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ORIGINAL ARTICLE

Measuring allocative efficiency in Cultural Economics: the case of "Fundación Princesa de Asturias" (The Princess of Asturias Foundation)

Víctor Fernández-Blanco[1] · **Ana Rodríguez-Álvarez**[2]

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Abstract The literature on Cultural Economics provides us with some examples for the measurement of technical efficiency. However, there are few case studies dedicated to the analysis of allocative efficiency. The aim of this paper is to fill this gap by incorporating a methodology that analyses both technical and allocative efficiency. We use the Shephard's distance function, particularly suitable when affronted with non-profit-making firms or institutions that are not interested in cost minimization. As an empirical application, we analyse the efficiency of *Fundación Princesa de Asturias* (*PAF*), a Spanish non-governmental organization devoted to promoting the cultural, scientific and humanistic values of universal heritage, the period of study being 1988–2012. Our findings suggest that *PAF* could have used 7% less inputs to achieve the same level of output. On the other hand, we have found allocative inefficiency. Concretely, the input for *other expenditures* appears to have been over-utilized in relation to both the inputs for *labour* and *current assets*, with *labour* in turn being over-utilized in relation to *current assets*. Moreover, our results indicate that both technical and allocative efficiency have clearly improved during the period analysed. In summary, our empirical application shows how distance function methodology can be successfully implemented to measure allocative efficiency in cultural firms and institutions.

Keywords Technical and allocative efficiency · Stochastic frontier analysis · Input distance function · Non-profit institutions

✉ Ana Rodríguez-Álvarez
ana@uniovi.es

Víctor Fernández-Blanco
vfernan@uniovi.es

[1] Department of Economics, University of Oviedo, Avenida del Cristo, 33006 Oviedo, Spain

[2] Department of Economics, University of Oviedo, Oviedo Efficiency Group, Avenida del Cristo, 33006 Oviedo, Spain

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1 Introduction

The aim of this paper is to measure technical and allocative efficiency in the performance of *Fundación Princesa de Asturias* (*The Princess of Asturias Foundation*, *PAF*), a Spanish non-governmental organization devoted to promoting the cultural, scientific and humanistic values of universal heritage whilst at the same time, aiming to promote and spread the image of the Principality of Asturias, in Northern Spain, worldwide. The paper tries to contribute to the literature on efficiency in cultural firms and institutions in different ways. First of all, it measures allocative efficiency, a field that had not yet been incorporated into the literature for Cultural Economics. Second, to achieve this goal, this paper applies a stochastic frontier approach estimating an input distance function. This methodology, which is especially adequate in the case of non-market-oriented firms and institutions where the minimizing cost principle may be under question, has to the best of our knowledge only been incorporated in studies to measure technical efficiency, but *not* allocative inefficiency. And third, in the case of parametric and non-parametric procedures, estimating a frontier function implies dealing with the information available from a set of firms or institutions involved in the same kind of activity. However, *PAF* is a unique institution and as such cannot be compared with any other institution, at least in Spain. This fact adds another challenge to our paper.

In summary, this paper contributes to the existing literature on Cultural Economics using firstly, a methodology that analyses both technical and allocative efficiency by means of a stochastic production frontier model and secondly, an empirical example developed in the field of non-profit cultural institutions. Moreover, in contrast to OLS, in a stochastic production frontier context, the heteroskedasticity problem is potentially more severe, since it can cause biased estimations (Kumbhakar and Lovell 2000). Because of this, we model heteroskedasticity in both the error terms of the frontier.

The paper is organized as follows. Section 2 briefly reviews the efficiency and productivity literature in Cultural Economics. Section 3 describes *The Princess of Asturias Foundation* (*PAF*), the non-profit non-governmental organization subject of our efficiency analysis. Section 4 contains the key theoretical features of the input distance function approach, and Sect. 5 provides the empirical procedure. Section 6 discusses our main results, and Sect. 7 concludes.

2 Efficiency and productivity in the Cultural Economics literature

Efficiency and productivity analysis is a well-established and fertile field of research in Economics. However, it is less frequent in Cultural Economics. We can track the first attempts to incorporate productivity analysis to cultural firms and organizations in Throsby (1977), who estimated a Cobb–Douglas production function for Australian performing arts institutions, or Gapinski (1980, 1984) and Zieba and

Newman (2007) who estimated transcendental production functions applied to performing arts firms in the USA and United Kingdom and Germany, respectively. Estimating cost functions is an alternative approach that has also been explored by different authors for different areas of culture: Globerman and Book (1974) and Lange et al. (1985) for US symphonic orchestras; Paulus (1995) for French museums; Fazioli and Filippini (1997) for Italian theatres; or Taalas (1997) for Finnish theatres, both using a flexible translog cost function.

These first approaches do not consider production and/or cost functions as frontiers, and additionally, they do not evaluate efficiency in terms of distance from this optimal frontier, as has commonly been considered in the efficiency and productivity literature from Farrell (1957) onwards. However, as Kumbhakar and Lovell (2000) pointed out, the information obtained from the estimation of production and/or cost frontiers is more accurate than that derived from research based on average functions, given that the former includes the possibility of not achieving the objective of maximizing output or minimizing costs, respectively. Hence, if there exists a difference between the potential and the observed frontier and it is not taken into account, the estimation of parameters describing technology will be biased.

The frontier can be defined in terms of a production, cost or benefit function, but also through a distance function, the approach selected here, and additionally, it can be either deterministic or stochastic. A deterministic frontier implies that when a firm is not on the frontier, it is exclusively due to an inefficient behaviour captured by a random disturbance (u). In presence of a stochastic frontier, any deviation can be a combination of inefficiency and the presence of certain exogenous effects, such as the institutional environment that the firm cannot control. Therefore, we face a composed error term ($v - u$) where u measures inefficiency and v incorporates those non-controllable shocks.

To estimate frontier functions, there are two general approaches, parametric and non-parametric. Nonparametric methods rather than impose a particular functional form allow the observed data from different firms to define the frontier using an envelope function and starting from some plausible assumptions about production technology. Among the nonparametric techniques, data envelopment analysis (DEA) is the most frequently used also in Cultural Economics. In the area of performing arts, Marco-Serrano (2006) estimated technical efficiency and cost efficiency in the case of Spanish and German theatres, respectively, using DEA. But, this approach is also frequent in many other fields of Cultural Economics such as cultural heritage (e.g. Guccio et al. 2014), libraries (e.g. De Witte and Geys 2011) or museums (e.g. Del Barrio et al. 2009; or Mairesse and Van den Eeckaut 2002 who used the Free Disposal Hull technique).[1] The estimation of parametric stochastic frontiers is a more recent and less frequent technique in Cultural Economics. This approach implies defining a specific functional form for the frontier, but its great advantage, coming from its composed error term, is that it allows us to distinguish whether a firm is not on the frontier due to either inefficiency or alternatively due to the presence of random shocks which are beyond the control of the agent's management capabilities. In 2003, Bishop and Brand opened this alternative estimating a stochastic frontier production

[1] For a more detailed overview, see Fernández-Blanco et al. (2013).

function in the case of British museums. Zieba (2011) estimated a stochastic production frontier applied to a sample of Austrian and Swiss non-profit theatres. Finally, Last and Wetzel (2010a, b) introduced a methodological novelty analysing efficiency, productivity and cost disease in German public theatres through an input distance function.

After this brief review, we have noted that efficiency analysis is present in Cultural Economics both in terms of parametrical and non-parametric methodologies. However, allocative inefficiency has not been explored yet. Our paper contributes towards filling this gap using the input distance function approach, a methodology that is particularly suitable for those institutions who do not seek to minimize cost behaviour.

3 The Princess of Asturias Foundation, a non-profit non-governmental organization

The Princess of Asturias Foundation (*PAF*) is a Spanish non-profit private institution, created in 1980, whose essential aims are to contribute to extolling and promoting those scientific, cultural and humanistic values that form part of the universal heritage of humanity and consolidate the existing links between the Principality of Asturias and the title traditionally held by the heirs to the Crown of Spain.

Along its 35 years of life, the Foundation has used different instruments to achieve these goals. The most powerful and relevant are the Prince (Princess since 2014) of Asturias Awards, conferred yearly and "aimed at rewarding the scientific, technical, cultural, social and humanistic work performed by individuals, institutions, or groups of individuals or institutions in any part of the world, especially in the Ibero-American community of nations" (Princess of Asturias Foundation 2014). These Awards comprise eight categories: the Arts, Literature, Social Sciences, Communication and Humanities, Technical and Scientific Research, International Cooperation, Concord and Sports.

These Awards have concentrated the efforts of *PAF*, attracting more than 60% of its resources in recent years. The Awards have reached 34 editions and have continued growing in terms of number, from six to eight awards, and complexity, involving a greater number of international institutions and personalities as well as participants and award-winners.

But *PAF* participates also in other aims. It contributes to the promotion of musical activities in Asturias, both in terms of musical concerts and events as well as developing music education programs.[2] Finally, *PAF* has fostered many other activities orientated towards promoting the cultural environment and abilities in Asturias (scholarships, the development of rural areas, and arrangements with

[2] Since 1985, *PAF* manages three choirs and an International Music School, launched in 1990, that offers summer courses, master classes, conferences and seminars. From 1992 onwards, *PAF* has scheduled more than four hundred concerts in different towns and villages of the Region.

several institutions such as The National Geographic or The Moscow Virtuosi Orchestra).

To summarize all these activities, *PAF* is satisfying some of the standard roles attributed to a non-profit organization (Moulton and Eckerd 2012), in particular service provision, individual expression and specialization, social capital and community building, and citizen engagement.

The financial figures can help us to draw a better image of PFA. In 2012, its income totalled €5.72 million, this being the result of a continuous downward trend in the funding commenced in 2008 which in turn represents a 42% decline for the four-year period. As shown in Fig. 1, 63% of this income comes from private donors and 19% from own assets. This composition is the outcome of a process reflecting the increasing relevance of income arising from private sources and the PFA's own assets income and a serious decrease in public grants, which have been reduced by around 75% in the last five years.

The total cost of activities carried out by *PAF* totalled 5.49 million Euros in 2012, having declined by 24% since 2008. The Princess of Asturias Awards account for 69% of total cost, and its dominance has been increasing during recent years. Musical activities represent 20% of costs, a percentage that has more or less been stable in the last few years. Finally, any other activities are more or less testimonial in terms of costs over latter years (Fig. 2). To summarize, as a result of the recent financial crisis, *PAF* has concentrated its efforts on its Awards.

In 2012, these expenditures have led to 17 events related to the Awards Ceremony, involving 14,000 attendees and 150 experts. PAF also organized 58 music concerts and 184 students from seven different countries attended its music summer courses, among other activities. Furthermore, according to the information provided by the media monitoring consultants Kantar Media, the activities organized by PAF reached 4905 references in the national media representing a cumulative audience of 1,663,302,000 people and an economic valuation of 43,555,822 euros. Finally, PAF's website received 304,397 visits from people in 182 countries (Princess of Asturias Foundation 2012).

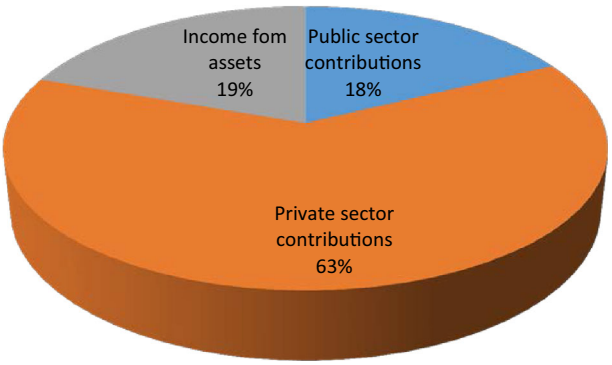

Fig. 1 Sources of Income. 2012 *Source*: Princess of Asturias Foundation

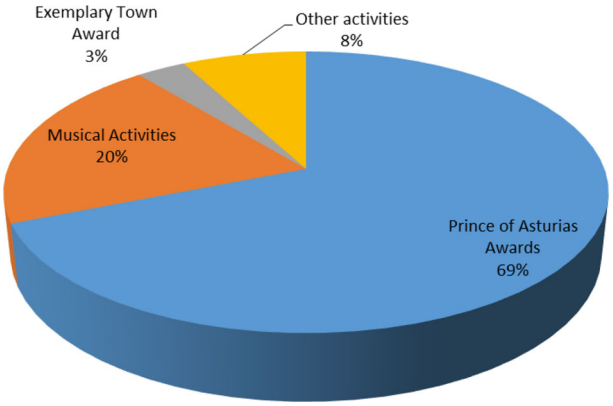

Fig. 2 Breakdown of expenditures. 2012 *Source*: Princess of Asturias Foundation

4 Measuring technical and allocative efficiency: the input distance function approach

The aim of our paper is to analyse efficiency in the *PAF's* performance, paying special attention to allocative efficiency, i.e. to test if *PAF* is using inputs in optimal proportions, given their respective market prices, the production technology and the desired level of output, or, if this is not the case, identify those inputs which are being relatively under or over-utilized. We use an input distance function in order to analyse the allocative efficiency of *PAF* that has some advantages in contrast to the more popular production function and cost function.[3] First, it is especially suitable in the presence of multi-output production. Second, it does not imply cost minimization. And third, it allows the obtainment of a measure of allocative inefficiency directly and independently of the degree of technical inefficiency.

Independent of whether an estimate is made using a distance function (as in our case) or cost or production functions or even by way of a non-parametric approach such as data envelopment analysis (DEA), the measurement of efficiency implies constructing an optimal frontier function and calculating how distant our institution (or firm) is from it. Usually, this frontier function is constructed using the information available from a set of institutions or firms involved in the same kind of activities. However, as we have pointed out above, *PAF* is a unique institution, so we find ourselves unable to define the aforementioned set or characterize similar existing institutions. In this case, the solution is to use the institution's own history as the source of information.[4] To do this, we have collected all the relevant *PAF*

[3] Since the major part of the resources of the *PAF* are devoted to the selection of the award-winners and the organization of the Awards Ceremony, with the number of awards having stabilized after the initial years of the period and no prevision existing in terms of notorious or relevant changes in future years, the main output can be considered more or less constant. This fact endorses our selection of an input-oriented distance function.

[4] This procedure has been successfully implemented in the case of Spanish National Railways (Baños-Pino et al. 2002).

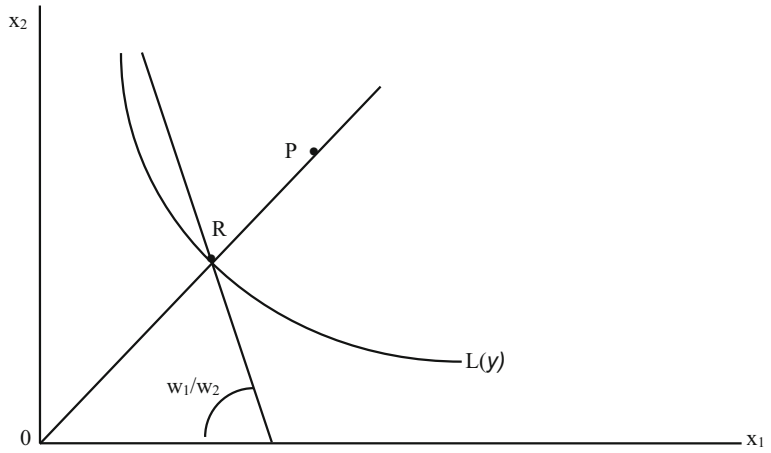

Fig. 3 Input Distance function

economic information for the period 1988–2012, which allows us to identify the most successful years of activity as well as detect possible areas for change and improvement.

4.1 The input distance function

An input distance function is the maximum possible reduction in the inputs vector necessary to achieve a given output level. Formally, given any two vectors x and y, the Shephard (1953, 1970) input distance function is defined as follows:

$$D_{\mathrm{I}}(y,x) = \max\{\delta > 0: x/\delta \in L(y)\} \tag{1}$$

where y (y_1, …, y_m) is the vector of outputs, x (x_1, …, x_m) is the vector of inputs and $L(y) = (x \in R_n^+: x$ can produce $y \in R_m^+)$ is the input requirement set. Graphically, and considering a firm that produces a single output (y) with two inputs (x_1 and x_2), the ratio $0R/0P$ is the Farrell (1957) input-oriented measure of technical efficiency ($\mathrm{TE_I}$) for the point P (Fig. 3). It indicates the maximum proportional reduction that can be achieved in the utilized inputs that allows production of the same quantity of output. Formally,

$$\mathrm{TE_I}(y,x) = \min\{\lambda: \lambda x \in L(y)\} \tag{2}$$

The maximum value of this index is one, which would mean that the firm is operating on the isoquant and is thus technically efficient. A value lower than one (as observed in Fig. 3) indicates the degree of technical efficiency achieved by the firm.

Using the reciprocal of this index, we obtain the definition of the input distance function, that is, $0P/0R$ represents the largest scalar (δ) for which all factors can be divided proportionally and continue producing the same output level. Evidently, $x \in$

$L(Y)$, if and only if $D_{\mathrm{I}}(y, x) \geq 1$. If $D_{\mathrm{I}} = 1$, this means that production is technically efficient. A value higher than one shows the degree of efficiency achieved.

Since the input distance function is dual for the cost function,[5] and following Shephard (1970), we are able to relate prices and quantities of the inputs using the following dual equations:

Shephard's Lemma:

$$x_i^{\mathrm{s}}(y, w) = \frac{\partial C(y, w)}{\partial w_i} \tag{3}$$

Dual of Shephard's Lemma:

$$w_i^{\mathrm{s}}(y, x) = \frac{\partial D_{\mathrm{I}}(y, x)}{\partial x_i} \tag{4}$$

where: $x_i^{\mathrm{s}}(y,\ w)$ denotes the least-cost input given $(y,\ w)$, $w_i^{\mathrm{s}}(y, x) = \frac{w_i^{\mathrm{s}}}{C(y, w^{\mathrm{s}})}$ is the normalized cost minimizing price given $(y,\ x)$.

Hence, we interpret w_i^{s} as the shadow price for x_i. According to Färe and Grosskopf (1990), we can write:

$$\frac{\partial D_{\mathrm{I}}(y, x)}{\partial x_i} = \frac{w_i^{\mathrm{s}}}{C(y, w^{\mathrm{s}})} \tag{5}$$

That is, the derivative of the input distance function with respect to an input is the normalized shadow price. From Eq. (5), with any two given inputs $i, j = 1, 2 \ldots n$, the shadow price ratio is obtained:

$$\frac{\frac{\partial D_{\mathrm{I}}(y, x)}{\partial x_i}}{\frac{\partial D_{\mathrm{I}}(y, x)}{\partial x_j}} = \frac{w_i^{\mathrm{s}}}{w_j^{\mathrm{s}}} \tag{6}$$

Thus, if the cost-minimization assumption is satisfied, this shadow price ratio should be the same as the input market price ratio. However, if the inputs are not selected in the appropriate proportion, that is to say, if allocative inefficiency occurs, the aforementioned price ratios will differ. To study the quantity and direction of such a deviation, a relationship between the shadow prices (obtained through the distance function) and the input market prices is introduced by means of a multiplicative price correction k_i (Färe and Grosskopf 1990):

$$w_i^{\mathrm{s}} = k_i w_i$$

Dividing this expression by that corresponding to input j, we obtain:

$$\frac{w_i^{\mathrm{s}}}{w_j^{\mathrm{s}}} = k_{ij} \frac{w_i}{w_j} \tag{7}$$

where $k_{ij} = k_i / k_j$

[5] The input distance function also satisfies the following properties: is decreasing in outputs, increasing in inputs, homogenous of degree one and concave in inputs.

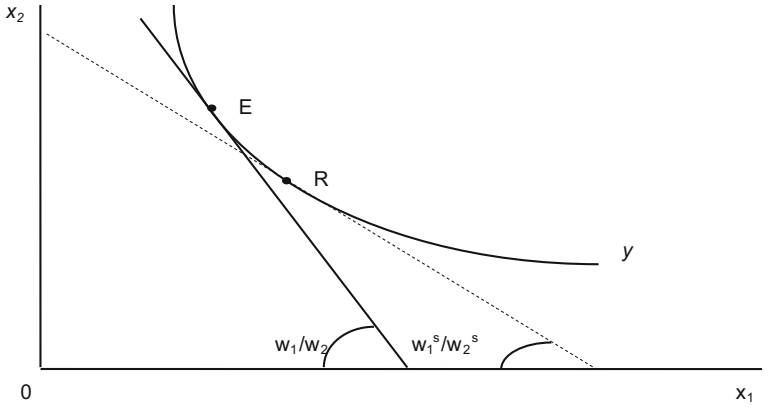

Fig. 4 Measuring allocative inefficiency

Hence, we can calculate the degree to which the shadow prices differ from the market prices. Likewise, the direction of said inefficiency can be identified as follows:

(a) If $k_{ij} = 1$, there is allocative efficiency.
(b) If $k_{ij} > 1$, the factor i is being underutilized relative to the j factor.
(c) If $k_{ij} < 1$, the factor i is being over-utilized relative to the j factor.

Figure 4 contributes to a better understanding of this technique. If we suppose a level of output y and a slope of the isocost, w_1/w_2, point E represents an input combination that is efficient both in technical and allocative terms, whereas point R is technically efficient but inefficient in allocative terms. Our procedure defines an isocost (the tangency line of the isoquant in R), the slope of which is w_1^s/w_2^s defined as the shadow prices ratio. In this way, by comparing both slopes w_1/w_2 and w_1^s/w_2^s, we obtain a measure of allocative inefficiency.

5 Empirical procedure

(a) An input distance function proposal

To compute technical and allocative efficiency, once we imposed the homogeneity of degree one in inputs[6] and applied a logarithmic Cobb–Douglas technology, the input distance function to be estimated is

[6] Homogeneity of degree one in inputs is a property of the input distance function (see for example Coelli and Perelman 2000). Also, note that in the right-hand side of Eq. (8) inputs appear as covariates in a ratio form. Hence, they will be independent of the random error term (see Coelli and Perelman 2000 or Kumbhakar 2011 for details). That is, by imposing the homogeneity of degree one in inputs, we are able to obtain consistent estimates, despite recognizing the possible endogeneity of the input variables.

$$-\mathrm{Ln}X_{1t} = \beta_0 + \sum_{1}^{3} \beta_i \mathrm{Ln}\left(\frac{X_{it}}{X_{1t}}\right) + \sum_{1}^{3} \alpha_i \mathrm{Ln}Y_{it} + \chi_D \mathrm{Aniv} + \theta_t \mathrm{Time} + v_t - u_t \quad (8)$$

where X is the input vector; Y is the output vector; Anniv controls for years when *PAF* held its anniversaries; Time is a temporal trend; $u_t \approx N^{+}(0, \sigma_u^2)$ reflects technical inefficiency; $v_t \approx N(0, \sigma_v^2)$ is an error term, and β, α, χ, θ are parameters to be estimated.

Nevertheless, ignoring heteroskedasticity in the composed error term will lead to biased estimations. In particular, not allowing for heteroskedasticity in the random error u causes bias both in the estimates of the parameters describing the structure of production frontier and in the estimates of technical inefficiency. Likewise, ignoring heteroskedasticity in the inefficiency error term v causes bias in estimates of technical inefficiency (u term) (Kumbhakar and Lovell 2000). Because of this, in Eq. (8), we allow for heteroskedasticity in either of the aforementioned error terms (u and v). Hence, we assume that the random error component (v) is heteroskedastic and its variance is dependent on a linear combination of variables (h):

$$v \approx iid\ N\left(0, \sigma_v^2\right),\ \sigma_v^2 = f(h, \varphi) \quad (9)$$

where ϕ is a set of parameters to be estimated.

Additionally, we model the variance of u as a linear function of a set of covariates z that can influence the distance to the frontier, with δ being the set of parameters to be estimated. Increases in the variance in turn represent increases in the distance to the frontier and vice versa (Caudill et al. 1995).

$$u \approx iid\ N^{+}\left(0, \sigma_u^2\right),\ \sigma_u^2 = g(z, \delta) \quad (10)$$

Concretely, we have a special interest in ascertaining how the presence of special years in the history of *PAF* together with time has impacted on the variance of the error terms. Because of this, we model both h and z as a function of Anniv and Time, respectively. This procedure allows us to analyse the evolution of technical efficiency over the whole time period being considered, as well as taking into account special events such as anniversaries. After estimating Eqs. (8, 9, 10), we can calculate technical efficiency indexes according to the following expression:

$$\mathrm{TE} = \exp(-u) \quad (11)$$

where given that $u \geq 0$, the values of the TE indexes range between zero and one. If TE = 1, *PAF* is technically efficient and the closer TE is to one, the lower the technical inefficiency. Moreover, and according to Färe and Primont (1995), the following expression allows us to calculate the scale elasticity:

$$\varepsilon_\lambda = \frac{-1}{\frac{\partial D_i}{\partial Y} Y} \quad (12)$$

where $\frac{\partial D_i}{\partial Y}$ is the first-order coefficient of the distance function with respect to the output vector. If the scale elasticity is higher (lower) than one, we face increasing

(decreasing) returns of scale; obviously, if it is equal one, we face constant returns of scale.

(b) The data

Our aim is to analyse the efficiency of the *PAF* for the period 1988–2012. To do so, we have collected all the information available in terms of inputs applied and outputs produced. It is true that we have only 25 years which could be considered a short time series. Nevertheless, it should also be taken into account that we have made use of the entire dataset which serves to document the history of *PAF*.

It is clear that PFA is a non-market oriented institution. This fact deeply influences how to measure and evaluate its behaviour. In this sense, our first challenge is to identify the output. As in any other cases, we could think in monetary or physical measures, both of which have advantages and difficulties. As far as physical measures are concerned, the numbers of visitants or attendees are frequently considered as good measures of output (Stiglitz et al. 2009). Nevertheless, in the case of *PAF*, we face at least two obstacles. On the one hand, the main activities of *PAF* are not oriented towards being delivered as a show. It is true that there is an official ceremony of The Princess of Asturias Awards, but for institutional reasons, it is not open to the public in general. Attendants are members of local, regional and national administrations, people representing firms and institutions sponsoring *PAF* and the civil society in general. There are other activities related to these Awards but many of them, such as the public parades, sports demonstrations, and open conferences, can hardly be measured by the number of participants. This applies also to most of the other activities organized by *PAF*. Finally, some of them are developed in villages and small towns with the goal of approximating cultural events in these areas, and hence, the number of attendants is not really a good measure of such activities: in many cases, a small number of attendants may still be considered a successful social event. In order to tackle these issues, we propose to employ monetary measures which are homogeneous and thereby facilitate comparisons. This alternative implies that we are not in the presence of *X* inefficiency (Leibenstein 1966) meaning that all of the people working in *PAF* are fully committed to the objectives of the institution and apply their optimal effort to achieving the *PAF* aims. It may therefore be a reasonable assumption to consider the history and nature of the PAF which, as mentioned above, is a non-profit institution whose essential aims involve the promotion of scientific, cultural and humanistic values.

In any case, one consideration must be taken into account when offering an empirical measure of output: *PAF* produces a multiple output, and we have to introduce some weights in order to achieve an accurate evaluation of how its resources have been used. Because of this, we have considered three activities or outputs, namely *the Prince of Asturias Awards* (PPA), *Musical Activities* (AM) and *Other Activi*ties (OAC). How to measure these outputs is really a great challenge due to their very nature. As pointed out above, we cannot use the usual measures such as number of visitors or attendants, total revenues, number of events or performances. In this situation, and as a first approach to a more accurate measure of

output, we propose using the amount of budget expenditure allocated to each of the three activities mentioned above for every year of the time period being studied. In this sense, we highlight that the Princess of Asturias Awards is the main output of the *PAF*. Each year, the same number of awards is conferred, but they are not always the same in terms of quality, in terms of global impact of acknowledgement. For example, sometimes, the prizes are mainly awarded to Spanish people, sometimes to well-known and recognized international people, like Francis Ford Coppola, Paul Krugman or Peter Higgs among others. Obviously, the output is not the same in both situations. On the other hand, the number of people invited to the awards ceremony is more or less the same each year and the Hall is always full, so we cannot use attendance or some similar variables to measure the output. However, the variability of the budget can show the variability in the quality of the output. Under the assumption of absence of *X* inefficiency, we can accept that the more money devoted to the Awards, the greater the quality of the output.

We have considered three inputs: *labour* (L), *current assets* (K) and *other expenditures* (OG). *Labour* is the number of employees.[7] *Current assets* have been measured using depreciation expense excluding building depreciation. *Other expenditures* incorporate those expenditures not included in current assets depreciation or labour expenses, and in particular, the expenditure incurred in outsourced activities. Table 1 displays the main descriptive statistics.

6 Empirical results

(a) Technical efficiency

Equations (8, 9, 10) have been estimated using the maximum likelihood procedure. Table 2 displays the estimated parameters of the input distance function.

The input and output variables are in the form of deviations with respect to their means. Thus, the first-order coefficients of the distance function can be interpreted as elasticities estimated at the sample mean. All these first-order coefficients are statistically significant, and with the expected sign; hence, the estimated input distance function, at the sample means, fulfils the regularity conditions: it is non-decreasing in inputs and decreasing in outputs.

The impact of the variables trend (Time) and special events (Anniv) is not significant at the frontier. However, these variables explain heteroskedasticity in the error term. Concretely, results obtained from the analysis of heteroskedasticity in the random error term v (Eq. 9) are presented in Table 3. Time increases heterokesdasticity in the v residual. This may be explained by the fact that the activity of *PAF* in its initial years was subject to more variability and as time went by, the activity became more centred on its tree main outputs.

[7] We have not distinguished between temporary and permanent personnel or different professional categories. Since we have no labour data for the first three years of our period, the final number of observations implied in our estimations is 22.

Table 1 Descriptive statistics 1988–2012

Variable	#Observ.	Mean	SD	Min	Max
PPA	25	2,669,304	831,647	1,408,987	4,121,670
AM	25	558,314	397,863	238,714	1,801,443
OAC	25	1,287,957	1,225,457	206,287	5,200,049
L	22	18	8	9	34
K	25	123,174	103,945	29,789	403,681
OG	25	3,747,926	1,061,626	2,085,990	6,241,177
Time	25	13	7	1	25

Table 2 Input distance function estimated

Variable	Coefficient	*t* statistic
Inputs		
Ln (L)	.3193	4.68***
Ln (K)	.5553	4.35***
Ln (OG)	.1248	2.12***
Outputs		
Ln (PPA)	−.5599	−7.67***
Ln (AM)	−.2303	−5.87***
Ln (OAC)	−.2169	−28.31***
Time	−.0170	−1.36
Aniv	.0130	1.29
Constant	.1444	4.89

Number of observations = 22

*** Statistically significant at 1%; ** statistically significant at 5%; * statistically significant at 10%

Table 3 Heteroskedasticity of the random error term *v*

Variable	Coefficient	*t* statistic
Time	−2.1059	−1.82*
Anniv	−12.8525	−.02
Constant	−20.3324	−1.92*

Number of observations = 22

*** Statistically significant at 1%; ** statistically significant at 5%; * statistically significant at 10%

To explain the variance of the *u* error term (Eq. 10), we have included the same set of variables as in the case of the *v* error term. Table 4 displays the estimated coefficients. Let us recall that increases in the variance of *u* represent increases in the distance to the frontier (and vice versa). The Anniv dummy variable coefficient is positive and statistically significant, which means that PAF has required more resources to deal with special activities and events in those special years. Finally, the negative and statistically significant coefficient of Time means that PAF has

Table 4 Heteroskedasticity of the random error term *u*: determinants of inefficiency

Variable	Coefficient	*t* statistic
Time	−.1305	−1.76*
Anniv	2.1513	2.00**
Constant	−4.5223	−8.59***

Number of observations = 22

*** Statistically significant at 1%; ** statistically significant at 5%; * statistically significant at 10%

improved its efficiency along the period considered (time reduces the distance to the frontier). In sum, we conclude that PAF has experienced a "learning by doing" effect. This conclusion is reinforced with Fig. 5 that displays the positive evolution of technical efficiency along the period.[8]

From this estimated input distance function, and using Eq. (11), we calculate the correspondent technical efficiency indexes (TE). On average, the value of the TE index is around .93. Table 5 displays a summary of the results obtained.

Finally using Eq. (12), elasticity of scale is .993, also statistically significant. Although it is closer to one, this value indicates that on the sample mean, the *PAF* presents small decreasing returns of scale.[9]

(b) Allocative efficiency

As we have discussed above, the distance function technology allows us to compute allocative inefficiency. To do this, and from the estimated input distance coefficients, we can calculate the k_{ij} coefficients, defined by Eqs. (6) and (7) and displayed in Table 6. We observe three different coefficients: $K_{L,K}$ indicates the relative allocation between *labour* (L) and *current ass*ets (K); $K_{L,OG}$ represents the relative allocation between *labour* (L) and *other expenditure*s (OG); and $K_{K,OG}$ incorporates the relative allocation between *current assets* (K) and *other expenditures* (OG).

$K_{L,K}$ is below one meaning that *labo*ur is being over-utilized with respect to *current assets*. $K_{L,O}$ is above one, and hence, *other expenditures* input is being over-utilized with respect to *labour*. Finally, since $K_{O,K}$ is also below one, *other expenditures* input is over-utilized with respect to *current assets*. In sum, *other expenditures* input appears to have always been utilized beyond its optimal level. Therefore, any improvement in allocative efficiency implies reducing the relative participation of *other expenditures*. On the other hand, *current assets* input has always been underutilized, so this input should increase its relative presence related

[8] The Appendix displays the evolution of the budget of PAF. Since the main output (Princess of Asturias Awards) is more or less the same before and during the financial crisis, *PAF* is achieving a similar level of output with less resources and this fact can be also considered as an inkling of an improvement in the efficiency of *PAF* (see Table 6 and Fig. 9).

[9] The test of constant returns of scale, that is the sum of the three output estimated coefficients equals one, implies a value $\chi^2(1) = 2340$. Then, the hypothesis of constant returns of scale can be rejected at a 1% significance level.

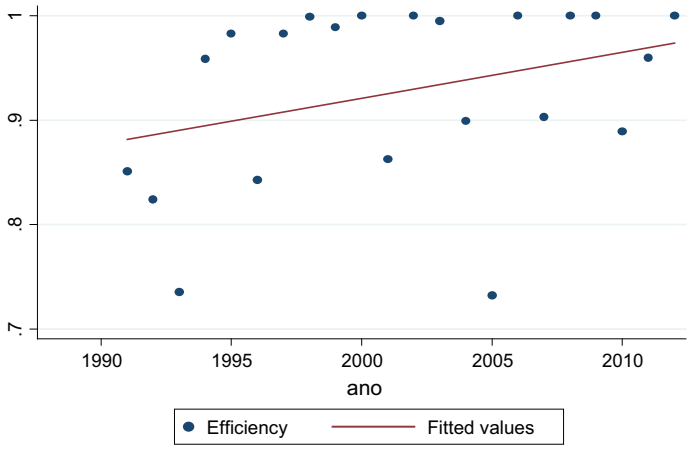

Fig. 5 Technical efficiency evolution

Table 5 Technical efficiency (TE) indexes (Summary)

Variable	#Obs.	Mean	SD	Min	Max
Technical efficiency	22	.9276	.0807	.7320	1

to the other inputs, although such a policy would obviously need time to achieve this.

The k_{ij} coefficients in Table 6 represent the average value corresponding to the analysed period. This information can be complemented with their time evolution (Figs. 6, 7 and 8). In all the cases, we see that the allocative efficiency coefficients have moved towards efficiency, especially in the latter years of the period. After a more or less stable phase during the initial years, *current assets* input (K) has improved continuously with respect to *labour* (L) and *other expenditures* (OG), although it is far from the efficient allocation. Finally, *labour* (L) has improved its position greatly with respect to *other expenditures* (OG), and at the end of the period, $K_{L,O}$ has decreased around fivefold and is closer to the optimum level. This result reinforces the idea that *PAF* has made special efforts to adequate inputs to appropriate levels focusing on cost saving for a given the output level. Obviously, the best results are obtained in those cases where inputs are easier to manage.

7 Conclusions

Nowadays, efficiency and productivity analysis is a relatively common research field in Cultural Economics and offers interesting results in different areas such as, for example, museums or performing arts firms. Both parametric and non-parametric procedures have been applied to measure technical efficiency

Table 6 Estimated allocative efficiency

K_{ij} coefficient	Mean
$K_{L,K}$	.26
$K_{L,O}$	2.11
$K_{O,K}$	.12

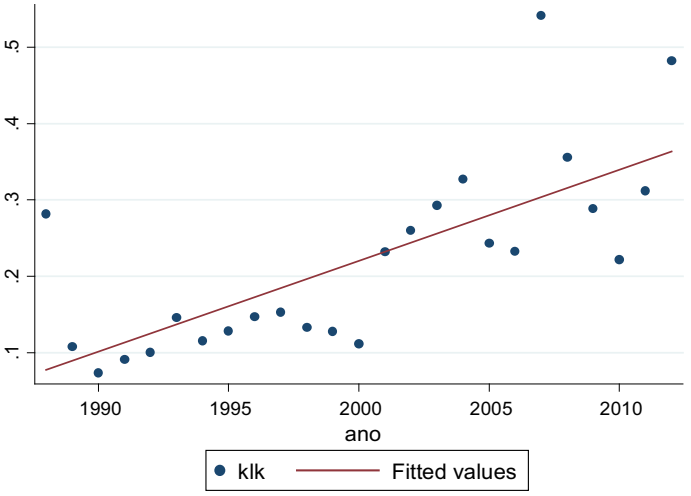

Fig. 6 K_{lk} coefficient evolution

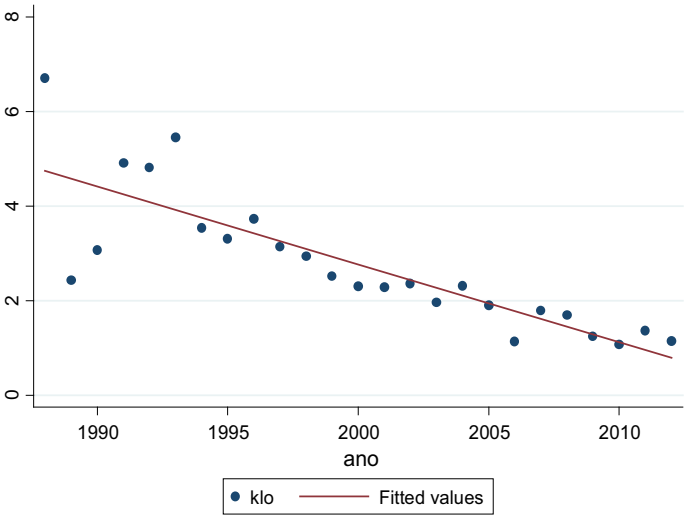

Fig. 7 K_{lo} coefficient evolution

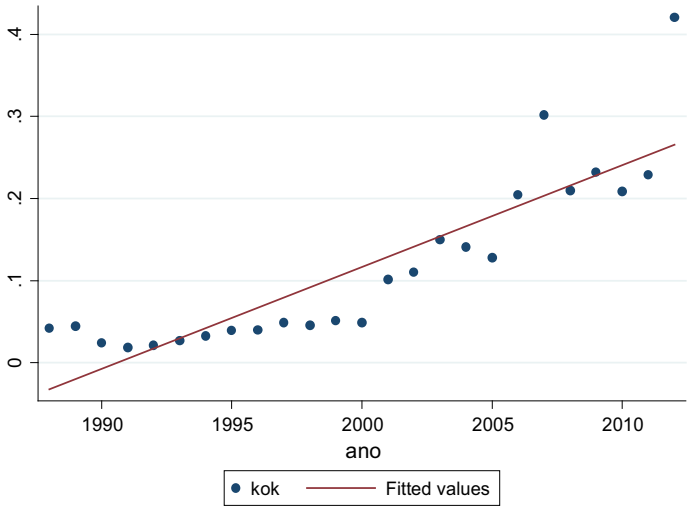

Fig. 8 K_{ok} coefficient evolution

successfully. However, there is a lack of analysis in terms of allocative efficiency. To fill this gap, our paper proposes a new methodology based on Shephard's distance function that allows measuring both technical and allocative efficiency. This methodology is particularly suitable when we face non-profit firms or institutions that are not interested in cost minimization. The empirical application presents such a case and offers an example of how this technique works. We analyse efficiency in the performance of *Princess of Asturias Foundation* (*PAF*) during the period 1988–2012. This is a Spanish non-governmental organization devoted to promoting, cultural, scientific and humanistic values of universal heritage, especially through the Prince (Princess since 2014) of Asturias Awards that reward scientific, technical, cultural, social and humanistic work undertaken in any place of the world.

Using the cumulative history of *PAF* during the period considered, we estimate an input distance function, in a multi-output production framework, that allows achieving different outcomes. First, we compute technical efficient indexes. Second, having obtained the shadow prices of inputs that would satisfy the condition of minimum cost, we use them to calculate the degree of allocative inefficiency of *PAF* and its origin by using a parametric correction of prices (k_{ij}).

With respect to technical efficiency, the average technical efficiency index is .93 that means that *PAF* could have used 7% less inputs to achieve the same level of outputs. Furthermore, technical efficiency has seen a progressive improvement during the analysed period.

On the other hand, there is no allocative efficiency. *Other expenditures* input has been over-utilized in relation to both *labour* and *current assets* inputs, and *labour* has been over-utilized in relation to *current assets*. However, we have identified a clear improvement in inputs allocation, especially in the latter years of the period.

Since the technical efficiency indexes are relatively close to the optimal value, and the greatest part of the outputs are and are going to be stables, perhaps the efficiency improvements might come from the qualitative rather than quantitative point of view. In this sense, and given that the workers are deeply committed in presence of special situations and events, it might be valuable to design and additional, and not necessarily monetary, incentive scheme to reinforce their link to the Foundation. Finally, "other expenditures" input has been always over-utilized. Since the core of this input are outsourced tasks, *PAF* should review the contracts signed with the outsourcing firms.

In conclusion, our paper contributes to the existing literature by offering an alternative methodology and a novel empirical procedure, which facilitates a dual analysis of technical and allocative efficiency applicable to Cultural Economics in general and in particular to a non-profit-making scheme.

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Compliance with ethical standards

Conflict of interest The authors declare that they have not conflict of interest.

Appendix

Table 7 PAF budget 1988–2012 (in constant 2011 euros). *Source*: Princess of Asturias Foundation

Year	Income	Year	Income
1988	1,062,109	2001	3,137,771
1989	1,255,971	2002	3,750,562
1990	1,653,979	2003	3,541,250
1991	2,870,602	2004	4,649,948
1992	2,813,795	2005	7,560,480
1993	2,909,524	2006	8,100,090
1994	2,501,316	2007	9,853,075
1995	2,505,031	2008	10,081,573
1996	2,673,290	2009	7,460,849
1997	2,492,229	2010	5,490,083
1998	2,517,712	2011	6,032,122
1999	2,532,485	2012	5,719,288
2000	2,745,201		

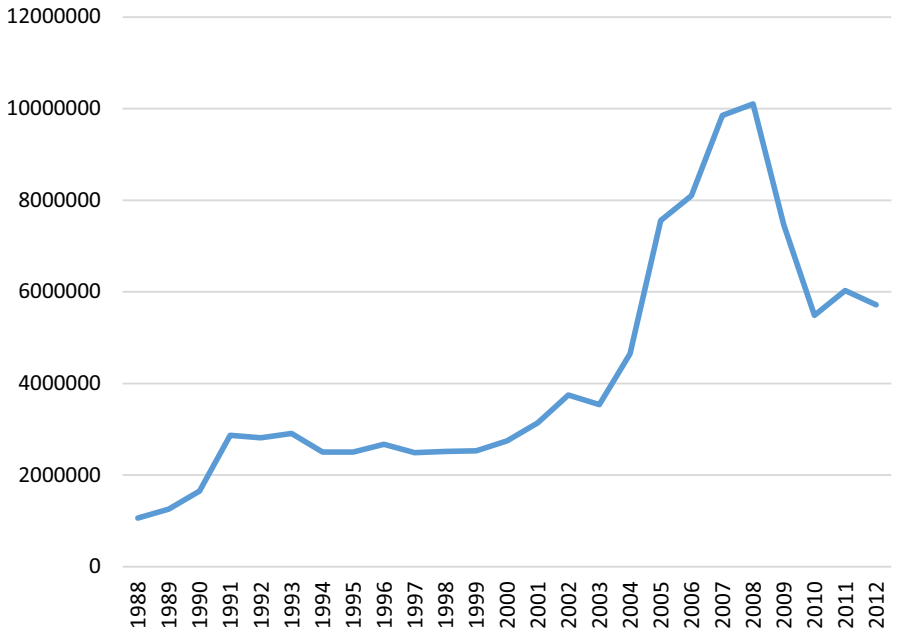

Fig. 9 PAF Budget 1988-2012 *Source*: Princess of Asturias Foundation

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