MEASURING TECHNICAL EFFICIENCY AND MARGINAL COSTS IN THE PERFORMING ARTS: THE CASE OF THE MUNICIPAL THEATRES OF WARSAW

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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. Firstly, we consider how the behaviour of a performing arts company can be analysed using multi-output production technology, given that these companies offer different products in terms of quantity and quality. Secondly, and to the best of our knowledge for the first time in the literature, we propose a procedure to measure the marginal costs associated with the production of performing arts firms. Moreover, this procedure can be applied to any other cultural sector successfully. To achieve our goals, we estimate a stochastic input distance function for a panel data set of nineteen public municipal theatres in Warsaw over 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, at the sample mean, these 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 extending innovation 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 one which stages one title already established in the repertoire. And, as already highlighted in other researches, we also confirm the presence of the cost disease and the positive effect of public subsidies on efficiency and quality in the performing arts.

Keywords: theatres, multi-output technology, marginal cost, duality theory, input distance function.

JEL Codes: D24, D70, L32, L82, Z11, Z18.

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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 over the period 2000-2012, at the same time offering an approximation for the measurement of the marginal cost associated with each theatre's production.

The analysis of technical efficiency has definitively gained a place in the field of Cultural Economics, in general, and performing arts in particular. This is due mainly to two factors. 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, the latter being essential for the sustainable future of the arts.

On the other hand, cultural firms' finances crucially depend upon public funding coming from either direct grants/subsidies or tax breaks favouring charitable contributors and donors. In both cases, citizens in general and donors in particular are interested in an appropriate use of those funds.[1] In our case this second reason is particularly relevant since the City Council of Warsaw has included improvements in cultural management as a specific goal within its cultural development program (Warsaw 2012). Hence, evaluating whether these public grants and tax benefits contribute or not to an efficient performance, may prove to be a key issue when assessing the outcomes of a public-based funding policy.[2]

To the best of our knowledge, previous parametric studies on efficiency in the performing arts consider companies as producing a unique output, independently if it is measured through visitors, performances, productions or any alternative measure. We maintain the view that, performing arts companies should in fact be considered as multi-output firms. Staging a new production or a repertory production released in previous seasons are two

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

[2]In this sense, but using a different methodology, Bertelli et al. (2013) have concluded that a well-managed public institution attracts more public grants.

distinct outputs. The type and quantity of resources employed and the optimal combination of inputs are different. Under these circumstances, any production technology estimates that consider new and old productions as the same output will prove biased. For these reasons, we propose using a multi-output approach. Furthermore, we estimate the marginal cost associated with any one of the outputs considered.

In order to analyse production technology for the public municipal theatres of Warsaw, we propose estimating an input distance function. 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 may be questionable. Our case study fits both these 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 consider theatres as multi-output firms. We believe that they offer not only a quantitative output (measured through variables such as the 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 discuss below. Taking into account this dual nature proves particularly interesting when trying to measure the impact on costs provoked not only by a new performance, but also by the incorporation of a new production into the theatre repertoire. This is especially so when we are aware of how the latter possibility changes the cost structure.

In sum, this paper tries to contribute to the literature on efficiency and productivity in performing arts firms and institutions in a number of different ways. For the first time, theatre production is incorporated into a multi-output scenario using a parametric approach. Furthermore, and to the best of our knowledge, this is the first time that marginal costs are computed in the case of performing arts. Lastly, our study provides new empirical evidence about technical efficiency in this field and, additionally, tries to characterize some of the determinants of this efficiency, paying special attention to the effect of public grants.

The paper is organized as follows. Section 2 briefly reviews efficiency and productivity literature in the performing arts. Section 3 describes the municipal theatres in Warsaw, these being the non-profit and public institutions subject of our efficiency analysis.

Section 4 describes the key theoretical features of the input-distance function approach and Section 5 outlines the empirical procedure. Section 6 discusses our main results and Section 7 concludes.

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

The analysis of production technology in the performing arts has come a long way since the pioneer work by Throsby (1977) who, for the first time, estimated short and long-run Cobb-Douglas production functions for non-profit performing arts firms in Australia. Gapinski (1980; 1984) go one step further. Using data for American performing arts and English theatres in the framework of a transcendental production function, he confirms decreasing marginal products for primary inputs (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 also been explored. Globerman and Book (1974) in Canada and Throsby (1977) in Australia are probably the first attempts at estimating 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 the 21st century has signified an important turning point in the analysis of the production technology for the performing arts. Since then, the efficiency and productivity analysis approach, inaugurated by Farrell (1957), has been incorporated with a view to estimating cost and production frontier functions in the cultural sector. As

[3]They estimate a fixed effects 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 revealed economies of scope.

Kumbhakar and Lovell (2000) point out, the estimation of production and/or cost frontiers provides more accurate information than average functions because when a difference exists between the potential and the observed output 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 scarcer. Studies include Marco-Serrano (2006) and Rausell et al. (2013) who measure technical efficiency in Spanish regional theatres and musical society networks, respectively.[6]

The estimation of parametric stochastic frontiers has been used more frequently in the field of the 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 positioned on the frontier either because of 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. (2017) 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 making theatres, concludes that "individual efficiency estimates are very sensitive to the econometric specification of the unobserved heterogeneity of theatres" (p. 274) and exogenous factors such as public subsidies, the number of theatres and regional differences can impact crucially on technical efficiency. Zieba and Newman (2013) state

[5] Although we have focused on the performing arts, the analysis of efficiency and productivity analysis has reached other fields of cultural economics.
[6] The DEA technique is more frequent in other fields of cultural economics such as 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. 2018), cultural heritage (Guccio et al. 2014a) or archives (Guccio et al. 2014b).
[7] Bishop and Brand (2003) inaugurated this approach measuring the efficiency of English museums through a Cobb-Douglas production function.
[8] A DEA procedure does not impose a specific functional form but, at the same time, it does not allow us to distinguish between inefficiency and random shocks within the error term.

that public theatres are more efficient than private theatres although the latter react better to market forces improving their efficiency whilst competition induces a decline in efficiency among the former. Castiglione et al. (2017), observe low technical efficiency indices in Italian performing arts firms and, at the same time, reveal that efficiency depends positively on a firm's quality and reputation and the quality of life of Italian provinces. Last and Wetzel (2010) reject a cost minimization environment in the case of public German theatres and reinforce how it is more convenient to consider unobserved heterogeneity in order 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 the German public theatres sector suffers from Baumol's cost disease although it could be alleviated by exploiting economies of scale.[9]

3. MUNICIPAL PUBLIC THEATRES IN WARSAW

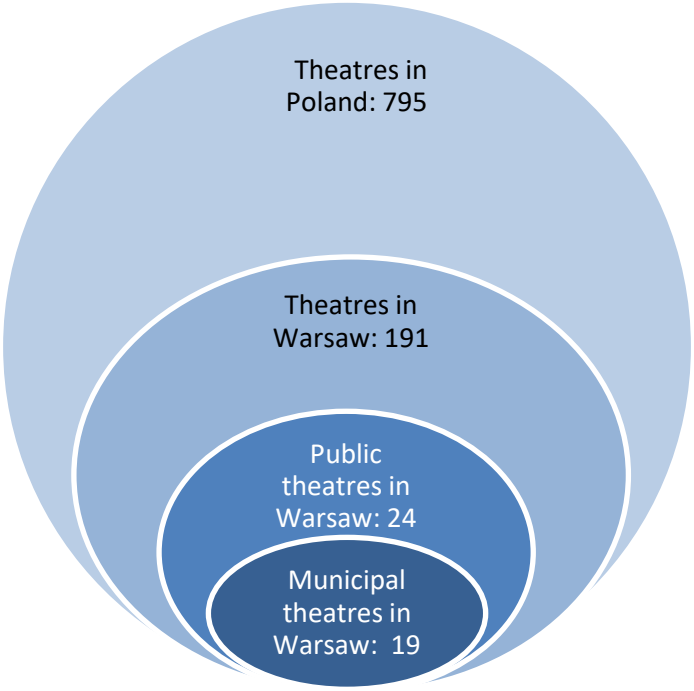
According to the Theatre Institute (TI) database, there are nearly 800 theatres in Poland, including public, private and non-governmental organizations. Of these, 120 are public theatres, run by central, regional or local administrations. They are hosts of about 75% of the country's performances and accommodate more than 90% of theatre-goers. In Warsaw itself, there are 191 theatres: 24 of which are public, performing regularly under stable conditions in own venues and often specializing in particular forms of repertoire. Within this group, there are 19 municipal theatres which constitute 2% of Polish theatre institutions and 10% of Warsaw theatres. This means that they face fierce competition (See Fig. 1).

Warsaw municipal theatres form a very diverse group of non-profit institutions that can be divided into four categories based on the repertoire in which they specialize (Wiśniewska and Czajkowski 2017). There are 6 entertainment theatres, including one of the biggest musical theatres in the country; 7 drama theatres playing only dramas and more ambitious comedies, often based on classical works, easily accessible to wider

[9]It is noticeable that all of these studies focus on technical efficiency. Taalas (1997), using a generalized cost function, and Fernandez-Blanco and Rodríguez-Álvarez (2018) estimate an input distance function, incorporating a measurement of allocative inefficiency for cultural economics.

audiences; 3 children's theatres serving younger audiences, offering puppet performances and fairy tales in relatively small venues; and 3 experimental theatres employing new techniques, frequently producing contemporary plays. These are located mostly in the city centre or in nearby districts with three of them situated on the right bank of the Vistula River, in less developed areas.

Fig.1
Theatres in Poland.



Beyond their specialization, they share similar organizational features. They are 'repertory' theatres: the performances of productions listed in the repertoire are spread over the theatre season; a title is staged 3-7 days on a set after which a break is required in order to change the set design for another play; the rehearsals for new productions take place continuously during the staging period and not during a seasonal break.[10]

They operate with one, two or three stages and differ greatly in terms of their capacity: the biggest stage contains nearly 1000 seats, while the smallest theatre has only one stage accommodating up to 100 theatre-goers only. For the period 2000-2012, on average, they gave 3 premiers, offered 15 different titles and more than 200 performances each year.

[10]The Polish theatre season lasts 12 months (from September to August) with 9-10 months of staging.

Annually, they attracted audiences of more than 860,000 persons, representing about 15% of the Polish theatre market, with an average attendance rate of 83%. Their budgets are distributed as follows: 66.5% come 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 one theatre to another not being regulated by the local government. On average, they are twice as expensive as cinema tickets. Yearly admission fees are very rare options in most Polish theatres (with the exception of operas), so ticket revenues are highly dependent on artistic success. In most cases, public subsidies are (nearly) enough to cover the fixed costs of the theatres. Since a stable artistic team is a fundamental characteristic of Polish public theatres, most artistic employees have permanent contracts, their salaries representing a relevant share of those fixed costs.

As public institutions, Warsaw municipal theatres should follow public goals. In its longer term programme of cultural development for Warsaw, the Municipality has defined two aims which contemplate aspects of efficiency for the cultural sector: to increase the quality and efficiency of cultural management and also make a better use of public space for cultural activities (Warsaw 2012), although this does not necessary imply an equal access policy (O'Hagan 2016).[12] Our analytical research of the technical efficiency of municipal theatres is closely connected with these objectives.

4. THE INPUT DISTANCE FUNCTION: A THEORETICAL APPROACH

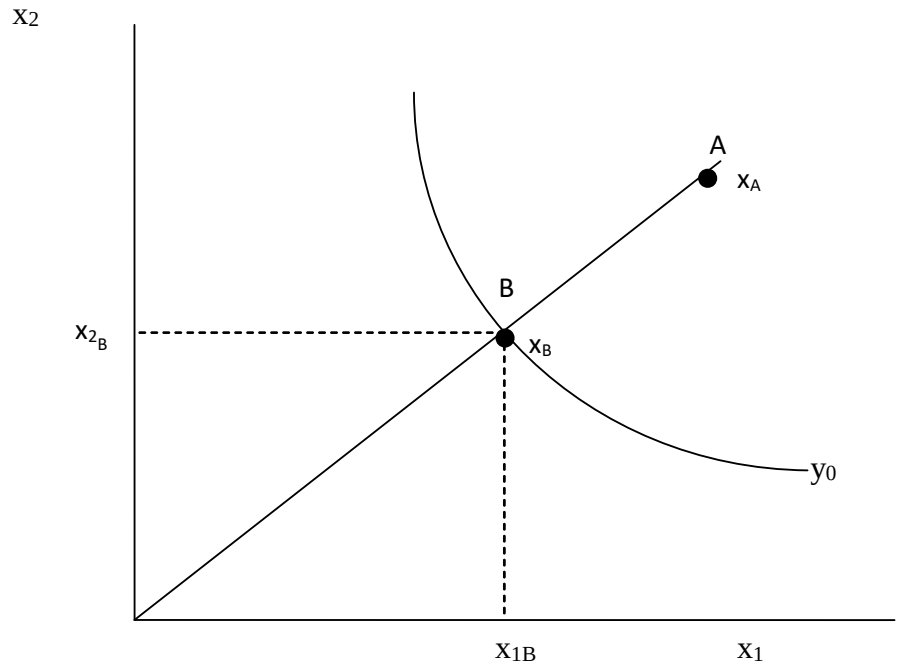
Independently of the methodological procedure we have selected, measuring efficiency implies constructing an optimal frontier function and calculating how distant our institution (theatre, in our case) is from it. We estimate a stochastic frontier function using a parametric approach that includes a composed error term, which allows us to disentangle whether a firm is not positioned on the frontier either due to inefficiency or the presence of uncontrollable random shocks, as already discussed above. Specifically,

[11]This percentage ranges from 80% to only 30% in the case of entertainment theatres.
[12]It is also noticeable that, during the financial crisis, local politicians reduced public subsidies to municipal theatres in Warsaw. Between 2010 and 2012, their budget suffered an almost 25% cut in absolute terms, although their weight in terms of the municipality's cultural expenditures grew from 16% to 22% in this period. This situation adds more interest to our analysis of the efficiency of these theatres.

we have decided to estimate an input distance function, which is the dual of the cost function.

In order to explain the input distance function, we initially assume the existence of two inputs (x_1 and x_2) as presented in Fig. 2 where y_0 is the isoquant *frontier* that, in our case, defines the potential or maximum amount of performances that can be provided by the theatre given technology and a set of input vectors (x).[13]

Fig. 2
The Shephard's input distance function



Formally, we define the input distance function (D_I) as a function of the input (x) and output (y) vectors:

$$D_I(y,x) = \max_{\delta}\{\delta=(1/\lambda)>0: y(\lambda x)\geq y_0\} \qquad 0 < \lambda \leq 1 \qquad (1)$$

where $D_I(y,x)$ is the input distance function. In Equation (1), $D_I = \delta = (1/\lambda)$ and represents the maximum reduction in inputs that allows the production of an output y_0. Graphically, D_I measures the distance of the theatre i to the isoquant, that is, the radial decrease in all the inputs which, given technology, still permits producing a quantity of output (y_0).Thus, the input distance function measures the distance to the isoquant. On point B, $D_I(x,y)$

[13]Without loss of generality, we initially assume that the theatre produces only one output.

takes the value of one when the theatre is on the isoquant curve frontier (Fig. 2). In contrast, on A, the distance function takes a value greater than one. This implies that if a theatre is on point A and it produces the output level $y_{0,}$ it is producing a lower level of output than could have been achieved with its available amount of inputs. This implies that the theatre is technically inefficient.

Formally, from (1) we can measure the distance to a point (e.g. point A in Fig.1) from the isoquant curve frontier as follows:

$$\frac{1}{\lambda} = D_I \rightarrow \quad \frac{1}{\lambda} = D_I(x, y), \qquad 0 < \lambda \leq 1 \tag{2}$$

Imposing homogeneity of degree one in x (e.g., x_1) in (2) we obtain:

$$\frac{1}{\lambda x_1} = D_I\left(\frac{x}{x_1}, y\right) \tag{3}$$

Taking natural logarithms and rearranging (3) we obtain:

$$\ln\left(\frac{1}{\lambda x_1}\right) = lnD_I\left(\frac{x}{x_1}, y\right) \tag{4}$$

$$-\ln x_1 = lnD_I\left(\frac{x}{x_1}, y\right) + ln\,\lambda \tag{5}$$

Specifying:

$$u = -ln\,\lambda \tag{6}$$

we have:

$$-\ln x_1 = lnD_I\left(\frac{x}{x_1}, y\right) - u \tag{7}$$

From (6) we know that:

$$exp(-u) = exp(ln\lambda) = \lambda \tag{8}$$

Finally, we define the Technical Efficiency index (TE) as:

$$\text{TE}=exp(-u) = \lambda \tag{9}$$

i.e. TE indicates the difference between the observed and the optimum (located on the frontier) output levels. The TE can take values between 0 and 1, given that *u* is non-negative.

Moreover, the input distance function $D_I(y,x)$ must set the properties of non-decreasing in inputs and non-increasing in outputs (for details, see Färe and Primont 1995).

One of our aims is to measure marginal costs and we 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:

$$\frac{\partial C(W,y)}{\partial y} = -\frac{\partial D_I(x,y)}{\partial y} \quad (10)$$

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

5. EMPIRICAL PROCEDURE

5.1. The model

From equation (7), the stochastic input distance function can be expressed as follows:

$$-\ln x_1 = lnD\left(\frac{x}{x_1}, y\right) - u + v \quad (11)$$

where again y and x are the output and input vectors, respectively. In equation (11) 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 distributions for v and u have been defined. In this sense, we assume $u \sim N^+(0, \sigma_u^2)$, while *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 variance of the error component u in (11) is modelled as a linear function of a set of covariates *z* as follows:

$$\sigma_u^2 = g(z, \delta) \qquad (12)$$

with δ being the set of parameters to be estimated. In (12), 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).

5.2. The data and variables

Our data set comprises unbalanced panel data for the period 2000-2012. It includes information for nineteen Warsaw municipal theatres sourced from the Department of Culture of the City of Warsaw[14]. All these theatres are public institutions where the cost minimization framework may be questionable. Our data set comes from annual reports that a public authority requires from the theatres on a yearly basis. These standardized reports contain artistic, organisational and financial information originating from box office, accountancy and other inner documents. The data are publicly available only under request.

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

The number of performances and the number of separate productions may be used as output measures for the supply side. The number of separate productions captures the idea that it is not the same to offer fifty performances of only one production as ten performances each of five productions because, in the latter case, the company "is, in some sense, producing more artistic experience" (Heilbrun and Gray 2001, p. 108). This goal is especially applicable to non-profit making theatres that care for repertoire choice (O'Hagan and Neligan 2005). Krebs and Pommerehne (1995), analysing multi-agent decision-making in public performing arts institutions, assign artistic quality maximizing

[14] In 2013 the number of municipal theatres declined, because two of them were merged into one organization.

goals to theatre managers frequently acting as directors at the same time. This is also the case of many municipal theatres in 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 the present study, we are interested in evaluating costs.[15]

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

Works	*Output*				
	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 (2017)				X	

Here we go a step ahead. The number of performances and number of productions can be considered not only as two output measures, but also as two different outputs. We believe that a company produces a quantitative output (performances) and also a qualitative output (productions).[16] Finally, taking into account that the local public theatres in Warsaw are "repertory" theatres, meaning that they continue playing the titles produced in previous years producing new ones at the same time, we can distinguish between new

[15] 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 theatre-goer which, except in the case of congestion, will be close to zero.

[16] As Werck and Heyndels (2007, p.27) have pointed out, "quality is a multidimensional concept" and it has been considered in some different subjective or objective ways, such as reviews or word of mouth (Urrutiaguer 2002, Grisolia and Willis 2011) or expenses relating to different elements of a performance (Zieba 2009, Zieba 2011, O'Hagan and Zieba 2010). In this paper we focus upon novelty and innovation as quality indicators.

productions and repertory productions each year because they have different effects on costs. The former type of titles suggests novelty, innovation and theatrical risk and probably, involves higher and different costs compared to the second type. Hence, each of these types can be considered as a different output. In sum, our output variables are *Performances* (total performances provided by the theatre in own venues), *Open nights* (number of new titles staged 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, i.e. the number of people who worked in a theatre during a given year, irrespective of 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 referring 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 *Atendeeperf*, the number of theatre-goers or viewers per performances, is included in order to control for the response of demand to input requirements.[18] We have also included the variable *Subsidy*, defined as the ratio subsidies/total cost that incorporates the presence of public grants and its relative weight in the total cost of the theatre. Finally, we have added a set of eighteen dummy variables to control for the theatres' fixed effects.

As regards equation (12), we have a special interest in ascertaining how the distance to the potential frontier for each theatre is affected by: the theatre-goers' response to the performances offered (*Atendeeperf*); its activity hosting other companies' performances (*Host*) or being a guest at other companies' venues (*Guest*); the presence of public grants (*Subsidy*); the percentage of new titles over the total titles that the theatre stages per season (*Pernew*),[19] and the time (*Time*) and size (*Size*) effect. In this sense, we model the *z* vector

[17] We have not distinguished between temporary and permanent personnel or different professional categories. In a previous estimation, we tested the inclusion of these variables separately, but it did not prove statistically significant and did nothing to improve our results.

[18] Werck and Heyndels (2007) have pointed out how different variables controlled by the managers affect demand in the case of Flemish theatres.

[19] We include this variable to avoid considering as inefficiency something that is really innovation, assuming that a new production implies more resources.

in (12) as a function of these variables. Variable definitions and a descriptive analysis of the data are reported in Table 2.

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
Atendeeperf	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
Variable	**Definition**	**%**	
Host	=1 If there are guest performances of other theatres in own venue	26.11	
	=0 Otherwise	73.89	
Guest	=1 If there are own performances as a guest at other venues	86.67	
	=0 Otherwise	13.33	

Number of observations: 180

5. EMPIRICAL RESULTS

Assuming a translog function functional form for the input distance function defined in (11) we have:

$$
\begin{aligned}
-\ln x_{1it} = {} & \alpha_0 + \sum_{r=1}^{K} \alpha_r \, Ln\, y_{rit} + 0.5 \sum_{r=1}^{K}\sum_{s=1}^{K} \alpha_{rs} \, Ln\, y_{rit} Ln\, y_{sit} + \sum_{m=2}^{M} \beta_m \, Ln\left(\frac{x_{mit}}{x_{1it}}\right) + \\
& + 0.5 \sum_{m=1}^{M}\sum_{n=1}^{M} \beta_{mnt} \, Ln\left(\frac{x_{mit}}{x_{1it}}\right) Ln\left(\frac{x_{nit}}{x_{1it}}\right) + \sum_{r=1}^{K}\sum_{m=1}^{M} \gamma_{rm} \, Ln\, y_{rit} Ln\left(\frac{x_{mit}}{x_{1it}}\right) + \rho_t \, Time + 0.5\, \rho_{tt} \, Time^2 + \\
& + \sum_{r=1}^{K} \rho_m \, Time \, Ln\, y_{rit} + \sum_{m=1}^{M} \rho_k \, Time \, Ln\left(\frac{x_{mit}}{x_{1it}}\right) + \sum_{i=1}^{18} \alpha_i \, D_i + \alpha_h \, D_{host} + \alpha_g \, D_{guest} + \\
& \beta_v Atendeeperf_{it} + \beta_s Subsidy_{it} - u_{it} + v_{it}
\end{aligned}
\tag{13}
$$

where again *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. In Equation (13) both inputs and subsidies may prove endogenous as they could be influenced by several theatres' unobserved characteristics, for example managerial ability, among others. Although this problem is partially tackled with a panel data model that captures the unobservable heterogeneity that does not vary over time, there may be non-observable factors which are not captured in these fixed effects. However, inputs and *Subsidy* appear in Equation (13) in ratio form (note also that the *Subsidy* is also defined as a ratio), and that their presence in a distance function depends on the same random shock (i.e. v). Thus, the ratio of quantities of these variables becomes an exogenous variable and we can obtain consistent estimates, despite recognizing the endogeneity of these variables (for details see Coelli, 2000 or Kumbhakar, 2011).

Jointly with equation (12), expression (13) is the function to be estimated.

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. Thus, the estimated input distance function, at the sample mean, fulfils the regularity conditions: that is, it is non-decreasing in inputs and decreasing in outputs.

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	**Theatre 2**	1.0122***	12.5700	0.0000
Ln(T)	-0.0842*	-1.8700	0.0620	**Theatre 3**	-0.6256***	-5.3600	0.0000
Ln(O)	-0.0774**	-2.1900	0.0290	**Theatre 4**	0.8784***	8.4900	0.0000
Ln(P)	-0.2524***	-3.1200	0.0020	**Theatre 5**	0.0307	0.2100	0.8330
Ln(L)Ln(L)	0.4806***	7.8500	0.0000	**Theatre 6**	0.8891***	5.9000	0.0000
Ln(K)Ln(K)	0.4806***	7.8500	0.0000	**Theatre 7**	0.5976***	7.5400	0.0000
Ln(L)Ln(K)	-0.4806***	-7.8500	-0.0000	**Theatre 8**	-0.9215***	-4.2900	0.0000
Ln(L)Ln(T)	-0.0550	-0.9500	0.3440	**Theatre 9**	-0.1549	-1.5800	0.1140
Ln(L)Ln(O)	-0.1556***	-3.8900	0.0000	**Theatre 10**	-0.2582	-1.2100	0.2270
Ln(L)Ln(P)	0.0096	0.1600	0.8700	**Theatre 11**	0.7999***	3.8500	0.0000
Ln(K)Ln(T)	0.0550	0.9500	0.3440	**Theatre 12**	0.0214	0.2500	0.8020
Ln(K)Ln(O)	0.1556***	3.8900	0.0000	**Theatre 13**	0.0609	0.6100	0.5410
Ln(K)Ln(P)	-0.0096	-0.1600	0.8700	**Theatre 14**	-0.4255***	-4.6500	0.0000
Ln(T)Ln(T)	0.0242	0.3500	0.7280	**Theatre 15**	0.8273***	6.7700	0.0000
Ln(O)Ln(O)	-0.0024	-0.2900	0.7710	**Theatre 16**	-0.3914**	-3.3100	0.0010
Ln(P)Ln(P)	-0.4977***	-4.2000	0.0000	**Theatre 17**	-0.0380	-0.3700	0.7110
Ln(T)Ln(O)	0.0307**	2.5800	0.0100	**Theatre 18**	0.0070	0.0900	0.9280
Ln(T)Ln(P)	0.0584	1.2600	0.2070	**Theatre 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	**Atendeeperf**	-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. ***, **, * denote significance at the 1, 5 and 10% levels of statistical significance, respectively.

The positive and significant sign of the coefficient of the variable *Host* implies that, ceteris paribus, hosting other companies reduces input requirements, although performing as guest in other venues (*Guest*) does not prove statistically significant. The negative and significant coefficient of *Atendeeperf* means that the frontier moves to the right, that is to say, the greater the attractiveness for the audience, the more the inputs required. The time

trend has a negative sign that suggests that time has negative impact on productivity. 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 encountered by theatres in taking advantage of technological improvements compared to other productive sectors, as pointed out by Baumol and Bowen (1966).

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) signifying 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 not only ensure the autonomy of individual artists (Hetherington 2017) and affect repertoire conventionality (Neligan 2006), but also result in managers being more efficient and, according to our selected outputs, thereby improves novelty and diversity. The coefficient of *Atendeeperf* is also negative and significant, and this signifies that managers make more of an effort when consumers are more interested in their performances.[20] Finally, the positive and significant sign of the coefficient of *Pernew* reveals 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 stage a new title. The variable *Size* is not statistically significant and we therefore conclude that no significant relationship exists between inefficiency and the differences in scale between theatres.

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

Variable	Coef.	z	P>|z|
Size	0.5620	0.7700	0.4390
Atendeeperf	-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

[20] Although the input distance function estimated indicates that audience success implies more resources, they are managed more efficiently (that is to say, companies are closer to its potential frontier).

Moreover, Figs. 3, 4 and 5 show the relationship between TE and *Subsidies; Atendeeperf and Pernew*. The results confirm those obtained in Table 4: subsidies and the number of viewers per performance increase technical efficiency. In contrast, the number of new titles over total titles increases the distance to the technological frontier, decreasing technical efficiency.

Fig. 3
Technical Efficiency (TE) Indices and Subsidy

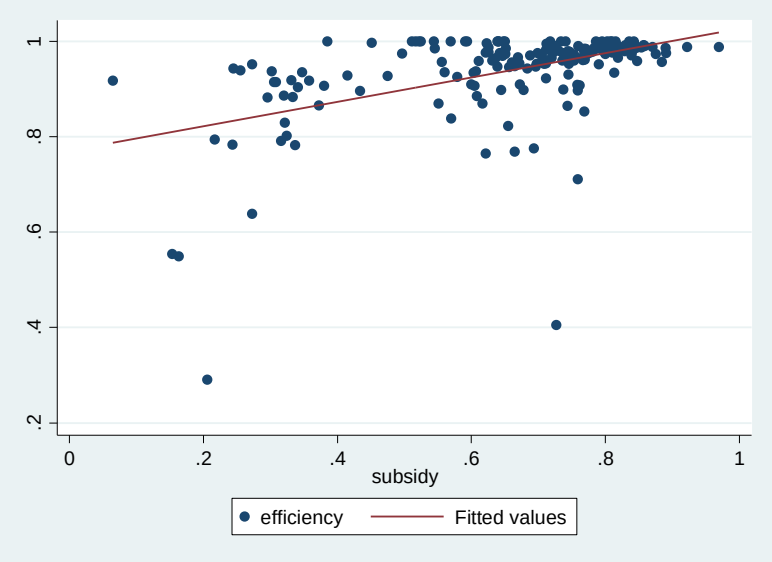


Fig. 4
Relationship between the TE and Atendeeperf

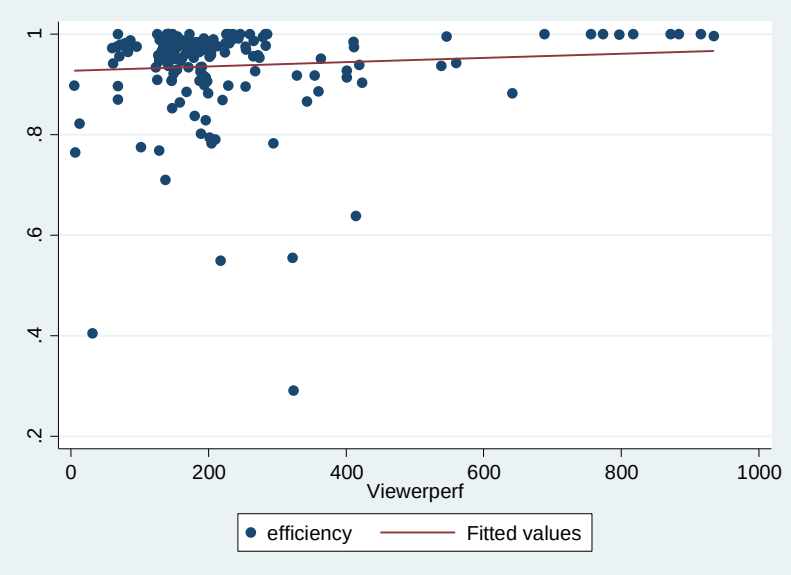


Fig. 5
Relationship between the TE and Pernew

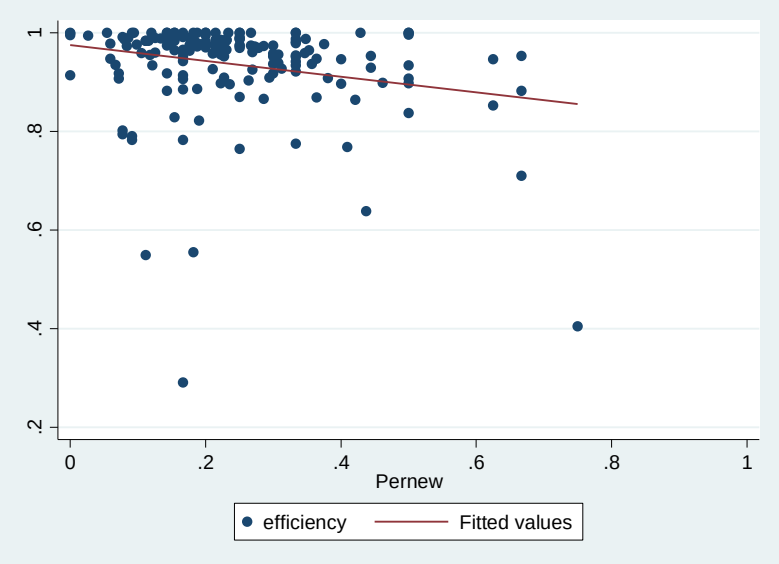


Table 5
Technical Efficiency (TE) Indices

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

From the estimated input distance function, and as already explained in Equation (9), we have calculated the correspondent average technical efficiency indices (TE) for each theatre during the period 2000-2012. Table 5 displays a summary of the results obtained.

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 corresponding percentage is about 1%.

b) Marginal costs estimates

Using Equation (10), we have calculated the marginal costs, evaluated at the frontier, associated with our three outputs (*Repertory titles*, *Open nights* and *Performances*) following this equation:

$$MC_y = \frac{\partial C(w,y)}{\partial y} = -\frac{\partial \ln D}{\partial \ln y}\frac{C}{y} \qquad (14)$$

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 of around 7,149 PLN.[21] Staging a new production implies 3.33 times more costs compared to staging a repertory production. This outcome confirms the idea that new productions are more expensive since they imply more expenses on new scenography, new costumes, more rehearsals, etc.

[21]This means 1,865.89€ or 2,457.37$, using the rate of exchange corresponding to the median year of our sample.

In the Appendix, Table A1 displays marginal costs for each one of the theatres considered in our research. Combining this information with that displayed previously on Table 5, we obtain several conclusions for some of the theatres. Firstly, theatres 2, 4 and 7 are children theatres and share some relatively common characteristics: their efficiency indices are above average and they present low marginal costs, particularly in terms of repertoire titles and performances.

Secondly, there are two theatres that present much higher costs than others in the group. Theatre 8 is the biggest musical theatre in Warsaw and one of the largest in the country. It has very exceptional production modes, similar to some commercial theatres on Broadway or the West End. It produces a huge new performance every two years and shows it continuously until the new production enters into a staging pattern of 8 times a week. Therefore, it has very high new production costs, high costs relating to maintaining the staging of a title, that is, high sunken and fixed costs, but not so high individual performance costs. Theatre 8 is run commercially with a significant part of its operating revenues coming from box office sales. Therefore, it needs to care about efficiency as confirmed by its high TE index. Meanwhile, theatre 10 bears very high marginal costs per performance, because it employs stars, requires a long performance preparation time and needs to rent a venue to stage the performance. By requiring substantial expenditure in order to stage a title, it very rarely performs in Warsaw, having a lot of guest performances abroad, often during famous festivals that coproduce their productions. The aim of this theatre is strictly artistic and this characteristic may contribute to explaining its low TE index.

Thirdly, theatres 6 and 11 are also two interesting cases because they present the lowest technical efficiency indices. The former is an entertainment theatre with one of the lowest subsidy rates in its budget and, during the observed period, it changed its venue. The latter is especially focused on educational and social goals rather than artistic and economic ones, and its marginal costs are below the average.

6. CONCLUSIONS

Measuring technical efficiency is a relatively frequent task for performing arts in general and theatres in particular. This paper analyses technical efficiency for nineteen municipal

theatres in Warsaw, but introducing some novelties. On the one hand, we consider theatres as multi-output firms, because they offer different products in terms of quantity and quality. Our estimates of production technology, via the estimation of an input oriented distanced function, confirm this hypothesis.

On the other hand, and to the best of our knowledge for the first time, we calculate the marginal costs associated with an additional performance and an additional production. In the latter case, we distinguish between staging either a new production or one that has already been staged in previous seasons. Obviously, this procedure of measuring marginal costs is applicable not only to the performing arts, but also to any other cultural sector.

Public municipal theatres in Warsaw form a set of nineteen "repertory" theatres that should in practice, follow public goals. For this reason, the cost minimization framework is questionable and thus we propose 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 questionable cost minimisation scenarios.

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

Firstly, we compute technical efficient indices. 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. Secondly, we have also analysed the determinants of inefficiency. Since the presence of public grants improves efficiency, we conclude that public grants move managers to be more efficient and, depending on the selected outputs, this leads to improvements in quality and diversity. Moreover, managers make more of an effort when consumers are more interested in their products and when they require more resources to stage a new title. Thirdly, and as already observed in previous studies, we conclude that, given we have found a negative and significant time trend we can conclude that, on average, the municipal theatres of Warsaw are affected by Baumol's

cost disease. Fourthly, we have calculated that, on average, the marginal cost of a new performance is circa 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 theatres in Warsaw.

These results serve to formulate policy implications for the City of Warsaw. Firstly, when judging theatre performance, these should be considered as multi-output firms, requiring evaluation form a three dimensional standpoint: total number of performances (availability of their services for citizens), number of new productions (which reveal the production of novelty) and number of productions from previous years in repertory (as an indication of diversity). Having as much as nearly twenty theatres under governance, the municipality might make recommendations to the theatre managers as regards the marginal costs of extending performances in terms of these three dimensions. It is potentially possible to encourage innovation especially in those theatres that are able to introduce new titles with lower costs.

There appears to be no room for increasing the efficiency of municipal theatres in Warsaw. Managers make more of an effort when consumers appear more interested in their products – i.e. when there are more viewers per performance. This means that the municipality needs to reward those theatres with higher attendance rates (given theatre capacity), especially when this occurs for performances on big stages in multi-stage theatres. Managers need more resources to stage a new title. Novelty is one of the main aims for the theatres, but it should not signify forgetting about efficiency targets. Since managers' contracts include a minimum number of new productions for each season, rewarding theatres for surpassing this minimum is unnecessary at least as long as additional production is risky in terms of attendance. However, changing the preferences of theatre audience should be taken into account. The desire for innovation is growing (and can be treated as more of a general societal shift not isolated to Poland; it may underlie the rise of the so-called joyful economy, as Hutter (2015) point out). Theatres change the repertoire more frequently than in the past and probably in the future this process will deepen in order to address the demands of new audiences. The most efficient theatres are those closer to the traditional model of repertoire theatre, working 6 days a week, with 2-month seasonal breaks in summer, and giving around 250 performances per season.

We conclude that public grants move managers to be more efficient and, based on our selected outputs, also contribute to further improving novelty and diversity. The decisions of the municipality moved in the opposite direction during the recent financial crisis, by precisely cutting public grants. However, theatres did not reduce the number of opening nights, titles in repertoire and performances. It seems that theatres considered the decrease in subsidies as a temporal problem and did not modify their goals. Finally, in recent years (2013-2016), the support started growing again, in 2016 achieving almost the level of 2010 and this new tendency should lead to improvements in the theatres' efficiency.

APPENDIX

Table A1
Estimated marginal costs by theatre (PLN)

THEATRES	OBSERVATIONS	MARGINAL COSTS REPERTORY TITLES	MARGINAL COSTS OPEN NIGHTS	MARGINAL COSTS PERFORMANCES
Theatre 1	10	93,892.6	125,123.9	6,692.4
Theatre 2	13	16,075.1	67,649.4	2,440.9
Theatre 3	4	69,814.5	135,551.2	17,938.3
Theatre 4	4	21,393.6	109,111.0	3,044.3
Theatre 5	13	57,671.9	149,840.6	6,257.4
Theatre 6	13	36,327.6	304,868.7	4,316.9
Theatre 7	13	21,785.9	120,988.7	3,110.2
Theatre8	13	329,046.3	738,395.0	1,956.6
Theatre 9	13	43,759.7	89,910.9	8,544.4
Theatre 10	4	338,535.3	311,351.3	62,934.2
Theatre 11	4	58,528.2	74,014.1	9,103.4
Theatre 12	13	32,006.6	98,742.6	5,220.8
Theatre 13	13	15,810.2	106,841.9	4,387.6
Theatre 14	12	48,634.6	156,032.1	12,553.7
Theatre 15	6	12,762.5	48,331.5	3,214.9
Theatre 16	4	58,736.1	133,627.5	13,240.5
Theatre 17	11	37,055.4	121,261.1	7,864.5
Theatre 18	13	73,212.9	208,735.3	6,056.5
Theatre 19	4	38,757.3	129,999.8	14,464.3

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