ACEI working paper series

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AWP-09-2017   Date: October 2017

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ABSTRACT

The aim of this paper is to bring new contributions to the analysis of efficiency and productivity in the performing arts. First, we consider that the behavior of a performing arts company can be analyzed under a multi-output technology of production, since they offer different products in terms of quantity and quality. Second, and for the first time to the best of our knowledge, we propose a procedure to measure the marginal costs associated with the production of performing arts firms. To achieve our goals, we estimate a stochastic input distance function to a set of nineteen public municipal theatres in Warsaw during the period 2000-2012. Additionally, we calculate the technical efficiency indices for these theatres and characterize some determinants of their efficiency, paying special attention to the effect of public grants. Our findings suggest that those municipal theatres in Warsaw could have used 7% less inputs to achieve the same level of outputs. At the same time, the presence of public grants improves efficiency and, so, contributes to extend novelty and diversity. The marginal cost of a new performance is around 7,149 PLN; and introducing a new title costs up to 3.33 times more than staging one title already established in the repertoire.

Key words: theatres, multi-output technology, marginal cost, duality theory, input distance function

JEL classification: L82 – D24 – Z10

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1. INTRODUCTION

The aim of this paper is to analyse technical efficiency in the performance of nineteen municipal theatres in Warsaw during the period 2000-2012 and to offer an approximation to measure the marginal cost associated with theatre's production.

The analysis of technical efficiency has been definitively placed on the field of Cultural Economics, in general, and performing arts in particular. This reality is the result of two reasons at least. On the one hand, managers are interested in improving their economic performance. Today it is widely accepted that a good performance is a multitask goal that incorporates artistic contributions, but also a professional managerial performance as a necessary piece for a sustainable future of arts.

On the other hand, cultural firms' finances depend crucially on public funds coming from direct grants/subsidies or tax breaks in favour of charitable contributors and donors. In both cases, citizens in general, and donors in particular, are interested in an appropriate use of those funds.[1] And in our case this second reason is particularly relevant since the City Council of Warsaw has included the improvement in cultural management as a specific goal in its culture development program (Warsaw 2010). Hence, to evaluate if these public grants and tax breaks contribute or not to an efficient performance may be a key point to evaluate the outcomes of a funding public policy.

All the previous studies on efficiency in the performing arts consider the companies produce a unique output, independently if it is measured through visitors, performances, productions or any alternative measure. From our point of view, performing arts companies may be considered as multi-output firms. It is not the same to stage a new production than a repertory production released in previous seasons. The kind and quantity of resources employed and the optimal combination of inputs are different. Under these circumstances, any kind of production technology estimates that consider new and old productions as the same output will be biased. For these reasons, we propose to use a multi-output approach. Furthermore, we will estimate the marginal cost associate with anyone of the outputs we will consider.

[1] In the case of performing arts firms totally market oriented, efficiency will be imposed through the control of the market.

To analyse production technology in the case of public municipal theatres of Warsaw, we propose to estimate an input distance function.[2] This function has some advantages over the traditional production or cost functions: it is especially suitable in the presence of multi-output production and when the cost minimisation scenario could be under question. And, our case study can fit both situations. On the one hand, we are dealing with public theatres and cost minimization may not be a relevant goal, particularly in the case of experimental and children's theatres. On the other hand, we think that theatres offer not only a quantitative output (measured through variables like number of performances, attendees or revenues), but also a qualitative output, in terms of novelty or innovation that can be approximated using some alternative variables that we will discuss below. To take into account this double nature may be particularly interesting when you want to measure the impact on costs provoked not only by a new performance, but also when a new production is incorporated to the theatre repertoire, especially when we are aware of how this possibility changes the cost structure.

In sum, this paper tries to contribute to literature on efficiency and productivity in performing arts firms and institutions in different ways. For the first time, theatres production has been incorporated to a multi-output scenario. Besides, and at best of our knowledge, this is the first time that marginal costs are computed in the case of performing arts. And finally, it provides new empirical evidence about technical efficiency in this field and, additionally, it tries to characterize some determinants of this efficiency, paying special attention to the effect of public grants.

The paper is organized as follows. Section 2 reviews efficiency and productivity literature in performing arts briefly. Section 3 describes the municipal theatres in Warsaw, the non-profit and public institutions subject of our efficiency analysis. Section 4 contents the key theoretical features of the input distance function approach and Section 5 provides the empirical procedure. Section 6 discusses our main results and Section 7 concludes.

[2]Moreover, the input distance function is also adequate to measure allocative inefficiency, directly and independently of technical inefficiency. However, this is not the aim of this paper.

2. EFFICIENCY AND PRODUCTIVITY IN PERFORMING ARTS: A BRIEF OVERVIEW

The analysis of production technology in the performing arts has come a long way from the pioneer work by Throsby (1977) who, for the first time, estimated short-run and long-run Cobb-Douglas production functions for nonprofit performing arts firms in Australia. Gapinski (1980, 1984) went one step ahead and, using data for American performing arts and English theatres in the framework of a transcendental production function, confirms decreasing marginal products for primary outputs (artists and capital) and decreasing returns of scale for the whole set of inputs. Zieba and Newman (2007) is, perhaps, the last outstanding paper that estimates a production function.[3] They confirm Gapinski's previous outcomes.

Simultaneously, the cost function approach has been also explored. Globerman and Book (1974) in Canada and Throsby (1977) in Australia are probably the first attempts of estimation cost functions in the field of the performing arts. Both papers observed the presence of economies of scale. Later, different examples of cost function estimates have discussed this outcome, at least partially: Lange et al. (1985) and Lange and Luksetich (1993) for American symphony orchestras; Taalas (1997) for Finnish theatre companies; Fazioli and Filippini (1997) for Italian theatres; or Gray (1997) for Norwegian performing arts companies.[4]

The arrival of 21st century means an important turning point in the analysis of production technology of the performing arts, when cost and production frontier functions begin to be estimated, following the efficiency and productivity analysis approach inaugurated by Farrell (1957). As Kumbhakar and Lovell (2000) has pointed out, the estimation of production and/or cost frontiers provides more accurate information than average functions because the former do not necessarily imply to maximize output or minimize costs, respectively. Hence, when there is a difference

[3]They estimate a fixed effect model using panel data.

[4]Lange et al (1985) and Lange and Luksetich (1993) found economies of scale in the case of small orchestras while large orchestras benefited from economies of scope. Gray (1997) also observed economies of scale in the case of small performing arts companies. The presence of economies of scale was confirmed in Taalas (1997) and Fazioli and Filippini (1997) who also founded economies of scope.

between the potential and the observed frontier and it is not taken into account, the estimation of parameters describing technology will be biased.[5]

Although these frontier functions can be estimated using parametric and non-parametric techniques, in the case of performing arts the last approach is more scarce and includes Marco-Serrano (2006) and Rausell et al (2013) measurement of technical efficiency in a Spanish regional theatres and musical societies networks, respectively.[6]

Meanwhile, estimation of parametric stochastic frontiers has been more frequently used in the field of performing arts.[7] This procedure defines a specific functional form for the frontier and incorporates an error term with two components: a standard random two-sided component and a non-negative component which takes into account technical efficiency. With this composed error term, we are able to state 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.[8]

We can group those studies analysing efficiency in the performing arts according to the kind of frontier they estimate. On the one hand, Zieba (2011), Zieba and Newman (2013) and Castiglione et al. (2016) estimate Cobb-Douglas and translog production functions. On the other hand, Last and Wetzel (2010 and 2011) apply an input distance function approach.

Summarizing all the findings, Zieba (2011), using a sample of Austrian and Swiss non-profit theatres, concludes that "individual efficiency estimates are very sensitive to the econometric specification of the unobserved heterogeneity of theatres" (p. 274) and exogenous factors like public subsidies, number of theatres and regional differences impact on technical efficiency crucially. Zieba and Newman (2013) state that public theatres are more efficient than private theatres although the later reacts better to market

[5]Although we have focused on the performing arts, the analysis of efficiency and productivity analysis has reached other fields of cultural economics

[6] DEA technique is more frequent in other fields of cultural economics like museums (Mairesse and Van den Eeckaut 2002; Del Barrio et al. 2009; Del Barrio and Herrero 2014), libraries (De Witte and Geys 2011; Guccio et al. 2017), cultural heritage (Guccio et al. 2014) or archives (Guccio et al. 2014).

[7]Bishop and Brand (2003) inaugurated this approach measuring the efficiency of English museums through a Cobb-Douglas production function.

[8]DEA procedure does not impose a specific functional form but, at the same time, does not allow us to distinguish between inefficiency and random shocks inside the error term.

forces improving their efficiency while competition induces decline in efficiency among the former. Castiglione et al (2016) observed low technical efficiency indices in Italian performing arts firms and, at the same time, efficiency depends positively on firm's quality and reputation and quality of life in general. Last and Wetzel (2010) reject a cost minimization environment in the case of public German theatres and reinforce how convenient is to consider unobserved heterogeneity to avoid biased efficiency values. Finally, Last and Wetzel (2010), decomposing the total factor productivity in technological change, technical efficiency change, and scale efficiency change, conclude that German public theatres sector is under the Baumol's cost disease although it could be alleviated exploiting economies of scale.[9]

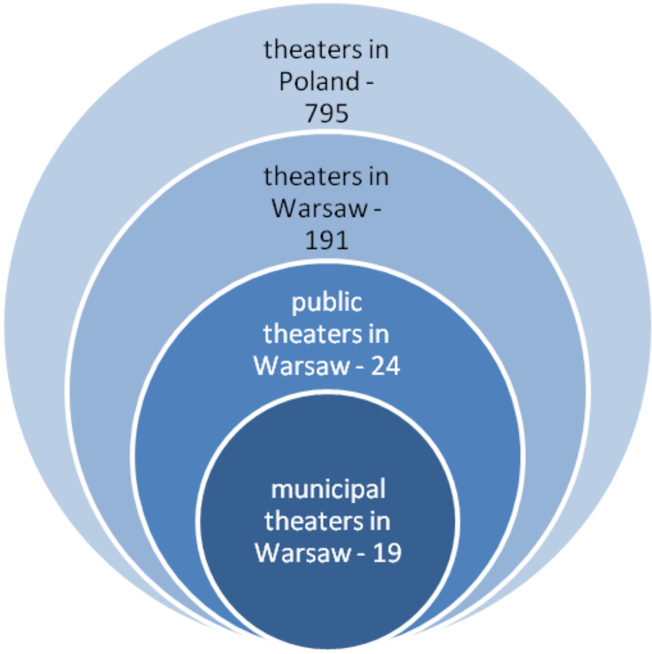
3. MUNICIPAL PUBLIC THEATRES IN WARSAW

According to Theater Institute (TI) database, there are nearly 800 theaters in Poland, including public, private and non-governmental organizations. 120 of them are public theatres, run by central, regional or local administrations. They are hosts of about 75% of performances shown in the country and more than 90% of theatre viewers. In Warsaw we can find 191 theatres: 24 among them are public, they perform regularly under stable conditions in own venues and often specialize in particular forms of repertoire, what is unusual for one-theater cities. Inside this group, there are 19 municipal theatres (Figure 1).

Warsaw municipal theaters are a very diverse group of non-for-profit institutions that can be divided into four categories on the basis of the repertoire they specialize in (Czajkowski and Wiśniewska 2017). There are 6 entertainment theaters, including one of the biggest musical theatre in the country; 7 drama theatres play dramas and more ambitious comedies, often on the basis of classical works, that are accessible for the broad audience; 3 children's theaters serve the youngest audience, play puppet performances and fairy tales in their relatively small venues; and 3 experimental theaters employ new techniques, often producing contemporary plays.

[9]It is noticeable that all of these studios focus on technical efficiency. Taalas (1997), using a generalized cost function, and Fernandez-Blanco and Rodríguez-Álvarez (2016), estimating an input distance function, incorporate the measurement of allocative inefficiency to cultural economics.

Figure 1.
Theatres in Poland.

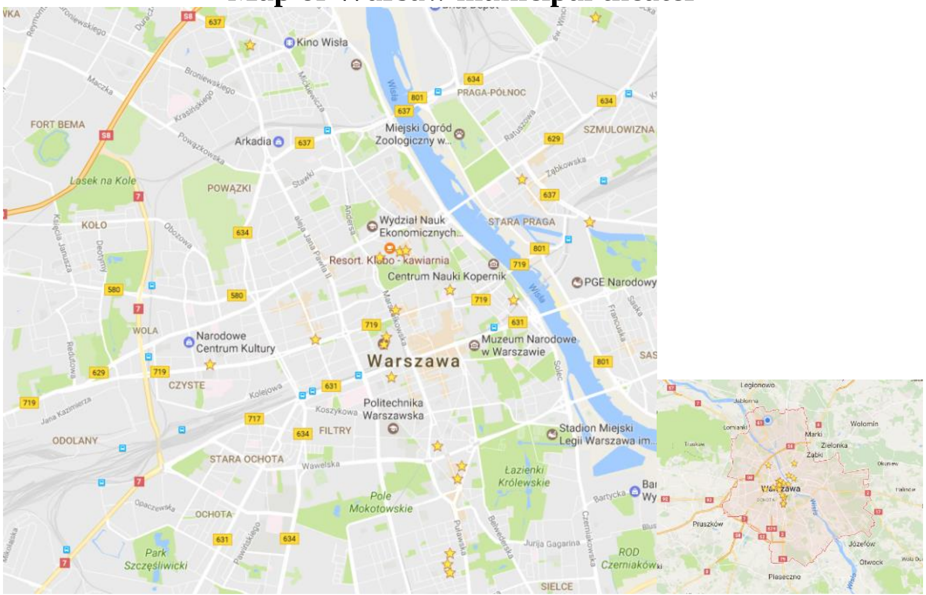


Beyond their specialization, they share similar organizational features. As public institutions Warsaw municipal theaters should follow public goals. In its long term program of cultural development in Warsaw, the Municipality has defined six aims (Warsaw, 2010). The first goal, 'increase and deepen of cultural attendance', might contribute to accessibility of culture for potential consumers (Hausner 2014), although this kind of policy could be questionable when "lack of interest" is the main barrier to cultural participation (see, for instance, O'Hagan 2016). The second aim is an artistic aim, "supporting and disseminating creation in arts and culture, including development of creative sector", particularly in those areas where the market might not recognize the artistic or intrinsic value of culture. Municipality aims also in promoting local identity, social cohesion, international reputation and prestige of the city, some of the well-known reasons that encourage the State participation in the Arts. Finally, the two remaining goals regard efficiency of cultural sector: the municipality aims in increasing quality and efficiency of cultural management and a better use of public space for cultural activities. Our research that analyses technical efficiency in municipal theatres is closely connected with these last objectives.

Warsaw municipal theatres are ‘repertory’ theaters: the performances of productions listed in the repertoire are spread over the theatre season; a title is staged 3-7 days in a set after which the break is needed to change a set design for another play; the rehearsals for new productions take place continuously during the staging period and not in a seasonal break.[10]

The theatres are located mostly in the city center or in nearby districts. Three of them are on the right bank of the Vistula River, on less developed areas (see Figure 2).

Figure 2.
Map of Warsaw municipal theater



Source: Google Maps. Theatres pointed as stars.

They operate on one, two or three stages and differ much in their capacity: the biggest stage contains nearly 1000 seats, while the smallest theater with one stage can host up to 100 viewers only. On average for the period 2000-2012, they gave 3 premiers, offered 15 titles and performed more than 200 times per year. They gathered yearly more than 860,000 viewers, which stands for about 15% of Polish theater market, with 83% of average attendance rate. Their budgets are distributed as follows: 66.5% comes from direct public subsidies;[11] 24.5% from ticket revenues and about 10% from other sources of income, including a small financial support from sponsorship (1.2%). Ticket prices differ from theater to theater; they are not regulated by the local government. On

[10]Polish theater season lasts 12 months (from September to August) with 9-10 months of staging.
[11]This percentage ranges from 80% to only 30% in the case of entertainment theaters.

average, they are twice expensive than cinema tickets. Yearly admission fee is very rare option like in most theaters in Poland (with except of operas), so revenues from tickets are highly dependent on artistic success. In most cases, public subsidies are (nearly) enough to cover fixed costs of theaters. Since a stable artistic team is a fundamental characteristic of Polish public theater, most of artistic employees have permanent contracts; then salaries are a relevant share of those fixed costs.

4. AN INPUT DISTANCE FUNCTION: THEORETICAL APPROACH PROCEDURE

Independently of the methodological procedure we have selected, measuring efficiency implies constructing an optimal frontier function and calculating how distant our institution (theatre, in our case) is from it. And we have constructed this frontier function using the relevant information from those nineteen theatres in Warsaw. We have decided to estimate a stochastic frontier function using the parametric approach. 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.[12] Specifically we have decided to estimate an input distance function.

a) 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:

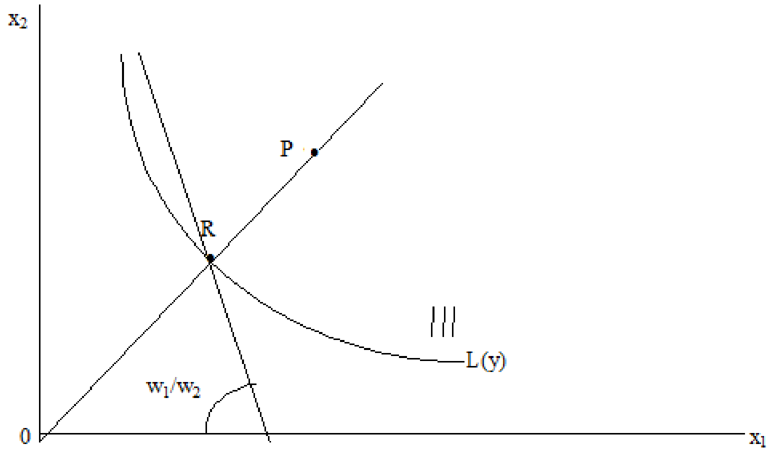
$$D_I\,(y, x) = \max\{\delta > 0 : x/\delta \in L\,(y)\} \qquad (1)$$

where y ($y_1 \ldots y_m$) is the vector of outputs, x ($x_1 \ldots x_m$) 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 0P/0R in Figure 3 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

[12] The non-parametric approach, in particular Data Envelopment Analysis, does not impose a particular functional form but assumes no random mistakes.

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

Figure 3.
The input distance function



Using the reciprocal of this index, that is to say, 0R/0P we obtain the Farrell (1957) input-oriented measure of technical efficiency (TE) for the point P. It indicates the maximum proportional reduction that can be achieved in the utilized inputs that allows production of the same quantity of output.

Formally,

$$TE = \frac{1}{D_I} = \frac{1}{\delta} \qquad (2)$$

The maximum value of the TE 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 Figure 3), indicates the degree of technical efficiency achieved by the firm.

One of our aims is to measure marginal costs and we can do this using the duality between the input distance function and the cost function defined by Shephard (1953). Following Cornes (1992, p. 128), we can define the dual relationship between the efficient normalized cost function and the input distance function as follows:

$$MC_y = \frac{\partial C(W,y)}{\partial y} = -\frac{\partial D_I(x,y)}{\partial y} \quad (3)$$

where MC is the marginal cost; C(W,y) is the normalized cost function and W is the vector of normalized input prices: $W = \frac{w}{C(w,y)}$

5. EMPIRICAL PROCEDURE

a) The model

The production technology of theatres' activity can be represented by a stochastic input distance function that can be expressed as follows:

$$ln1 = ln\, D_I(\mathbf{y}, \mathbf{x}) - u + v \quad [4]$$

where, again, y and x are the output and input vectors, respectively. In equation (4) u and v are the error terms. When u = 0 the distance function takes the value 1, with the firm producing on the frontier, while values of u > 0 mean that the firm is producing above the isoquant, so it is technically inefficient. The parameters of this function can be estimated by maximum likelihood once the distribution for v and u have been defined. In this sense, we assume $u \sim N^+ (0, \sigma_u^2)$. On the other hand, v is the term of random perturbation that follows the distribution $v \sim N(0, \sigma_v^2)$.

Moreover, in this study we propose a model where the error component u is normally distributed with the mean equal to zero and variance σ_u^2. The latter is modeled 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. That is to say:

$$u \approx iid\ N^+\left(0, \sigma_u^2\right), \sigma_u^2 = g(z, \delta) \quad (5)$$

Increases in the variance in turn represent increases in the distance to the frontier and vice-versa (see Caudill and Ford 1993; Caudill et al. 1995 or Hadri, 1999, for details).

b) The data and variables

Our data set is an unbalanced panel data for the period 2000-2012. It includes information about nineteen Warsaw municipal theaters coming from Department of Culture of the City of Warsaw [13]. All these theaters are public institutions where the cost minimization framework can be under question.

The measurement of the output of performing arts institution is a discussed question (Throsby and Withers 1979; Heilbrun and Gray 2001) and several empirical papers have used different variables related to supply or demand side, as Table 1 displays.

Table 1.
Output selection in the literature on performing arts production function

	Output				
Works	Performances	Attendance	Supplied tickets	Ticket revenues	Other
Globerman and Book (1974)	X				
Throsby (1977)		X			
Gapinski (1980)		X			
Gapinski (1984)		X			
Lange et al. (1985)	X				
Lange and Luksetich (1993)	X				
Fazioli and Filippini (1997)	X				
Gray (1997)	X				
Taalas (1997)		X			
Marco-Serrano (2006)	X	X			
Zieba and Newman (2007)		X			
Last and Wetzel (2010)			X		
Last and Wetzel (2011)			X		
Zieba (2011)		X	X		
Rausell et al (2013)	X				X
Zieba and Newman (2013)		X			
Castiglione et al (2016)				X	

[13] In 2013 the number of municipal theaters declined, while two of them were merged into one organization.

Among those variables that include the demand, theatre attendance, measured for instance through the total tickets sold in a season, has some advantages: it approximates the idea of output as a "cultural experience" (see, for instance, Gapinski 1980, 1984; or Marco-Serrano (2006) and also a kind of visitors' valuation of quality. Revenues and the percentage of tickets sold over the total tickets on supply are other alternatives in the same line.[14]

The number of performances and the number of separate productions can be used as output measures from the supply side.[15] The number of separate productions captures the idea that it is not the same to offer fifty performances of only one production than ten performances each of five productions because, in the last case, the company "is, in some sense, producing more artistic experience" (Heilbrun and Gray 2001, p. 108). This goal regards especially non-profit theaters which care for repertoire choice (O'Hagan and Neligan 2005). Krebs and Pommerehne (1995), analyzing multi-agent decision making in public performing arts institutions, assign artistic quality maximizing goals to theater manager being often at the same time a director. It is also the case of many municipal theaters of Warsaw. **S**ince costs depend on the number of productions as well as on the number of performances, both can be considered suitable output measures when, as in our case, we are interested in evaluate costs.[16]

But we think we can go a step ahead. Number of performances and number of productions can be considered not only as two output measures, but also two different outputs, particularly if we consider that the number of productions approximate a qualitative aspect including novelty, diversity and innovation. In other words, we think that a company produces a quantitative output (performances) and also a qualitative output (productions). Finally, taking into account that the local public theatres in Warsaw are "repertory" theatres, what means that they continue playing titles produced in previous years and produce new ones in the same time, we can distinguish between new productions and repertory productions each year because they have different effect on costs. Former indicates novelty, innovation and the risk a theater undertakes to

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[14] Obviously, these measures can be seen as the result of both demand and supply.

[15] The number of tickets available on offer can be another measure of output from the supply side.

[16] From the manager's point of view, it is more interesting to know the marginal cost of a new performance or a new production rather than the marginal cost of a new viewer that, except in case of congestion, will be close to zero.

produce artistic (among others) value. The second shows diversity of artistic experience on offer. In sum, our output variables are *Performances* (Total performances provided by the theatre in own venues), *Open nights* (number of new titles stages by the theatre), and *Repertory titles* (the difference between total and new titles).

We have included two inputs: *Labour* (L) and *Capital* (K). *Labour* is the number of employees that is the number of people who worked in a theater during a given year, irrespectively the nature and characteristics of their job [17]. *Capital* has been measured subtracting labour costs from total costs. We have included a quadratic time trend (*Time*) and some variables referred to the specific characteristics of each theatre that can affect its performance. Concretely, we have incorporated a couple of dummy variables to control for delivering guest presentations and for own performances as a guest in other venues (variables *Host* and *Guest*, respectively); the variable *Viewerperf*, the number of viewers per performances, is included in order to control for the response of demand on input requirements. We have also included the variable *Subsidy*, defined as the ratio subsidies/total cost that incorporates the presence of public subsidies and its relative weight in total cost of the theatre. Finally, we have added a set of eighteen dummy variables to control for the theatres fixed effects.

As regard equation (5), we have a special interest in ascertaining how theatre productivity (efficiency) is affected by the viewers' response to the performances it offers (*Viewerperf*); its activity hosting other companies' performances (*Host*) or being a guest in other companies' venues (*Guest*); the presence of public grants (*Subsidy*); the percentage of new titles over the total titles that the theatre stages a season *(Pernew)*; and the time (*Time*) and size (*Size*) effect. In this sense, we model the z vector in (5) as a function of these variables. Variable definitions and a descriptive analysis of the data is reported in Table 2.

[17] We have not distinguished between temporary and permanent personnel or different professional categories. In a previous estimation, we have tested to include these variables separately, but it was not statistically significant and did not improve our results.

Table 2: Variables Definitions

Variable	Definition	Mean	S.D.
L (Labour)	Number of workers	178.69	108.35
K (Capital)	Total costs minus labour costs (PLN)	3,133,646.00	2,833,774.00
P (performances)	Number of own performances in own venue	226.59	94.51
T (repertory titles)	Number of titles without open nights	11.77	7.07
O (open nights)	Number of open nights	3.24	1.92
T (Time)	Trend variable	6.89	3.73
Subsidy	Total subsidies/total costs	0.65	0.18
Viewerperf	Number of viewers/Performances	225.15	169.90
Pernew	New titles/Total titles	0.25	0.16
Size	Maximum number of seats in each theatre per season	84,842.59	63,777.94
		%	
Host	= 1 If there are guest performances of other theaters in own venue = 0 Otherwise	26.11 73.89	
Guest	= 1 If there are own performances as a guest in other venues = 0 Otherwise	86.67 13.33	

Number of observations: 180

6. EMPIRICAL RESULTS

Assuming a translog function functional form for the input distance function defined in (4), and imposing homogeneity of degree (1) in inputs, we have:

$$-\ln x_{1it} = \alpha_0 + \sum_{r=1}^{K} \alpha_r \, Ln\, y_{rit} + 0.5 \sum_{r=1}^{K}\sum_{s=1}^{K} \alpha_{rs} \, Ln\, y_{rit} Ln\, y_{sit} + \sum_{m=2}^{M} \beta_m \, Ln\left(\frac{x_{mit}}{x_{1it}}\right) +$$

$$+0.5 \sum_{m=1}^{M}\sum_{n=1}^{M} \beta_{mnt} \, Ln\left(\frac{x_{mit}}{x_{1it}}\right) Ln\left(\frac{x_{nit}}{x_{1it}}\right) + \sum_{r=1}^{K}\sum_{m=1}^{M} \gamma_{rm} \, Ln\, y_{rit} Ln\left(\frac{x_{mit}}{x_{1it}}\right) + \rho_t \, Time + 0.5 \rho_{tt} \, Time^2 +$$

$$+ \sum_{r=1}^{K} \rho_m \, Time\, Ln\, y_{rit} + \sum_{m=1}^{M} \rho_k \, Time\, Ln\left(\frac{x_{mit}}{x_{1it}}\right) + \sum_{i=1}^{19} \alpha_i \, D_i + \sum_{h=1}^{2} \alpha_h \, D_{host} + \sum_{g=1}^{2} \alpha_g \, D_{guest} +$$

$$\beta_v Viewerperf_{it} + \beta_s Subsidy_{it} + v_{it} - u_{it} \qquad (6)$$

where x and y are inputs and outputs, respectively; subscripts m and n refer to inputs, r and s refer to outputs, and i and h refers to theatres. *Time* is a trend variable and D_i; D_{host} and D_{guest} are dummy variables. Finally, α's; β's; γ´s and ρ`s are the parameters to be estimated.

The expression (6) is the function to be estimated jointly with equation (5).

a) Technical efficiency

Table 3 displays the parameters of the input distance function estimated using the maximum likelihood procedure. 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. Then, the estimated input distance function, at the sample means, fulfils the regularity conditions: it is non-decreasing in inputs and decreasing in outputs.

The positive and significant sign of the coefficient of the variable *Host* implies that, ceteris paribus, hosting other companies reduces the input requirements, meanwhile performing as guest in other venues (*Guest*) is not statistically significant. The negative and significant coefficient of *Viewerperf* means that, on average, the more the attractiveness for the viewers, the more the inputs requirement. The time trend has a negative sign that means the presence of regressive technical change. This outcome is consistent with previous research (Last and Wetzel 2010, Zieba 2011) and, following Fazioli and Filippini (1997), it can be interpreted in terms of the difficulties of theatres to take advantage of technological improvements compared to other sectors, as Baumol and Bowen (1966) pointed out.

Table 3.
Distance function parameters

Variable	Coef.	z	P>z	Variable	Coef.	z	P>z
Ln(L)	0.2375	8.2700	0.0000	**Ln(T)Time**	0.0192	1.7500	0.0790
Ln(K)	0.7625	26.5700	0.0000	**Theater 2**	1.0122	12.5700	0.0000
Ln(T)	-0.0842	-1.8700	0.0620	**Theater 3**	-0.6256	-5.3600	0.0000
Ln(O)	-0.0774	-2.1900	0.0290	**Theater 4**	0.8784	8.4900	0.0000
Ln(P)	-0.2524	-3.1200	0.0020	**Theater 5**	0.0307	0.2100	0.8330
Ln(L)Ln(L)	0.4806	7.8500	0.0000	**Theater 6**	0.8891	5.9000	0.0000
Ln(K)Ln(K)	0.4806	7.8500	0.0000	**Theater 7**	0.5976	7.5400	0.0000
Ln(L)Ln(K)	-0.4806	-7.8500	-0.0000	**Theater 8**	-0.9215	-4.2900	0.0000
Ln(L)Ln(T)	-0.0550	-0.9500	0.3440	**Theater 9**	-0.1549	-1.5800	0.1140
Ln(L)Ln(O)	-0.1556	-3.8900	0.0000	**Theater 10**	-0.2582	-1.2100	0.2270
Ln(L)Ln(P)	0.0096	0.1600	0.8700	**Theater 11**	0.7999	3.8500	0.0000
Ln(K)Ln(T)	0.0550	0.9500	0.3440	**Theater 12**	0.0214	0.2500	0.8020
Ln(K)Ln(O)	0.1556	3.8900	0.0000	**Theater 13**	0.0609	0.6100	0.5410
Ln(K)Ln(P)	-0.0096	-0.1600	0.8700	**Theater 14**	-0.4255	-4.6500	0.0000
Ln(T)Ln(T)	0.0242	0.3500	0.7280	**Theater 15**	0.8273	6.7700	0.0000
Ln(O)Ln(O)	-0.0024	-0.2900	0.7710	**Theater 16**	-0.3914	-3.3100	0.0010
Ln(P)Ln(P)	-0.4977	-4.2000	0.0000	**Theater 17**	-0.0380	-0.3700	0.7110
Ln(T)Ln(O)	0.0307	2.5800	0.0100	**Theater 18**	0.0070	0.0900	0.9280
Ln(T)Ln(P)	0.0584	1.2600	0.2070	**Theater 19**	0.1823	1.5000	0.1330
Time	-0.0112	-1.6900	0.0910	**Host**	0.1327	2.9100	0.0040
Time^2	0.0221	8.4700	0.0000	**Guest**	-0.0743	-1.4600	0.1450
Ln(L)Time	0.0172	2.2600	0.0240	**Viewerperf**	-0.0012	-2.9800	0.0030
Ln(K)Time	-0.0172	-2.2600	0.0240	**Subsidy**	0.1211	0.5200	0.6010
Ln(O)Time	-0.0225	-2.5600	0.0100	**_cons**	0.0153	0.0700	0.9470
Ln(P)Time	-0.0057	-2.3500	0.0190				

Number of observations: 180

Table 4 displays the estimate of the variance of the error term. Let us recall that increases in the variance of *u* represent increases in the distance to the frontier (and vice versa) that means an increase in technical inefficiency. The negative and statistically significant coefficient of *Subsidy* means that the presence of public grants improves efficiency (as in Zieba 2011), hence public grants move manager to be more efficient and, according to our selected outputs, to improve novelty, quality and diversity. The coefficient of *Viewerperf* is also negative and significant, and then managers put more efforts when consumers are more interested in their performances. Finally, the positive and significant sign of the coefficient of *Pernew* tell us that the higher the percentage of new titles, the higher the variance of the error term (the inefficiency). We can interpret this last result in the sense that more resources are needed to put a new title on the stage.

Table 4
Heteroskedasticity of the random error term u: Determinants of inefficiency

Variable	Coef.	z	P>|z|
Size	0.5620	0.7700	0.4390
Viewerperf	-0.0143	-1.8700	0.0610
Pernew	8.6854	2.5600	0.0100
Host	0.9602	1.0700	0.2850
Guest	28.9436	0.0100	0.9890
Subsidy	-12.6505	-3.0600	0.0020
Time	0.0820	0.4500	0.6540
_cons	-32.1957	-0.0100	0.9880

Number of observations: 180

Moreover, Figures 1, 2 and 3 show the relationship between TE and *subsidies; Viewerperf* and *Pernew*. The results confirm those obtained in Table 4: subsidies and the number of viewers as a percentage of the total performances increase technical efficiency. In contrast, the number of new titles over the total titles increases the distance to the technological frontier.

Figure 4: Technical Efficiency (TE) Indices and Subsidy

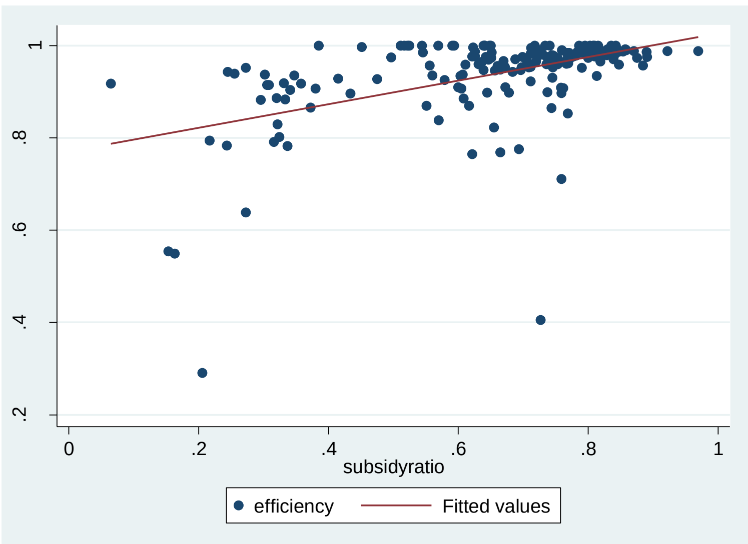


Figure 5: Relationship between the TE and Viewerperf

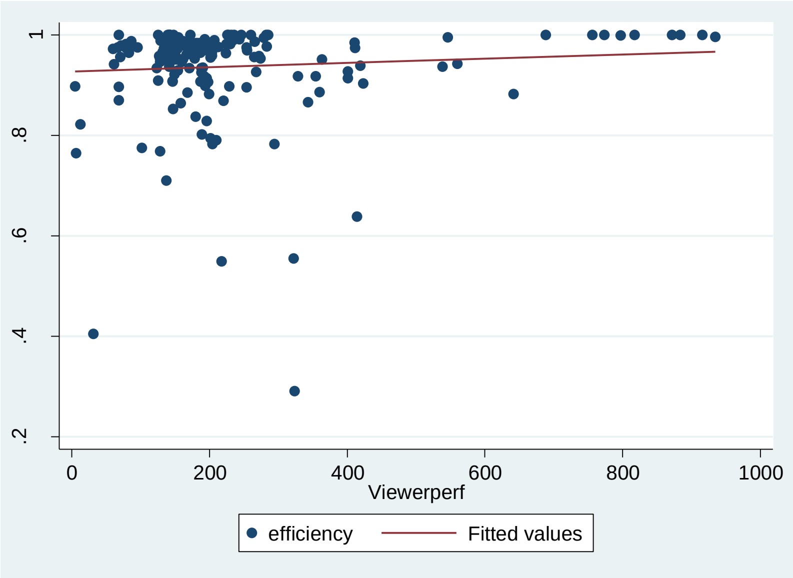
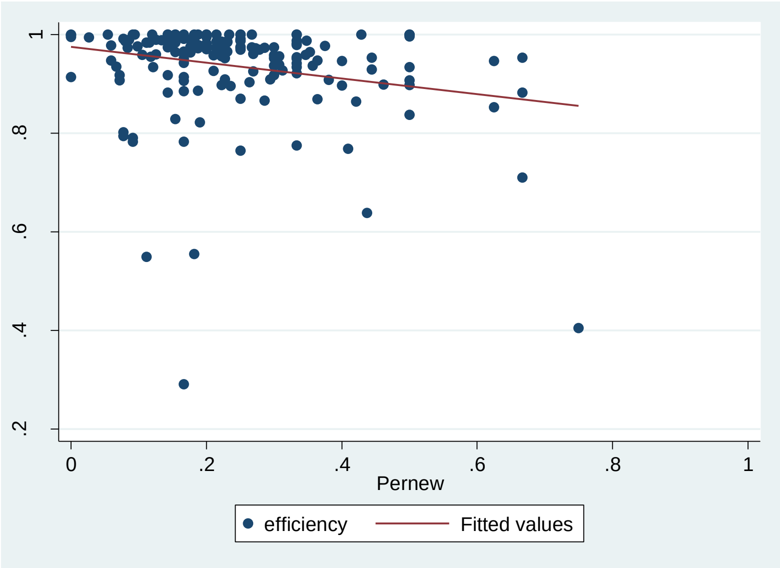


Figure 6: Relationship between the TE and Pernew



From the estimated input distance function, and as we have already explained in Equation (2), we have calculated the correspondent average technical efficiency indexes (TE) for each theatre during the period 2000-2012. Table 5 displays a summary of the results obtained.

Table 5
Technical Efficiency (TE) Indices

Theaters	Mean	Std. Dev.
Theater 1	0.9023	0.0812
Theater 2	0.9887	0.0144
Theater 3	0.9483	0.0269
Theater 4	0.9468	0.0274
Theater 5	0.8926	0.0919
Theater 6	0.7654	0.1896
Theater 7	0.9808	0.0133
Theater 8	0.9810	0.0370
Theater 9	0.9391	0.0413
Theater 10	0.9150	0.0668
Theater 11	0.7784	0.2509
Theater 12	0.9413	0.0761
Theater 13	0.9916	0.0180
Theater 14	0.9668	0.0267
Theater 15	0.9753	0.0059
Theater 16	0.9423	0.0527
Theater 17	0.9222	0.0728
Theater 18	0.9789	0.0095
Theater 19	0.9786	0.0135
Mean	0.9334	
Maximun	0.9887	
Minimum	0.7654	

On average, the value of the TE index is around 0.93, suggesting an input potential saving of 7%. The worst theatre shows a potential input reduction of about 24% and, for the best theatre, the correspondent percentage is about 1%.

b) Marginal costs estimates

Using Equation (3), we have calculated the marginal costs associated with our three outputs (*Repertory titles*, *Open nights* and *Performances*) following this equation:

$$MC_y = \frac{\partial C}{\partial y} = -\frac{\partial \ln D}{\partial \ln y}\frac{C}{y} \quad (7)$$

Table 6 summarizes our outcomes.

Table 6
Estimated marginal costs (PLN)

Variable	Mean
Repertory titles	45,928.1
Open nights	153,192.8
Performances	7,149.5

Number of observations: 180

On average, a new performance implies a marginal cost around 7,149 PLN. And to stage a new production implies 3.33 times more costs than to stage a repertory production. This outcome confirms the idea that new productions are more expensive since they imply more expenses on new scenography, new dresses, more rehearsals, etc.

In the Appendix, Table A1 displays marginal costs for each one of the theatres considered in our research. Briefly, there are two theaters that perform much higher costs than any other in the group. Theater 8 is the biggest musical theater in Warsaw and one of the biggest theaters in the country. It has very exceptional mode of production, however similar to some commercial theaters on Broadway or West End. It produces a huge new performance every two years and shows it continuously until the new production enters staging 8 times a week. So it has very high costs of new production, high costs of maintaining the title on the stage, but not as high costs per performance. Contrary, theater 10, described above has high, but comparable with some other theaters costs of new production, but very high marginal costs of a performance, while it employs stars, requires long performance preparation and need to rent a venue to give a performance.

7. CONCLUSIONS

Measuring technical efficiency is a relatively frequent task in performing arts in general and theatres in particular. This paper continues this line analyzing the case of nineteen municipal theatres in Warsaw, but introducing some novelties. On the one hand, we consider that theatres can be considered as multi-output firms, because they offer different products in terms of quantity and quality. Our estimates of the production technology, through the estimation of an input oriented distanced function, confirm this hypothesis.

On the other hand, and for the first time to the best of our knowledge, we calculate the marginal costs associated with an additional performance and an additional production. In the last case we distinguish between to stage a new production or a production that had been staged in previous seasons.

Public municipal theatres in Warsaw area set of nineteen "repertory" theatres that should follow public goals. For this reason, the cost minimization framework can be under question, and then we have proposed an input oriented distance function to estimate their production technology. The distance function approach is a procedure particularly suitable in the presence of multi-output production and when the cost minimisation scenario is questionable.

Using information coming from Department of Culture of the City of Warsaw, we have constructed an unbalanced panel data for the period 2000-2012. Since our interest is focused on measuring marginal costs, we have chosen our outputs coming from the supply side: number of performances, number of new titles and number of titles that have been staged previously.

First, we compute technical efficient indexes. The average technical efficiency index is 0.93 that means that municipal theatres in Warsaw could have used 7% less inputs to achieve the same level of outputs. Second, we have also analysed the determinants of inefficiency. Since the presence of public grants improves efficiency, we conclude that public grants move manager to be more efficient and, according to our selected outputs, to improve quality and diversity. Moreover, managers put more efforts when consumers are more interested in their products and need more resources to put a new title on the stage. Third, we have calculated that, on average, the marginal cost of a new performance is around 7,149 PLN. Finally, we confirm the common idea that introducing a new title costs significantly more than staging one already established in the repertoire, up to 3.33 times more in the case of municipal theaters in Warsaw.

APPENDIX

Table A1
Estimated marginal costs by theatre (PLN)

THEATRES	OBSERVATIONS	MARGINAL COSTS REPERTORY TITLES	MARGINAL COSTS OPEN NIGHTS	MARGINAL COSTS PERFORMANCES
Theater 1	10	93,892.6	125,123.9	6,692.4
Theater 2	13	16,075.1	67,649.4	2,440.9
Theater 3	4	69,814.5	135,551.2	17,938.3
Theater 4	4	21,393.6	109,111.0	3,044.3
Theater 5	13	57,671.9	149,840.6	6,257.4
Theater 6	13	36,327.6	304,868.7	4,316.9
Theater 7	13	21,785.9	120,988.7	3,110.2
Theater 8	13	329,046.3	738,395.0	1,9560.6
Theater 9	13	43,759.7	89,910.9	8,544.4
Theater 10	4	338,535.3	311,351.3	62,934.2
Theater 11	4	58,528.2	74,014.1	9,103.4
Theater 12	13	32,006.6	98,742.6	5,220.8
Theater 13	13	15,810.2	106,841.9	4,387.6
Theater 14	12	48,634.6	156,032.1	12,553.7
Theater 15	6	12,762.5	48,331.5	3,214.9
Theater 16	4	58,736.1	133,627.5	13,240.5
Theater 17	11	37,055.4	121,261.1	7,864.5
Theater 18	13	73,212.9	208,735.3	6,056.5
Theater 19	4	38,757.3	129,999.8	14,464.3

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