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## Case study

# Measuring the relative efficiency of cultural-historical museums in Tehran: DEA approach

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## ABSTRACT

Heritage institutions, as one of the main aspects of culture, play an important role in economic prospect of culture by promoting tourism industry. Turning to the interpretation of culture in economic terms, the goal of this paper is to adopt a practical evaluation tool in order to assess the efficiency of heritage institutions. This study evaluates the technical efficiency of a regional system of museums in Tehran, the capital of Iran, using Data Envelopment Analysis approach. The findings may prove useful for management of these institutions in economic point of view, as well as for those responsible for public resource allocation policies in the area of cultural heritage.

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## 1. Research aims

The overall objective of this study is to measure relative efficiency of cultural-historical museums in Tehran, the capital of Iran. These museums consist of institutions that are dedicated to exhibit cultural and historical heritages of the nation for the purpose of study, education, and enjoyment of the people. Other objectives of the study include revealing how management of museums' inputs and outputs can improve the efficiency of these institutions. The study aims to increase the knowledge about the influence of distinct factors on museum management to support a common understanding among authorities of the action space for use and management of cultural-historical museums. This will help decision makers and managers to understand their relative performance among the similar institutions.

The objective of the present paper is to report the results from Data Envelopment Analysis of 19 cultural-historical museums in Tehran; with the aim to take into account both the resources used by museums and the results of their activities. In this case, the efficient museums are distinguished and deficiencies in inefficient institutions are introduced for further revisions.

## 2. Introduction

Museums are one of the most appropriate representatives of cultural institutions for several reasons. First and foremost, as it is stated by del Barrio et al. [1], they are clearly bounded, and directly reflect consumers' preferences and interests through visits to the museum, which is generally quantified, thus encouraging great number of studies into careful scrutiny and estimation. Secondly, varied analyses emerge from the study of museum management, which may differ significantly, ranging from purely public ownership to private stakeholders and, increasingly, non-profit foundations. The differing legal status closely reflects how each country handles its public commodities, in particular cultural assets and facilities, the crucial consequences of which merit analysis, both in terms of institutional management as well as in terms of the likely impact of museum activities. Finally, museums form a symbolic part of cultural policies and economic development plans, as they are regarded as a source of wealth and a magnet for tourism and the resulting spending.

Museum economics constitute a well-established and fertile sector within the field of economics of heritage, covering issues which range from research into scale and economic impact, to areas related to microeconomic aspects linked to management, cost structures and admission price policy, and finally works addressing financial assessment and demand curves for non-market goods [2–4]. Bowitz and Ibenholt [5] address some methodological questions regarding economic impact studies of investments in cultural heritage projects. They propose a short overview over several

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studies of economic impact of different cultural and tourism activities. This is done by discussing the different channels, through which the investment affects society, the use and misuse of economic impact studies of culture-related investment projects, and which channels or factors are important when investigating a place.

Griffin [6] outlines the economic and political changes that have influenced museums in the last several decades, including recent developments in museums themselves. He also reviews the best practices in organizational behavior generally and its relevance to museums. Kim et al. [7] investigate the economic value of the World Heritage site to users or tourists in levels exceeding its monetary benefits in Korea.

This study is dedicated to the evaluation of museums in Tehran. The structure of this paper is as follows: Section 3 focuses on the most recent museum literatures, divided into two separate parts: performance measurement and Data Envelopment Analysis (DEA). Section 4 presents the experimental section of the research containing the method and materials. Finally, summary and conclusion are given in Section 5.

### 3. Literature review

#### 3.1. Performance measurement

Performance measurement is a relatively new activity in the economic point of view towards cultural heritage sector especially in Iran. However, this is not an easy task to accomplish since museum activities are often undertaken by non-profit organizations, having a public nature. For these organizations, we cannot use profit to measure the fulfilment of their objectives. This difficulty is mainly related to the absence of a simple objective function, be it the profit or some other overall quantity to be optimized. Indeed, some organizations may have several conflicting objectives; for example, some goals of the organization management may be in contrast with the aims of the financing bodies. Moreover, Basso and Funari [8] propose that it may be difficult to define the various goals precisely.

One of the first attempts to measure the performance of a group of museums was undertaken by the British Audit Commission (1991), which proposed a series of Performance Indicators (PIs) for the analysis of museums subsidized by local governments. The collection and interpretation of PIs appeared to be difficult, and only a few institutions used them. This led the British Department for Cultural Media and Sport (DCMS) to commission a new study, in 1999, centered on efficiency and effectiveness of museums and galleries. This study underlines the role of performance indicators and suggests 365 such indicators in order to measure the performance of various activity centers in the museum [9].

One area arousing growing interest in performance measurement is efficiency analysis of these institutions, since museums are in fact public entities managing a series of resources (for example different types of labor skills and capital) aimed at producing various goods and services for society. It is thus important that they optimize the way of using the resources, taking into account the objectives to be pursued.

Chiaravalloti and Piber [10] analyze research on the evaluation of the artistic outcome of arts organizations. Inspired by Wicks and Freeman's new pragmatic approach to organization studies, they give an ethical question a central role in their analysis: to what extent is current research able to serve the needs of individual arts organizations and their communities? Their results highlight the influence of research traditions on the ethical implications of performance evaluation research.

Boorsma and Chiaravalloti [11] also suggest evaluating the performance of arts making based on the contribution made to the

achievement of the arts organization's artistic mission and proposes a model based on Kaplan and Norton's Balanced Scorecard to guide the artistic-mission-led evaluation of arts marketing performance. By paying attention to the new strategic role of arts marketing within the emerging relational view of the arts and by integrating recent literature on performance management in non-profit organizations, they make a theoretical contribution to the body of knowledge on arts marketing performance evaluation.

In these two researches, non-parametric quantitative methods are not applied and therefore efficiency analysis of multiple decision units is not possible.

Non-parametric models are usually used to measure the relative efficiency of service producers where the use of parametric approaches would prove more restrictive, through the need to specify a functional mathematical relation between input and output. Non-parametric efficiency analysis, DEA has often been used to assess public services thanks to their flexibility, since they impose less restrictive conditions on the reference technology, and can easily be adapted to multi-product scenarios. These models allow for the calculation of efficiency indicators using multiple models of linear programming, based on the data from a series of units to be assessed.

Several studies have applied DEA to evaluate the efficiency in tourism industry and in particular hotels. Barros [12] discusses the efficiency of individual hotels belonging to the Portuguese public chain by means of Data Envelopment Analysis. He identifies the efficient hotels in a sample and considers the Data Envelopment Analysis as one of the most promising techniques to aid the improvement of efficiency.

Koksal and Asku [13] seek to evaluate the comparative operating efficiency of 24 A-Group Travel Agencies, which are operated internationally in Turkey, using DEA. They conclude that there is no operating efficiency difference between the travel agency groups. However, travel agencies and managers who scored low mean efficiency ratings were recommended how to improve their rating. The ranking methods of these recent researches are limited to cross sectional ranking method.

Hsieh and Lin [14] utilize relational network Data Envelopment Analysis to construct a model to analyze the efficiency and effectiveness of international tourist hotels (ITHs) in Taiwan. They recommend ways of enhancing the overall performance of the hotel industry in Taiwan.

Bi et al. [15] focus on the efficiency evaluation of the Chinese tourism industry to diagnose inefficiency and provide insight for improvement. Their proposed model evaluates the efficiency of each stage, as well as the whole process, resulting in a comprehensive performance measurement.

#### 3.2. Data Envelopment Analysis (DEA)

DEA is a widely used tool in efficiency evaluation for public organization such as orchestras [16], religious organizations [17], libraries [18–20] and public health centers [21–23], universities [24] and railways [25].

However, it has rarely been developed in the case of cultural institutions. In fact, applying Data Envelopment Analysis for evaluating technical efficiency of museums has been less noticed in the pertinent literature. Nonetheless, Basso and Funari [8] carry out an empirical analysis on data from Italian municipal museums by means of DEA techniques to evaluate the technical efficiency of cultural institutions. In addition, del Barrio et al. [1] evaluate the technical efficiency of a regional system of museums through DEA approach, the hypothesis being that these bodies represent one organization of productive resources (employment, equipment, art collections, and so on), aimed at providing various goods and services linked to their fundamental functions: conservation,

exhibiting, research and dissemination of cultural heritage. Bishop and Brand [26] also examine the technical efficiency of museums based upon data derived from a questionnaire survey of South West England. In this study, a stochastic frontier production function is estimated with output measured in terms of visitor numbers. They conclude that high levels of public funding and voluntary activity have a significantly negative impact on technical efficiency. Full ranking of the decision units are not performed in the recent studies. The utilized ranking procedures in the literature of museums do not yield relative rankings for those units with 100% efficiency. Andersen and Petersen [27] have proposed a modified efficiency measure for efficient units, which can be used for ranking, but this ranking breaks down in some cases, and can be unstable when one of the DMUs has a relatively small value for some of its inputs. MAJ (Mehrabian, Alirezaee, Jahanshahloo) [28] solves the previous problems and helps to achieve full ranking which helps us distinguish between efficient decision units.

Our work falls within nonparametric efficiency analysis using the DEA method of a regional system of museums in Iran. In this paper, we use Data Envelopment Analysis to evaluate the performance of cultural-historical museums in Tehran. This is the first quantitative study in the region with aim of investigating the economic perspectives of cultural institutions. The DEA model used in this research is known as basic CCR (Charnes, Cooper, Rhodes) [29] model matching the pertinent literature. However, this study attempts to apply full ranking methods so that clear differentiation of museums is conceivable for decision makers.

#### 4. Experimental

The efficiency frontier approach should be based on a complete description of the activities of a museum in connection with existing museum theories. This description would include not only the output, or the technical activities, but also the connections between the museum and its community, in order to give a global point of view that jointly satisfies the curator, the educator, the manager and the public. The model should not only be applied to “one shot” analyses (one year), but it should also be used with a long-term perspective. The short-term does not fully reflect the activity of a museum. For example, a medium or large-scale exhibition takes at least two or three years to prepare, but the indicator will only reflect the result. This applies for most of the museum’s activities: research, conservation, publications, etc. Consequently, working based on three-year “windows”, which aggregate data over three years is highly appreciated. [3,4]

Museums have several missions and functions that can hardly be ranked by order of importance: research cannot be undertaken without conservation, but the reverse is also true. All the main functions such as acquisitions, research and exhibitions are equally important (and all museologists and curators agree on this). This does not necessarily mean that the activity of a museum cannot be schematized; different models have been suggested. Noble [30] distinguishes five main activities: collection, conservation, study, interpretation and exhibition. For many years, Noble’s view was the main Anglo-Saxon way of thinking [31]. A new paradigm appeared at the end of the 1980s, the PRC model: Preservation (including acquisition), Research and Communication (interpretation, temporary and permanent exhibitions). Both models focus on the technical aspects of museums, in a curatorial sense, but do not consider “outcomes” such as tourism, economic development, or social activities. Indeed, for most authors the outcomes generated by museums mainly consist of preserving for future generations, value added for the community and satisfying visitors (DCMS [32]). These are all difficult to measure other than by surveys. However, as suggested by subsidizing authorities (Audit Commission, 1991),

museums have an important role within the local economy: they attract visitors who will spend a few days, consume, and contribute to developing the region. This last point of view is not really of interest to curators, but a global approach should focus on it as well, because it is sometimes the only viewpoint taken into account to justify subsidies.

#### 4.1. Methodology

##### 4.1.1. Data envelopment analysis

The DEA technique searches for an efficiency measure and is able to overcome some of the restrictions of traditional evaluation approaches, even if the problem of using a quantitative approach to the efficiency analysis of cultural organizations is not completely solved.

DEA is an operational research technique that allows the researcher to obtain efficiency measures, which are computed by solving special mathematical programming problems. Originally proposed by Charnes et al. [33], DEA has proved to be a useful approach for evaluating the efficiency of organizations, which have a multiple input and a multiple output structure. In the past, it has been mainly applied to measure the efficiency of non-profit institutions, schools, universities, hospitals and public agencies, but now it is also applied to banks, insurance companies and so on (in Seiford [34] almost 400 articles on the DEA methodology are listed).

However, the disadvantages of DEA method are as follows:

- it is used to measure relative efficiency and not to measure absolute efficiency;
- it is non-parametric and it is difficult to perform statistical tests;
- adding a new unit to set up in previous units alters the efficiency of total units;
- number of required models and solving them depend on the number of units. This fact increases the volume of calculations [35].

In general, it is much more common to find applications of the DEA methodology in output-oriented form than in an input-oriented one. The CCR output oriented model, which we propose in order to evaluate the efficiency of museum organizations, is the following linear programming problem.

$$\text{Maximize } \theta = \sum_{r=1}^t u_{rk} y_{rk} \tag{1}$$

Subject to:

$$\sum_{r=1}^t u_{rk} y_{rj} - \sum_{i=1}^m v_{ik} x_{ij} \leq 0 \quad (j = 1, \dots, n)$$

$$\sum_{i=1}^m v_{ik} x_{ik} = 1$$

$$u_{rk}, v_{ik} \geq \varepsilon \quad (r = 1, \dots, t; i = 1, \dots, m)$$

In this model,  $y_{rj}$  and  $x_{ij}$  are output variables and input variables, respectively.  $U_{rk}$  and  $V_{ik}$  are the CCR weight coefficients.

##### 4.1.2. Full ranking method

The standard DEA method assigns an efficiency score less than one to inefficient DMUs, from which a ranking can be derived. However, efficient DMUs all have an efficiency of one so that for these units no ranking can be given. A model for ranking efficient DMUs was proposed by Andersen and Petersen [27]. They proposed

the idea of modifying the envelopment Linear Programming (LP) formulation so that the corresponding column of the DMU being scored is removed from the coefficient matrix. Banker and Gifford [36] are the first to recognize the possibility of infeasibility of Andersen and Petersen's model. They proved that for positive inputs the infeasible case could not arise.

In addition to the occurrence of the infeasibility of Andersen/Petersen's model, the difficulties do not end here. Andersen/Petersen's approach may be unstable because of extreme sensitivity to small variations in the data when some DMUs have relatively small values for some of its inputs [37].

Mehrabian et al. [28] suggested a modification to the dual formulation in order to ensure feasibility. In their paper, an alternative definition of efficiency is proposed that can be extended for ranking efficient DMUs. This model successfully removes the above-mentioned difficulties arising from Andersen/Petersen's model. Leading to the following model:

$$j_p^c = \min \omega_p + 1 \tag{3}$$

Subject to:

$$\sum_{j=1}^n \lambda_j X_j \leq X_p + \omega_p 1$$

$$j \neq p$$

$$\sum_{j=1}^n \lambda_j Y_j \leq Y_p$$

$$j \neq p$$

$$\lambda_j \geq 0 \quad j = 1, \dots, n$$

Although the optimal objective function values for the MAJ-model depend upon the units of measurement of input data,  $X_j$ ,  $j = 1, \dots, n$ , unit independence is obtained by normalization [27], that is, dividing input data by the maximum input (for each input). Note that for the case of full inefficiency, that is, when a DMU uses maximum inputs, for no production, both models provide zero scores, and for the case of full efficiency, both models provide not less than one scores. Hence,  $a_p^*$  and  $j_p^*$  lie between 0 and  $\infty$ .

The following feasibility condition for the MAJ-model is readily verified.

Proposition: (necessary and sufficient condition for feasibility in the MAJ-model). The MAJ-model is feasible for evaluation of DMU<sub>p</sub> with output vector  $Y_p > 0$  if and only if for each  $r$ ,  $r = 1, \dots, s$ , either  $y_{rp} = 0$  or there exists a DMU<sub>j</sub>,  $j \neq p$ ; such that  $y_{rj} \neq 0$ .

In summary, the AP-model can, in practical application, lead to infeasible programs when some of the inputs vanish or large efficiency score when some of the inputs are small. The MAJ-model alleviates these problems.

Actually, when evaluating the efficiency of a set of museums, both the input and output-oriented forms of the DEA model may be significant, the choice of which orientation has to be considered as a matter of managerial significance. In effect, if the amount of inputs assigned to the cultural organizations is not modifiable in a short period, as is sometimes the case for public museums, the output form of the model could also be used; in this case, the DMUs are assumed to pursue the objective of maximizing outputs while using no more input levels.

The starting point for applying the DEA methodology for analyzing the relative performance of a given set of organizations, as well as the performance of museums, is the selection of inputs and outputs to be considered in the evaluation process. Normally, any resources used by the organizations should be included among

inputs, whereas any products or services provided should be taken into consideration as outputs.

As far as non-profit and public organizations are concerned, there are some problems in identifying the services provided by them. Therefore, in depth analysis of the non-profit sector, in particular in the cultural sector, great caution are required to select the most appropriate factors for DEA efficiency measures. Indeed, it is not convenient to include in a DEA model non-relevant inputs and outputs, otherwise a museum could be judged efficient on grounds of its minor features. Moreover, the total number of inputs and outputs must not be excessive in relation to the number of museums in order to enable the model to discriminate the efficient from the inefficient ones.

Inputs include all the resources required by the organization for its activities, such as, for example, the square meters of exhibition area, number of custodians and number of other workers. Outputs may take into consideration the services provided by the museums at all levels, that is activities generally recognized as characterizing museums: exposition, conservation, research and education. Some measures of services provided by museums are the total number of visitors, the number of schoolchildren visiting the museum, the number of special temporary exhibitions organized by the museum, the number of congresses organized, the number of research projects undertaken.

By taking into account multiple inputs and multiple outputs simultaneously, the DEA model can overcome some of the restrictions of the partial ratios for museums. Inputs and outputs can be of a different nature, so that their measurement units need not be congruent. This allows us to include in the efficiency analysis qualitative variables such as binary or categorical variables, even if the inclusion of such variables requires some adjustment to the basic DEA model (see Banker and Morey [38]). Examples of relevant binary variables are the presence of auxiliary services such as bookstores and bars, and the eventual institutional accreditation by the American Association of Museums [39].

#### 4.2. Case study/data collection

##### 4.2.1. An overview of museums in Tehran

In order to provide a thorough analysis of the museum sector in Tehran, a comprehensive overview of the industry's status is indispensable.

The first museum was founded in Iran during the Qajar era and Naser-al-din-Shah kingdom (1916). He dedicated his palace to be a museum. Although this museum was not a modern public museum in comparison with nowadays museum definition, its establishment adopted a different attitude toward museums. Since 1861, museum's role in the society has faced a great deal of variation due to many different social and political developments in Iran. For instance, Iranian Constitutional Revolution in 1904 led to the emergence of Iran's National Museum. On the other hand, nationalistic view during the Pahlavi era (1925–1979) caused establishment of Iran Ancient Museum. Then, Islamic Revolution in 1979 shared a religious view toward museums and developed new types of museums called palace museums. Right after that, during eight-year Iran-Iraq war, museums functioned as conservation institutions. Thus, some of the active museums were closed at that time.

Right after the Iran-Iraq war, the rise of reconstruction government (1989–1997) led to a growth in the number of museums and in the attention to research and social interaction. Then, at late 1990s, emerging of reformist government changed the museums' focus from conservation to social interaction by drawing more attention to cultural heritage institutions. Furthermore, merging Cultural Heritage Organization with Tourism Affairs Organization eventuated in more concentration on tourism attraction and the quantitative growth of visitors in this period. Consequently, there

was less attention to other functions of a museum such as research, education and publications. In recent years, the fundamentalist government also continues this quantitative approach so that for example last New Year's holidays in Iran (March 21 to 28), the number of visitors of Niavaran Palace was reached to nearly 15,000. Yet, this inordinate number of visitors probably damages this museum.

Based on museum experts' statements in *Dariche*, the journal of Malek museum, there are about 600 museums (every institute, which is considered museum, based on ECOM definition of a museum) in Iran, which are mostly public. Moreover, there are a few numbers of museums governed by private sector (as the museum experts said, less than 10) [40]. It is inevitable to mention that this data is not exact due to the lack of concise and aggregate statistics of recent 20 years.

Today, as a general overview, Iran's museum sector faces crucial issues. At first glance, even an exact number of museums in the country are not determined. Even Cultural Heritage Organization, which is the main governing authority of museum sector, does not have any database of museum information.

In addition, variation of museums in function, subject, service and structure in Iran make it difficult to evaluate them. The custodians are also reluctant to evaluate the museum's performance due to their governmental nature. Therefore, official statistic is not easily available.

One of the main shortcomings of museums in Iran is the insufficiency of exhibitions area. For example, the National Museum of Iran, aged more than 70 years which is the largest museum of history and archaeology in the country, has about 550,000 objects to be shown but only 2350 objects can be on exhibition due to the lack of enough exhibition area. Furthermore, there are irrefutable shortages in number of proficient curators who can improve the quality of museums' services. Moreover, in terms of management-related shortages, there is no data gathering system and computerized database of museums' activities and visiting statistics. Therefore, it is difficult for curators to manage their resources efficiently.

Overall, it should be mentioned that currently the museum industry in Iran is developing quantitatively without considering museum standards. In other words, it is expected that during the next few years, the number of museums increase extensively. Hence, due to the lack of quality, new museums will be faced by so many crises such as the lack of standardization, the lack of effective social interaction and inefficient functionality. The solutions are obtained by discussing how to increase the quality of museums and strengthen their other aspects like marketing, advertising, research and introduction. This will be conceivable by periodic efficiency evaluation of the museums.

#### 4.2.2. Museums selection and data collection

Using efficiency model carried out to analyze 19 cultural-historical museums in Tehran, the purpose of this study is neither description of the museums' management processes, nor even analysis of the efficiency of each museum considered separately, as many empirical studies do; instead, we aim at comparing the technical and the scale efficiency of set of museums. Clearly, this means that a change in the set of museums would affect the relative efficiency measures and thus it changes the results in terms of efficiency and the consequences associated with them.

In order to apply DEA approach to compare the efficiency of a set of decision-making units, it is necessary to compare homogeneous DMUs, for example, units of similar size or units operating in similar markets in order to isolate disruptive impacts of external factors on the analysis of efficiency. In this case, cultural-historical museums were examined owing to their multiplicity and importance to governmental decision makers.

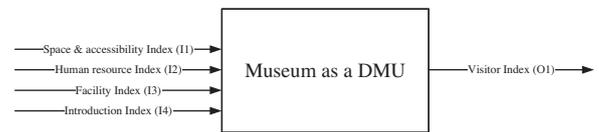


Fig. 1. Conceptual model of a typical museum.

Our database focuses on Tehran Museums.<sup>1</sup> This database is established by aggregation of the data of three years (2008–2010) based on the presented recommendations by [3,4]. As far as it is mentioned before, Cultural-Historical Museums were selected among Tehrans' Museums, which their main purpose of existence is to introduce the cultural-historical aspects of various subjects to public visitors. Comparability, possibility to be considered in a cluster, united management and monitoring are the main reasons that these museums are taken into account together. This is the basic assumption of DEA approach. After preparing the list of the potential museums, museum expert's point of view and ECOM representative's opinion generated the final list with regard to availability of accurate and valid data.

There are many difficulties in performing an empirical analysis in Iran especially in cultural heritage sector, mainly due to the difficulty of gathering integrated information on museums. Data on museums are often scattered in different parts of the administrative organizations to which the museums' affairs pertain. Moreover, data on museums are not always uniformly and regularly collected.

In order to evaluate the inputs and outputs of a museum as a DMU regarding the Social Impact aspect, related dataset need to be available. However, unfortunately, the only data that the Bureau of Museum could offer us was the statistics of visitors, which was not sufficient. A questionnaire including some general information of museums, questions about quality and quantity of spaces, human resources and facilities, questions related to social impact and presentation of museum to visitors is used to gather the essential information. This questionnaire was designed based on the several interviews with museum experts and the indexes are selected based on the literature. As it is stated by Basso and Funari [8], inputs include all the resources required by the organization for its activities, such as, for example, the square meters of exhibition area, number of custodians and number of other workers. Outputs may take into consideration the services provided by the museums at all levels. Some measures of services provided by museums are the total number of visitors, the number of schoolchildren visiting the museum, the number of special temporary exhibitions organized by the museum, the number of congresses organized, the number of research projects undertaken.

On the one hand, del Barrio et al. [1] state that on the input side, we have the factor linked to work or staff employed in the various activities a museum is engaged in (administration, technical staff, security, and so on); the capital factor (number of rooms and museum area in square metres) as well as an indicator for equipment and museum facilities (reflecting the existence of library facilities, archives, a restoration workshop, museum guide, storage room, webpage, conference room, cafeteria and souvenir shop); together with other variables representing access, such as opening hours and admission price.

Therefore, the structure of the questionnaire was organized based on the following concept.

Fig. 1 illustrates the conceptual model of a typical museum. The first input variable, that was named Space & Accessibility Index,

<sup>1</sup> The data was gathered using a questionnaire, which is designed by the authors. However, for the sake of brevity, it is not reported, but is available upon request.

**Table 1**  
Data set of the empirical analysis.

	I1(Space & Accessibility)	I2(Human Resource)	I3(Facility)	I4(Introduction)	O1(Visitor)
Bargh	0.557793	0.035961	1	2.25	9767
Cinema	0.44564	0.086045	1.95	2.75	11,600
Farsh	0.408079	0.169696	2.5	2.45	18,732
Honar haye Ziba	0.563	0.20345	2.2	2.05	165,210
Kakhe Akhtesasi	0.734616	0.167193	1.75	1.9	135,880
Kakhe Mellat	0.59625	0.23007	2.25	2.95	330,420
Kakhe Sabz	0.499624	0.154057	2.35	2.05	275,350
Kooshk	0.545233	0.133502	1.85	2.1	113,924
Malek	0.389116	0.385218	2.1	2.4	50,000
Meli	0.686616	1	3	3.25	108,253
Moghadam	0.423723	0.112077	1.8	1.95	4100
Motahri	0.600442	0.035974	1.45	1.75	1500
Naghashie Poshte Shishe	0.36943	0.097851	1.7	1.4	4466
Reza Abbasi	0.357991	0.112638	1.5	2.5	12,117
Saheb Gharanie	0.481241	0.255102	1.8	2.05	150,978
Seke-Sepah	0.191692	0.075748	1.75	2	1760
Shariati	0.579293	0.033387	1.95	1.85	4440
Tarikhe Moaser	0.4855	0.165244	1.5	1.25	220,280
Zoruf v Sanaye dasti	0.6955	0.160767	0.95	1.4	110,140

includes the time and space that were used by each museum. This index is calculated by aggregating the space of exhibition in square meters and total museum opening hours per year. The Human Resource Index contents the value of employees working at a museum in the matter of educational level, occupation

background and related university field. Different facility should be gathered in a museum such as guide signs, welfare facilities and IT equipments considered in the Facility Index. The final input index considered introduction index, which includes promotion activities. This index consists of 16 variables including museum strategic

**Table 2**  
Museums considered in the empirical analysis and results obtained with the DEA approach using the CCR output-oriented model (DEA efficiency indexes, relative ranking and reference sets).

Code	DMU name	Technical Efficiency	Scale Efficiency	Ranking	Reference set
M1	Bargh	0.1519588	0.1519588	14	M1
M2	Cinema	0.075427828	0.635845396	12	M1, M7, M16
M3	Farsh	0.08283265	0.857931474	7	M7, M16
M4	Honar haye Ziba	0.571914553	0.949806812	3	M6, M7, M18
M5	Kakhe Akhtesasi	0.555405715	0.984237273	2	M6, M7, M18
M6	Kakhe Mellat	1	1	1	M6
M7	Kakhe Sabz	1	1	1	M7
M8	Kooshk	0.502638202	0.914975956	4	M1, M7, M18
M9	Malek	0.231874734	0.813293011	8	M7, M16, M18
M10	Meli	0.284901615	0.869603536	6	M6
M11	Moghadam	0.020467545	0.707531155	11	M1, M7, M12, M16, M18
M12	Motahri	0.023329248	0.023329248	16	M12
M13	Naghashie Poshte Shishe	0.025535788	0.025535788	15	M13
M14	Reza Abbasi	0.064684263	0.32057701	13	M1, M16, M18
M15	Saheb Gharanie	0.592329609	0.911908149	5	M7, M16, M18
M16	Seke-Sepah	0.016568038	0.016568038	17	M16
M17	Shariati	0.074405233	0.074405233	10	M17
M18	Tarikhe Moaser	1	1	1	M18
M19	Zoruf v Sanaye dasti	0.789473684	0.789473684	9	M19

DEA: Data Envelopment Analysis.

**Table 3**  
Changes to be made to get efficient.

Museum Name	I1 (Space & accessibility) (%)	I2 (Human resource) (%)	I3 (Facility) (%)	I4 (Introduction) (%)	O1 (Visitor) (%)
Bargh	0.00	0.00	0.00	0.00	0.00
Cinema	-24.77	-25.64	-24.77	-24.80	0.00
Farsh	-30.38	-46.32	-31.53	-30.38	0.00
Honar haye Ziba	-27.33	-30.51	-27.33	-27.92	0.00
Kakhe Akhtesasi	-23.79	-23.45	-23.45	-23.45	0.00
Kakhe Mellat	0.00	0.00	0.00	0.00	0.00
Kakhe Sabz	0.00	0.00	0.00	0.00	0.00
Kooshk	-18.93	-18.93	-18.93	-18.93	0.00
Malek	-23.29	-75.41	-23.29	-23.29	0.00
Meli	-47.50	-88.37	-47.50	-49.09	0.00
Moghadam	-13.73	-13.73	-13.73	-13.73	435.01
Motahri	0.00	0.00	0.00	0.00	0.00
Naghashie Poshte Shishe	0.00	0.00	0.00	0.00	0.00
Reza Abbasi	-3.54	-44.02	-3.54	-17.06	0.00
Saheb Gharanie	-14.49	-47.26	-14.49	-26.69	0.00
Seke-Sepah	0.00	0.00	0.00	0.00	0.00
Shariati	0.00	0.00	0.00	0.00	0.00
Tarikhe Moaser	0.00	0.00	0.00	0.00	0.00
Zoruf v Sanaye dasti	0.00	0.00	0.00	0.00	0.00

plan, guide signs, website, leaflet, cultural products store, library and so forth.

The only output variable suggested was Visitors Index that is calculated from the number of visitors during the recent years. As far as the social impact aspect of a museum was only considered in this paper, it seems this output could be sufficient.

Table 1 demonstrates the data set of the empirical analysis. It is of a great importance to mention that the data is normalized so that it could be mathematically comparable.

### 4.3. Empirical Result

#### 4.3.1. Basic Data Envelopment Analysis

The results developed by running the CCR Output Oriented Model are presented in Table 2. Output Oriented model was selected because of its compatibility to the case's consequences.

The analysis shows that three museums have a DEA index equal to 1 and therefore can be considered as relatively efficient; these are Kakhe Mellat (M6), Kakhe Sabz (M7), and Tarikhe Moaser (M18).

The scores of the inefficient museums range from 0.016 to 0.0.98, pointing out that some organizations are so much close to while others are too far from efficiency. The reference set of inefficient museums is made up of a combination of efficient museums M6, M7 and M18 and in some cases M16.

Table 3 indicates the changes in specific input-output levels that would lead inefficient museums to achieve efficiency. The gains are derived from a DEA assessment in an output-oriented version.

As far as the outputs are concerned, the gain represents the percentage increase of a given output from its actual level to the target level of the virtual activity that lies on the efficient frontier and would make a museum relatively efficient. This is calculated using the following formula:

$$\frac{\text{target value} - \text{actual value}}{\text{actual value}} \times 100 \quad (2)$$

On the other hand, when referring to inputs, the gain illustrates the percentage reduction from the actual to the target input level. As a matter of fact, efficient museums do not need any improvements as they are already on the efficient frontier; therefore, no input/output gain is obtainable for these units.

Table 3 indicates that most of the inefficient museums should change their inputs largely. It shows that Moghadam's output should be changed enormously.

#### 4.3.2. Full ranking

As far as mentioned before, the problem of CCR or CCR DEA Models are that they cannot make a difference between efficient DMUs. Therefore, we applied full efficiency with the help of MAJ method and the results are presented in Table 4.

Tarikhe Moaser Museum is one the most efficient museum because it was recently established and nonetheless it was well mobilized and well-structured. The number of visitors of this museum was almost high whereas it is located near Kakhe Mellat and Kakhe Sabz museum, which are the most visited museums. Generally, as it is also implied by data analysis, museums, which are established on contemporary palaces because of their wide range campus, attracts more visitors especially during holidays and weekends. Beside the cultural-historical influences on visitors, the wide and untouched spaces of palace museums largely attract the visitors and their families.

The results obtained from this study even though are specialized to its dataset and environment has several similarities with the

**Table 4**  
Ranking the efficient DMUs with the help of MAJ.

DMU name	Efficiency	Rank
Kakhe Mellat	1.166667	1
Kakhe Sabz	1.037195	3
Tarikhe Moaser	1.134918	2

literature such as F. Mairesse, P. Vanden Eeckaut [9] due to efficiency of small museums like Tarikhe Moaser.

## 5. Conclusions

In this paper, we propose a quantitative method to evaluate, compare, and rank the relative technical and scale efficiency of Tehran's cultural-historical museums. Data Envelopment Analysis allows us to overcome some of the difficulties found when applying more traditional indicators in measuring the technical and the scale efficiency of cultural institutions. DEA considers the best museum efficiency index and measures museum inefficiency by deviation from the frontier line; therefore the DEA methodology differs from regression analysis, a statistical approach, which reflects the average behavior of the observations. Beside classical basic model of CCR. We used MAJ full ranking method to be able to rank the efficient DMUs. This is rarely implied to museum evaluation in the literature.

The whole process of comparison is difficult not only because of the difficulty of specification and gathering of adequate data, but also because of the difficulty of their interpretation. Nevertheless, an empirical analysis, which is the result of a questionnaire-based data gathering, is performed. This analysis illustrates that this methodology can be usefully applied and gives information on the relative efficiency of cultural organizations. As was expected, the results showed that palace museums because of their wide and intimate environment are the most efficient museums in the aspect of visitors' number. Besides, the reference set of the museums is proposed, on which each inefficient museum can be modelled. In this way, inefficient museums are guided to follow their reference museums to improve their efficiencies.

A possible direction for future research could consider some variants of the basic DEA model, in order to take into account other aspects that can influence the efficiency of museums. We hope that other prospects of a museum such as conservation will be evaluated in the next research. Expanding the research to the whole country's museums will be noticed either.

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