore, adopt a two-stage network approach (Färe and Grosskopf, 1996) that includes cultural heritage as an "intermediate output", in order to better understand how the latter could affect performances. Different methods can be used to implement a network multistage-stage estimate (Kao, 2014). In this preliminary phase of our analysis, we restrict ourselves to the simplest possible method to apply DEA to estimate efficiency in two separate stages. We are aware of the shortcomings of this simple approach[13], notwithstanding its wide adoption in the literature (Seiford and Zhu, 1999; Zhu, 2000; Sexton and Lewis, 2003). However, we proceed with following such a method taking into account the exploratory scope of our preliminary analysis. Table 4 shows estimates for first and second stages.

The analysis of data for the first stage reveals that the average level of efficiency of DMUs is significantly higher than that found in previous estimates, albeit a smaller number of variables is included. This outcome suggests that PHAs have a

[13] In particular, do not address potential conflicts between the two stages arising from the intermediate measures (Chen et al., 2010).

quite high efficiency level as far as conservation is concerned. Namely available resources appear to be used relatively more efficiently when we consider intermediate output than when we refer to the managerial model. This seems to be in line with the above mentioned peculiar features of PHAs, producing the 'public good' of conservation alongside the divisible utilization services. This result seems confirmed by the observation of second-stage efficiency scores, where the final output depend on the intermediate one. The extent of fruition seems moderate considering the amount of available patrimony of documents. Moreover, unlike the first step, average efficiency decreases from North to South. However, it has to be noted that, as it was outlined in section 3, 88 out of 101 PHAs are accessible through web and, therefore, our variables, measuring the utilization services provided in site or by mail do not catch the web dimension of utilization.

Table 4 - The descriptive statistics of the model outcomes (two-step)

Sample	CRS				VRS			
	Average (%)	St. dev. (%)	Min (%)	Max (%)	Average (%)	St. dev. (%)	Min (%)	Max (%)
First step								
All sample	**64.35**	**25.12**	**13.36**	**100.00**	**70.45**	**23.37**	**19.43**	**100.00**
Year 2011	63.50	25.52	13.36	100.00	69.56	23.45	25.02	100.00
Year 2012	65.20	24.82	14.66	100.00	71.33	23.37	19.43	100.00
With sub-section	56.52	21.74	21.06	100.00	62.54	21.38	25.02	100.00
With school	71.68	21.28	39.91	100.00	75.37	20.54	43.62	100.00
North	74.08	21.37	27.30	100.00	80.03	19.29	33.21	100.00
Centre	66.81	25.75	29.05	100.00	70.89	25.57	29.05	100.00
South	51.13	23.30	13.36	100.00	58.67	21.24	19.43	100.00
Second step								
All sample	**45.54**	**27.89**	**8.46**	**100.00**	**49.91**	**28.41**	**9.83**	**100.00**
Year 2011	47.32	28.60	8.46	100.00	51.82	29.56	9.83	100.00
Year 2012	43.76	27.19	9.50	100.00	47.99	27.22	9.90	100.00
With sub-section	53.90	27.85	17.12	100.00	57.78	27.74	17.64	100.00
With school	34.15	27.17	8.46	100.00	47.97	34.85	9.83	100.00
North	38.17	20.78	8.46	100.00	41.98	22.19	9.83	100.00
Centre	42.46	30.35	12.14	100.00	48.12	30.87	15.00	100.00
South	56.33	30.61	12.96	100.00	60.53	30.41	13.17	100.00

Source: our elaboration on data provided by MIBACT Statistical office

Therefore, caution is needed when interpreting these results. Such a partial representation of the utilization function, in fact, might affect both the average

level of efficiency as well as its geographical variability, depending on the geographical differences in the web uses of PHAs collections.

Furthermore, Table 5 provides the pairwise correlation matrix for estimated models, under CRS assumption, whereas the Graph 1 show the scatterplot between efficiency estimates. The results, reported in the Table 5 and in Graph 1, show a potential trade-off between first-step, where inputs produce 'intermediate outputs', and the second-step where the final outputs are produced.

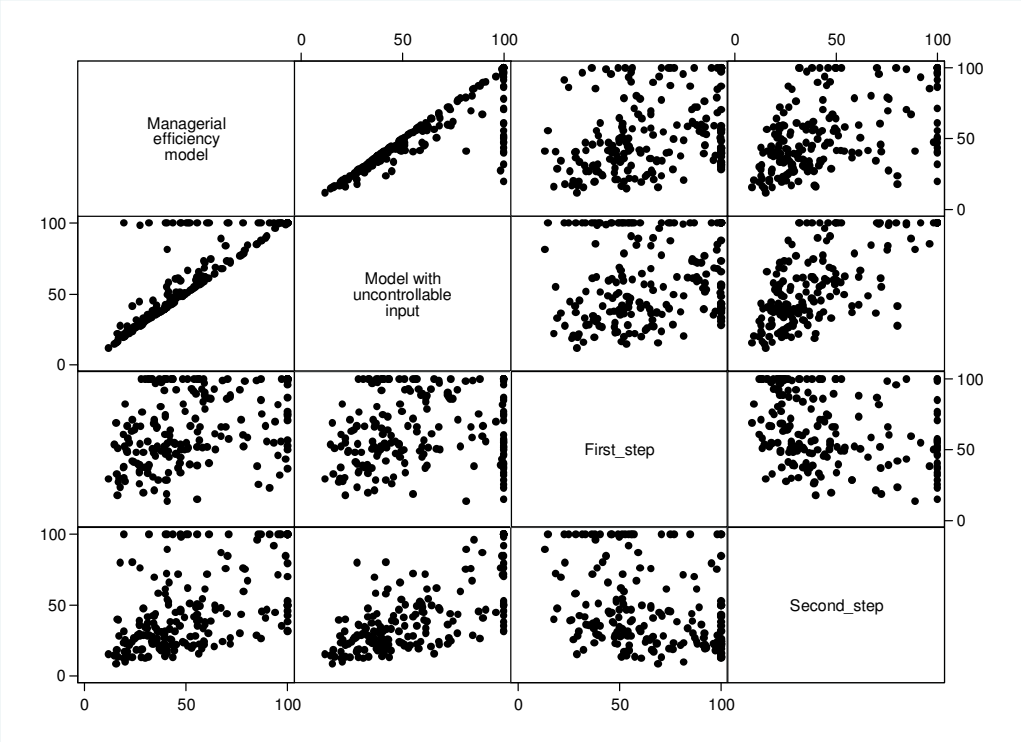
Table 5 – Correlation between estimated models

Models		(1)	(2)	(3)	(4)
(1)	Managerial efficiency model	1.0000			
(2)	Model with uncontrollable input	0.8540*	1.0000		
		(0.0000)			
(3)	First step	0.3361*	0.1807	1.0000	
		(0.0000)	(0.0108)		
(4)	Second step	0.4981*	0.7428*	-0.3046*	1.0000
		(0.0000)	(0.0000)	(0.0000)	

Note. * significant at 1%.

Source: our elaboration on data provided by MIBACT Statistical office

Graph 1 – Scatterplot between estimated models



Source: our elaboration on data provided by MIBACT Statistical office

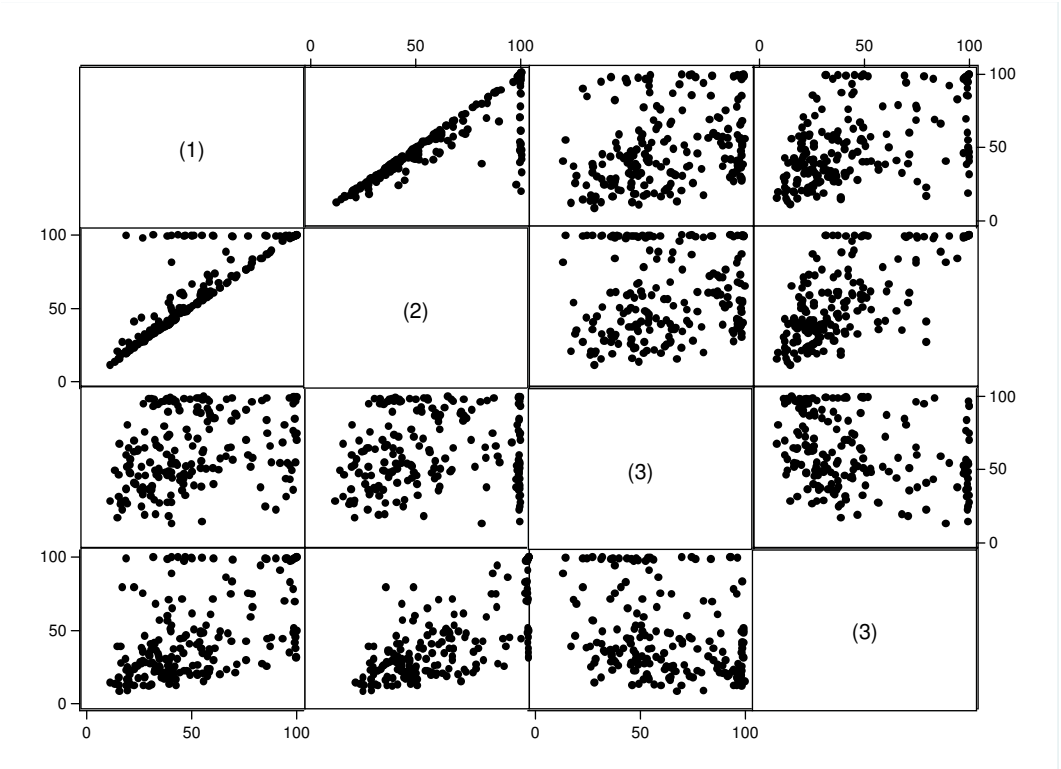
In addition, the DEA efficiency estimate measures performance relative to an estimation of the true and unobservable production frontier and provides point estimates of performance. Since estimates on the frontier are based on finite samples, DEA measures, based on these estimates, are subject to sampling variation of the frontier.

Table 6 – Uncorrected and bias corrected estimate

Model		Obs	Mean	Std. Dev.	Min	Max
(1)	Managerial efficiency model	198	51.936	25.580	11.820	100.000
	Bias_corrected estimate	*198*	*51.018*	*25.475*	*11.250*	*99.940*
(2)	Model with uncontrollable input	198	59.026	28.321	11.820	100.000
	Bias_corrected estimate	*198*	*58.414*	*28.282*	*11.440*	*99.980*
(3)	First step	198	64.349	25.123	13.360	100.000
	Bias_corrected estimate	*198*	*62.906*	*24.780*	*13.190*	*99.700*
(4)	Second step	198	45.543	27.889	8.460	100.000
	Bias_corrected estimate	*198*	*44.714*	*27.839*	*8.190*	*99.970*

Source: our elaboration on data provided by MIBACT Statistical office

Graph 2 – Scatterplot of bias corrected estimates



Source: our elaboration on data provided by MIBACT Statistical office

To address this problem, we implement a bootstrap procedure, with 2,000 bootstrap draws as described by Simar and Wilson (1998), to correct the bias in DEA estimators and obtain their confidence intervals. Table 6 reports the average values of technical efficiency at PHA level, estimated with different models under CRS assumption. Moreover Graph 2 provides the scatterplot matrix between bias-corrected efficiency estimate under CRS assumption. The reported results show that, from the perspective of sensitivity analysis, estimated efficiency scores are robust with respect to sampling variation since there are only slight differences due to bootstrapping efficiency estimates.

6. Conclusion

This study represents, to the best of our knowledge, the first attempt to investigate the technical efficiency of public historic archives (PHA). We focus on PHAs and apply DEA estimators. Previous recent literature studying efficiency of cultural institutions, however, adopts a one-stage-production model, implicitly assuming that the investigated institution use its resources just to supply services. The efficiency analysis is then confined to managerial decisions and excludes variables connected to preserved cultural heritage that could be treated as an 'uncontrollable' variable. We, then, generalise previous analysis by distinguishing a 'managerial' model and a model with uncontrollable input represented by cultural heritage, which is taken as an input of the production technology that affects technical efficiency but is not under managerial control in the PHA. We, therefore, adopt a two-stage-production framework for DEA (see Färe and Grosskopf, 1996) which assumes that, at stage one, managers combine a PHA's resources and generate a set of 'intermediate outputs' that, at stage two, are used for the supply of PHA services ('final outputs').

Overall, at this first stage, a preliminary tentative conclusion is that there are wide margins for improving Italian PHAs average efficiency, that, at the same time, marked variability exists and that there are not significant scale effects. Notwithstanding the difficulties depending on the availability of data, we have tried more than one approach, obtaining interesting differences as far as results are concerned.

The two-steps model seems to be the most suitable to grasp the peculiar features of PHAs activities: such an approach, in fact, allows for disentangling conservation and utilization functions included in the 'black box' of the PHAs production process. Average efficiency increases when considering the cultural heritage/collections managed by PHAs as intermediate output, to catch the conservation function they perform. A marked geographical variability results, with average efficiency decreasing from North to South. On the contrary, PHAs exhibit lower average efficiency in the second step, when the intermediate output is used as input to provide the utilization output. At the same time, is inverted, with average efficiency decreasing from South North. Caution, however, is needed in interpreting such a result: available data do not allow for measuring the web utilization of PHAs collection and, therefore, the representation of such activity of PHAs is partial.

For a better understanding of the relative efficiency of PHAs and of its policy implications, future developments of the analysis might be aimed at a better representation of PHAs outputs and at explore the determinants of their efficiency

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