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Baumol's Cost-Disease, Efficiency, and Productivity in the Performing Arts: An Analysis of German Public Theaters

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This paper analyzes the productivity development in the German public theater sector for the seasons 1991/1992-2005/2006. Using a stochastic distance frontier approach that allows to decompose total factor productivity change into different sources we examine (a) whether Baumol's cost-disease hypothesis is valid in this sector and (b) if so, whether its negative influence on productivity can be compensated by efficiency gains. The findings indicate an increase in real unit labor cost as a result of rising wage rates and, thus, support the cost- disease hypothesis. Furthermore, increasing returns to scale are observed for the majority of the theaters which implies that significant efficiency gains can be realized by the exploitation of scale economies. However, because of the increasing unit labor cost and an increasing scale inefficiency we find an overall decrease in average productivity of about 8 percent within the sample period.

Keywords: Public theaters, cost-disease, efficiency, stochastic frontier analysis

JEL-Classification: D24, O12, Z10

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1 Introduction

In 1965, Baumol and Bowen proposed a concept which today is called “Baumol’s cost-disease” or ”Baumol’s law” (Frey, 1996). The concept states that, in sectors with limited or non-existent technological progress, such as the cultural sector, wage increases based on productivity gains in other sectors of the economy lead to an increase in unit labor cost and, therefore, to a decrease in productivity.

In particular, the performing arts, as a highly labor-intensive field of cultural activity, seem prone to this cost-disease effect. This, in combination with the sector’s high level of dependence on public funding and the increasing cost-pressure on public cultural expenditures in times of severe budgetary problems, leads to increasing difficulties by performing arts institutions in covering their financial needs. Thus, managers of these institutions have to seek alternative ways to improve their economic performance. Given the labor-intensive production process and the lack of significant technological progress that would reduce this labor-intensity, they need to employ their resources more efficiently. From an input-oriented view, gains in technical efficiency can be realized by lowering the use of inputs to the absolute minimum level necessary for a given output level. In addition, altering the scale of operations to an optimal level will result in gains in scale efficiency. Both lead to an increase in productivity, which could countervail a negative productivity development caused by the cost-disease effect.

So far, only a few studies have addressed the relationship between the cost-disease effect and efficiency gains in the performing arts. Felton (1994) conducted a study on 25 American orchestras for the period 1971/72-1991/92. By comparing the productivity, the compensation per worker and the unit labor cost of orchestras with the manufacturing sector, Felton found that the orchestras in her data set were affected by the cost-disease effect. However, her results also showed that productivity increases are possible by increasing the number of performances, that is, by increasing scale efficiency via the exploitation of scale economies.

In a study on theaters, Marco-Serrano (2006) pointed out that “where lack of productivity growth had been substituted by increasing amounts of public funding an alternative had to be found.” Focusing on possible efficiency gains as an answer to the cost-disease effect, Marco-Serrano analyzed an unbalanced panel of Spanish theaters organized in a network in the Valencia region during 1995-1999. By utilizing the data envelopment analysis, he showed a decrease in the efficiency scores over the analyzed period, during which the network expanded steadily because of the incorporation of new theaters. Furthermore, by decomposing the results into technical efficiency change and scale efficiency change, he found that the decrease in overall efficiency referred mainly to a decrease in technical efficiency, while scale efficiency remained stable.

Overall, previous studies have suggested that the performing arts are subject to the cost-disease effect. However, the relevance of technical and scale efficiency gains as a counterpart to the resulting productivity decrease remains ambiguous. We use a data set of 174 German public theaters observed over 15 seasons from 1991/92 to 2005/06 to assess (a) whether the cost-disease effect is present in this sector and (b) if so, whether its negative influence on productivity can be compensated for by technical or scale efficiency gains. The methodology applied is a stochastic distance frontier approach that can decompose total factor productivity change into technological change, technical efficiency change and scale efficiency change. The aim is to provide insights into the production process of theaters and detailed information on the constraints and drivers of productivity in that sector.

The remainder of the paper is organized as follows. Section 2 presents the theoretical foundations of the cost-disease effect in the performing arts and the decomposition of the total factor productivity change. Section 3 discusses the estimation methodology and is followed by a description of the data set in Section 4. Estimation results of the empirical analysis are presented in Section 5. Section 6 summarizes and presents conclusions.

2 Theoretical background

Although the cost-disease concept has been criticized, and certain cultural fields have been excluded from its scope[1], the (live) performing arts seem prone to its effect. On the one hand, there has been only a small (or even no) technological progress that could significantly reduce the input requirements because of the specific production process of the performing arts, which is characterized by rehearsing and performing a play or concert: the number of required actors, singers and/or orchestra members, as well as the length of the play or concert, cannot be changed, apart from the director's artistic scope. Since rehearsing and performing are the most cost-intensive stages of the production process, the percentage of costs associated with labor is by far the highest.

On the other hand, productivity gains based on technological progress in other sectors of the economy cause a broad increase in wage rates that transcends sectors. Thus, despite the lack of significant technological progress in the performing arts, its labor costs increase similar to those of the rest of the economy. According to Baumol's cost-disease hypothesis, this effect results in an increasing unit labor cost and, finally, in a decrease in productivity.

Figure 1 displays a graphically illustration of the relationship between increasing wages, the lack of technological progress and total factor productivity (TFP). The vertical axis shows output (y) measured in physical terms (for example the number of sold or supplied tickets) and the horizontal axis shows an aggregated input vector (x) measured in monetary terms (for example the sum of salary expenses and operating expenses). $F^t(x)$ represents a variable returns to scale production frontier that shows the minimal input level necessary for every output level in period t. For example, at the production point A^t in period t, the output level y^t_A can be realized using at least the input level x^t_A. The second production frontier $F^{t+1}(x)$ results from an downward shift of the production frontier $F^t(x)$. That is, in period $t+1$ a higher input level measured in monetary terms than in period t is needed to produce every level of output. For example, at production point A^{t+1}, the same output level (y^{t+1}_A equals y^t_A) can only be produced with a higher input level (x^{t+1}_A). Further, since TFP is defined as the ratio of the outputs to

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[1] In particular, the technology of electronic reproduction has led to a significant increase in productivity in some fields of the cultural sector (Cowen, 1996).

the inputs, TFP at each production point can be represented by the slope of the ray through the origin and the respective production point (P^t and P^{t+1}). Clearly, the TFP at point A^{t+1} is lower than that in point A^t. Hence, a downward shift of the production frontier, ceteris paribus decreases TFP. Following Baumol's cost-disease hypothesis this development is due to two effects: On the one hand, the monetary value of the necessary minimal input level increases as a result of increasing wage rates, and on the other hand, the limited of even non-existent technological progress prevents any significant input reduction in physical terms that could countervail this effect. In other words, there is no significant productivity-promoting technological progress that can countervail the negative productivity trend caused by increasing wages.

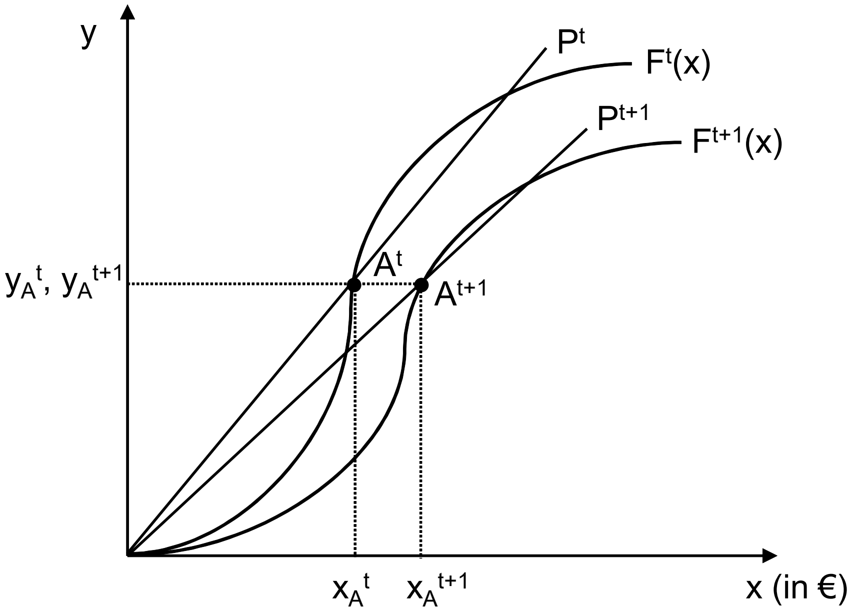

Figure 1: Increasing wages, lack of technological progress and productivity

However, what has remained largely unconsidered in the discussion of the cost-disease hypothesis is that the development of TFP is determined not only by technological progress, but also by technical efficiency change and scale efficiency change. Thus, even if there is no technological progress, TFP can increase or at least be constant as a result of positive technical efficiency change, the exploitation of scale economies, or both. These two effects are displayed graphically in Figure 2. As before, the vertical axis represents output (y) measured in physical terms and the horizontal axis represents an aggregated input vector (x) measured in monetary terms. Since the production point B is located on the production frontier $F(x)$, it is considered technically efficient. In comparison, point A needs a higher input level in order to produce the same output level (y_A equals y_B), so production at point A is considered technically inefficient. The level of technical inefficiency can be measured by the distance between A and B.[2] Considering again the slope of the rays through the origin and the production points (P^t and P^{t+1}), we see that the slope at point B is higher than at A, which means production at point B has a higher TFP. Thus, from a dynamic view, improving technical efficiency and, therefore, moving from point A to B increases TFP.

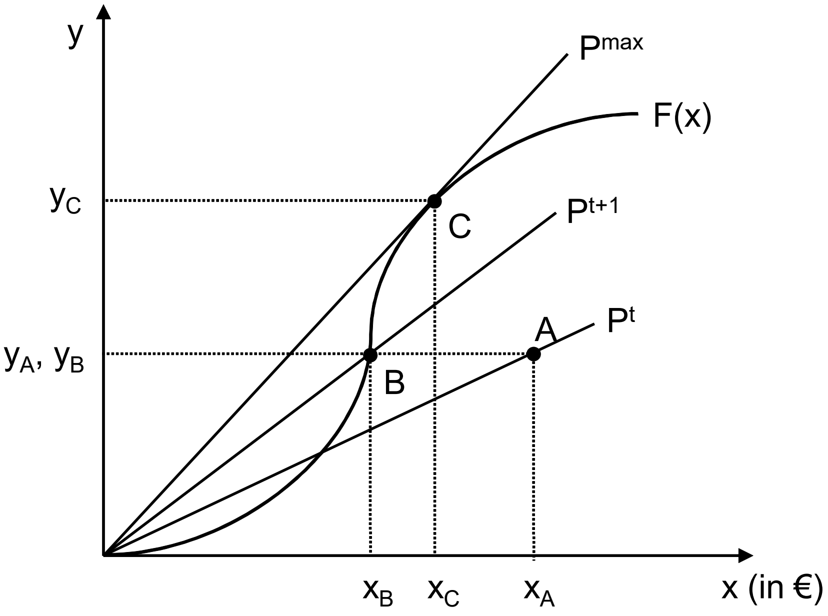

Figure 2: Technical efficiency, scale efficiency and productivity

However, the technically efficient point B does not have the highest TFP of all technically efficient points on $F(x)$. Instead, the highest TFP is at point C, where the ray through the origin (P^{max}) is tangent to the given production function. At any point to the left of C, the production function exhibits increasing returns to scale, and at any point to the right of C, the production function shows decreasing returns to scale. Therefore, a theater operating at point C is technically efficient as well as scale efficient, so the distance between B and C provides information about the level of scale inefficiency. Again, from a dynamic view, exploiting scale economies and thereby moving from point B to point C increases TFP.

Overall, the TFP change is determined by three factors: technological change, technical efficiency change and scale efficiency change. Hence, the technical efficiency change and the scale efficiency change can compensate for a lack of technological progress and, thus, can countervail a negative productivity development caused by the cost-disease effect. Following this argument, in order to assess the impact of the cost-disease effect

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[2] Since the input vector is measured in monetary terms, the inefficiency reflects the cost savings possible from the use of a technically efficient input vector (Grafton et al., 2000). Thus, the technical inefficiency could also be denoted as technical cost inefficiency. Here, however, we stick to the term technical (in)efficiency.

on the productivity of German public theaters, it is not enough to analyze whether there are rising unit labor costs; one must also evaluate in detail the production process, the corresponding TFP change and its drivers.

3 Methodology

To specify the production technology of public theaters, we apply an input distance function approach. In contrast to other representations of technologies, such as cost or revenue functions, this approach requires no specific behavioral assumptions, such as cost-minimization or profit maximization. Last and Wetzel (2010) showed that, in the case of German public theaters, the cost-minimization assumption cannot be maintained. Moreover, since the public theaters are part of the public non-profit sector, the assumption of profit maximization is not realistic. Thus, the input distance function is an appropriate specification for our analysis.

By modeling a production technology as an input distance function, one can investigate how much the input vector can be proportionally reduced while holding the output vector fixed. Following Coelli et al. (2005), the input distance function can be defined as:

$$D_I\left(x,y\right)=\max\{\theta:(x/\theta)\in L\left(y\right)\},\tag{1}$$

where $L(y)$ represents the set of all non-negative input vectors $x=(x_1,...,x_K)\in\mathbb{R}_+^K$ that can produce the non-negative output vector $y=(y_1,...,y_M)\in\mathbb{R}_+^M$; and θ measures the proportional reduction of the input vector x. The function is homogeneous of degree one in inputs and satisfies the economic regularity conditions of monotonicity and concavity, that is, the function is non-decreasing and concave in inputs and non-increasing in outputs (see, for example, Kumbhakar and Lovell, 2000).

From $x\in L(y)$, $D_I(x,y)\geq 1$ follows. A value equal to one identifies the respective input vector x as being fully efficient and located on the frontier of the input set. Values greater than one belong to inefficient input vectors above the frontier. This concept is closely related to Farell's (1957) measure of input-oriented technical efficiency, which can be calculated by the reciprocal of the input distance function:

$$TE(x,y)=1/D_I\left(x,y\right)\leq 1.\tag{2}$$

Technical efficiency values equal to one identify efficient firms that use an input vector located on the production frontier. Technical efficiency values between zero and one belong to inefficient firms that use an input vector above the frontier.

To estimate the input distance function, we adopt a translog (transcendental-logarithmic) functional form. Unlike a Cobb-Douglas form, which assumes the same production elasticities, the same scale elasticities, and a substitution elasticity equal to one for all firms, the translog does not impose such restrictions, so it is more flexible (see, for example, Coelli et al., 2005). The translog input distance function for K (k=1,...,K) inputs and M (m=1,...,M) outputs can be written as

$$
\begin{aligned}
ln\, D_{it}^{I} \;=\;& \alpha + \sum_{m=1}^{M} \alpha_m \, ln\, y_{mit} + \frac{1}{2} \sum_{m=1}^{M} \sum_{n=1}^{M} \alpha_{mn} \, ln\, y_{mit} \, ln\, y_{nit} + \sum_{k=1}^{K} \beta_k \, ln\, x_{kit} \\
& + \frac{1}{2} \sum_{k=1}^{K} \sum_{l=1}^{K} \beta_{kl} \, ln\, x_{kit} \, ln\, x_{lit} + \sum_{k=1}^{K} \sum_{m=1}^{M} \gamma_{km} \, ln\, x_{kit} \, ln\, y_{mit} \qquad (3) \\
& + \theta_t \, t + \frac{1}{2} \theta_{tt} \, t^2 + \sum_{k=1}^{K} \lambda_{kt} \, ln\, x_{kit} \, t + \sum_{m=1}^{M} \phi_{mt} \, ln\, y_{mit} \, t + \sum_{s=1}^{S} \psi_s \, z_{sit},
\end{aligned}
$$

where the subscripts i and t denote the firm and year, respectively; D_{it}^{I} is the input distance term; x_{kit} and y_{mit} denote the input and output quantity, respectively; $t = 1, ..., T$ is a time trend; z_{sit} $(z = 1, ..., S)$ is a vector of observable firm-characteristics expected to influence the production technology; and $\alpha, \beta, \gamma, \theta, \lambda, \phi$, and ψ are unknown parameters to be estimated.

For the theoretical conditions of symmetry and linear homogeneity in inputs to be guaranteed, several linear restrictions must hold for the input distance function. Symmetry requires the restrictions

$$\alpha_{mn} = \alpha_{nm}, \quad (m, n = 1, 2, ..., M) \quad \text{and} \quad \beta_{kl} = \beta_{lk}, \quad (k, l = 1, 2, ..., K), \qquad (4)$$

and linear homogeneity in inputs is given if

$$\sum_{k=1}^{K} \beta_k = 1, \quad \sum_{l=1}^{K} \beta_{kl} = 0, \quad \sum_{k=1}^{K} \gamma_{km} = 0, \quad \text{and} \quad \sum_{k=1}^{K} \lambda_{kt} = 0. \qquad (5)$$

The econometric method applied to estimate the distance function is the stochastic frontier analysis. Compared to other benchmarking methods, such as data envelopment analysis, the main advantage of stochastic frontier analysis is that it accounts for measurement errors and other random factors by using a two-part error term that allows the separation of statistical noise from firm-specific inefficiency. In particular, the true random effects model proposed by Greene (2005a, 2005b) is employed. In contrast to conventional stochastic frontier analysis models for panel data, the random effects model accounts for unobserved heterogeneity by adding a term that captures and also separates the time-invariant firm-specific unobserved heterogeneity from time-varying inefficiency. Compared to an alternative true fixed effects model, the true random effects model incorporates both within and between variations and, therefore, is richer in information (see, for example, Proppe, 2007).

Further, following a suggestion by Farsi et al. (2005), we use Mundlak's formulation (1978) to reduce a possible heterogeneity bias that can occur in random effects models when there is correlation between the unobserved heterogeneity and the explanatory variables. Through the use of this approach, these correlations are captured with an auxiliary regression that can be written as:

$$\alpha_i = \gamma' \bar{r}_i + \delta_i, \quad \bar{r}_i = \frac{1}{T_i} \sum_{t=1}^{T_i} r_{it}, \quad \delta_i \sim N(0, \sigma_\delta^2), \tag{6}$$

where $\bar{r}_i$ represents a vector of the group means of all explanatory variables; γ' is the corresponding vector of coefficients to be estimated; and δ_i is a normally distributed random term that is not correlated with the explanatory variables. Incorporated in the estimation model, the auxiliary coefficients γ_i capture any linear correlation between α_i and $\bar{r}_i$ and, thus, minimize the possible bias of the main model's coefficients (Farsi et al., 2005).

To yield the estimable form of the translog input distance function, the homogeneity restrictions of Equation 5 must be imposed. Thus, the distance term and the inputs in Equation 3 are normalized by one of the inputs (Lovell et al., 1994). Further, the negative log of the distance term $-ln\,D_{it}^I$ is replaced with a composed error term $\varepsilon_{it} = v_{it} - ln\,D_{it}^I = v_{it} - u_{it}$, where v_{it} is an iid normally distributed random error term that is independently distributed from the iid half-normally distributed inefficiency term u_{it}. Finally, adding the iid normally distributed random term α_i yields

$$\begin{aligned}
-ln\,x_{Kit} \;=\;& \alpha_0 + \sum_{m=1}^{M} \alpha_m\, ln\,y_{mit} + \frac{1}{2} \sum_{m=1}^{M} \sum_{n=1}^{M} \alpha_{mn}\, ln\,y_{mit}\, ln\,y_{nit} + \sum_{k=1}^{K-1} \beta_k\, ln\,x_{kit}^* \\
& + \frac{1}{2} \sum_{k=1}^{K-1} \sum_{l=1}^{K-1} \beta_{kl}\, ln\,x_{kit}^*\, ln\,x_{lit}^* + \sum_{k=1}^{K-1} \sum_{m=1}^{M} \gamma_{km}\, ln\,x_{kit}^*\, ln\,y_{mit} \\
& + \theta_t\, t + \frac{1}{2} \theta_{tt}\, t^2 + \sum_{k=1}^{K-1} \lambda_{kt}\, ln\,x_{kit}^*\, t + \sum_{m=1}^{M} \phi_{mt}\, ln\,y_{mit}\, t + \sum_{s=1}^{S} \psi_s\, z_{sit} \\
& + \alpha_i + v_{it} - u_{it},
\end{aligned} \tag{7}$$

where $x_{kit}^* = (x_{kit}/x_{Kit})$. The unknown parameters of Equation 6 and 7 are jointly estimated by simulated maximum likelihood, and the firm's inefficiency is estimated by using the conditional mean of the inefficiency term $\hat{u}_{it} = E\,[u_{it}|\hat{\omega}_{it}]$, where $\omega_{it} = \alpha_i + \varepsilon_{it}$ (Farsi et al., 2006).

According to the generalized Malmquist productivity index approach proposed by Orea (2002), the estimated parameters of Equation 7 can then be used to calculate and decompose the TFP change into technical efficiency change, technological change and scale efficiency change. Following Coelli et al. (2003), who applied this approach to an input distance function, the TFP change for the i-th firm between two periods t and $t+1$ is given by:

$$\begin{aligned}
ln\,(TFP_{it+1}/TFP_{it}) \;=\;& ln\,(TE_{it+1}/TE_{it}) \\
& + 0.5\,[(\partial\, ln\,D_{it+1}/\partial\, t) + (\partial\, ln\,D_{it}/\partial\, t)] \\
& + 0.5 \sum_{m=1}^{M} [(SF_{it+1}\, \varepsilon_{mit+1} + SF_{it}\, \varepsilon_{mit})\, (ln\,y_{mit+1} - ln\,y_{mit})]\,,
\end{aligned} \tag{8}$$

where the terms on the right represent the technical efficiency change, the technological change and the scale efficiency change, respectively. As shown, the measure of technical efficiency change is simply the log of the ratio of the i-th firm's predicted technical efficiency scores in the two periods.

Technological change is measured by the mean of the i-th firm's technological change in the two periods, which is equal to the mean of the partial derivatives of the distance function with respect to time in period t and $t+1$. Given Equation 3, the i-th firm's technological change in the t-th period is:

$$\partial \, ln \, D_{it} / \partial \, t = \theta_t + \theta_{tt} t + \sum_{k=1}^{K} \lambda_{kt} \, ln \, x_{kit} + \sum_{m=1}^{M} \phi_{mt} \, ln \, y_{mit}. \tag{9}$$

Finally, the measure of scale efficiency change requires the computation of the i-th firm's output elasticities and scale factors in each period. Given Equation 3, the i-th firm's output elasticity for each output in the t-th period is:

$$\varepsilon_{mit} = \partial \, ln \, D_{it} / \partial \, ln \, y_{mit} = \alpha_m + \sum_{m=1}^{M} \alpha_{mn} \, ln \, y_{mit} + \sum_{k=1}^{K} \gamma_{km} \, ln \, x_{kit} + \phi_{mt} t. \tag{10}$$

For an input distance function, the i-th firm's returns to scale in the t-th period (RTS_{it}) are equal to the negative of the inverse of the sum of the output elasticities (Färe and Primont, 1995):

$$RTS_{it} = -\left(1 \Big/ \sum_{m=1}^{M} \varepsilon_{mit} \right), \tag{11}$$

Therefore, the i-th firm's scale factor in the t-th period (SF_{it}) is given by:

$$SF_{it} = \left(\sum_{m=1}^{M} \varepsilon_{mit} + 1 \right) \Big/ \sum_{m=1}^{M} \varepsilon_{mit} = 1 - RTS_{it}. \tag{12}$$

That is, if the firm exhibits increasing returns to scale, $RTS > 1$ and the SF is negative, and if the firm exhibits decreasing returns to scale, $RTS < 1$ and the SF is positive. In the former case, an increase in scale of operations results in an increase of scale efficiency and, hence, an increase in TFP; however, in the latter case, an increase in scale of operations results in a decrease of scale efficiency and TFP. Finally, if the firm exhibits constant returns to scale, $RTS = 1$, the SF is equal to 0 and TFP change is influenced only by technical efficiency change and technological change.

4 Data and empirical model

The data set is an unbalanced panel of 174 German public theaters observed for the seasons 1991/1992 to 2005/2006. The data were taken from the theater reports published annually by the Deutscher Bühnenverein (German Stage Association) (1993-2007).

First, to identify and eliminate any outliers, we apply the method suggested by Hadi (1992, 1994), which identifies multiple outliers in multivariate data. Moreover, all theaters with fewer than four observations are excluded from the estimation. This procedure leaves a total of 1433 observations from 126 theaters.

We use a supply-based output measure, as proposed by Tobias (2003), and include three input variables as measures for labor and capital input. Since the theaters run stages with auditoriums of different sizes, including only the number of performances as an output measure would bias the use of inputs regarding the quantity of output. Hence, in order to account for the differences in size, we measure the output using the variable *number of supplied tickets* (Y), calculated as the number of performances per season multiplied by the number of seats.[3] The total salary expenses and the *operating expenses* (X_C) per season are used as monetary measures for the quantities of labor and capital,[4] with the salary expenses are divided into *salary expenses for artistic staff* (X_{Lart}) and *salary expenses for administrative and technical staff* (X_{Lad}) in order to provide a more detailed identification of possible sources of inefficiency. The operating expenses include, among other things, administration costs, leasing and fire service expenditures.

To account for observed heterogeneity, three firm characteristic variables are taken into account. First, the theaters are aware of the amount of subsidies granted by the public authorities when they plan productions for upcoming seasons, so we include a variable reflecting the *amount of subsidies* (SUB) in the model in order to test for the impact of public funding on efficiency and assume that this variable has a negative impact on efficiency. Further, the production technology of the theaters differs significantly in terms of the number of stages that belong to one theater. Given the same amount of output, it can be assumed that a theater with more than one stage has higher input requirements than a theater with only one stage. Therefore, we expect the second firm-characteristic variable included in the model, the *number of stages* (ST), to have a negative impact on efficiency. Finally, the third firm characteristic incorporated in the model is the number of different productions per season. Besides their public mission regarding the maintenance of cultural diversity, theaters have incentives to offer a range of different plays in order to attract a wide audience. However, producing plays is cost-intensive and is expected to have a negative impact on efficiency, while re-runs of established productions are much less expensive for the theater. Moreover, the necessary rearrangements of stage designs that result from changing productions, irrespective of whether the productions are new or not, result in higher costs. Therefore, the variable, *number of productions* per season ($PROD$), is included in order to control for the impact on input requirements.

The descriptive statistics reported in Table 1 show significant variance regarding all variables. For example, the largest theater in terms of output supplies 97 times more

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[3] Most theaters run several stages, so the number of tickets supplied is calculated for every stage and then summed.

[4] All monetary measures are adjusted for inflation using the consumer price index for Germany (Statistisches Bundesamt (Federal Statistical Office), 2009). Values are stated in year-2005 €.

tickets than the smallest theater in the data set.[5] This variance results from the different auditorium sizes and number of stages run by each theater.

Table 1: Descriptive statistics

Variable description	Variable	Mean	Median	Std. Dev.	Min	Max
Number of supplied tickets (10^3)	Y	171	160	108	6	596
Salary expenses for artistic staff (10^3 €)	X_{Lart}	6432	5899	5082	163	27800
Salary expenses for administrative and technical staff (10^3 €)	X_{Lad}	5257	4229	4139	23	25300
Operating expenses (10^3€)	X_C	2559	2074	1928	42	11400
Amount of subsidies (10^3 €)	SUB	13000	11500	9540	218	54700
Number of stages	ST	4	4	2	1	13
Number of productions	$PROD$	29	26	14	2	79
Number of observations			1433			

Source: Deutscher Bühnenverein (German Stage Association) (1993-2007)

Including all described output and input variables and all firm characteristics results in the following input distance function model to be estimated:

$$\begin{aligned}
-\,ln\,X_{C_{it}} \;=\;& \alpha_0 + \alpha_1\,ln\,Y_{it} + \frac{1}{2}\,\alpha_{11}\,(ln\,Y_{it})^2 \\
&+ \beta_1\,ln\,(X_{Lart_{it}}/X_{C_{it}}) + \beta_2\,ln\,(X_{Lad_{it}}/X_{C_{it}}) \\
&+ \frac{1}{2}\,\beta_{11}\,(ln\,(X_{Lart_{it}}/X_{C_{it}}))^2 + \frac{1}{2}\,\beta_{22}\,(ln\,(X_{Lad_{it}}/X_{C_{it}}))^2 \\
&+ \beta_{12}\,ln\,(X_{Lart_{it}}/X_{C_{it}})\,ln\,(X_{Lad_{it}}/X_{C_{it}}) \\
&+ \gamma_{11}\,ln\,(X_{Lart_{it}}/X_{C_{it}})\,ln\,Y_{it} + \gamma_{21}\,ln\,(X_{Lad_{it}}/X_{C_{it}})\,ln\,Y_{it} \\
&+ \theta_t\,T + \frac{1}{2}\,\theta_{tt}\,T^2 + \lambda_{1t}\,ln\,(X_{Lart_{it}}/X_{C_{it}})\,T + \lambda_{2t}\,ln\,(X_{Lad_{it}}/X_{C_{it}})\,T \\
&+ \phi_{1t}\,ln\,Y_{it}\,T + \psi_1\,ln\,SUB_{it} + \psi_2\,ln\,ST_{it} + \psi_3\,ln\,PROD_{it} \\
&+ \alpha_i + v_{it} - u_{it}.
\end{aligned} \tag{13}$$

5 Results

The parameter estimates of Equation 13 are presented in Table 2. To conserve space, the jointly estimated Mundlak terms of the auxiliary regression (Equation 6) are not reported. Altogether, 17 out of the 20 Mundlak coefficients are statistically different from zero at the 5 percent level, suggesting that the applied Mundlak formulation is

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[5] The largest theater in terms of tickets supplied is Niedersächsisches Staatstheater Hannover, which includes the state opera house and the Schauspielhaus, resulting in about 2360 seats overall. The smallest theater is the Schlosstheater Moers, which has about 300 seats.

able to account for correlations between the firm-specific effects and the explanatory variables and, thus, to reduce the resulting heterogeneity bias.[6]

Since each variable is in natural logarithm and is normalized by its sample median, the first-order coefficients can be interpreted as elasticities of the sample median firm. All first-order coefficients have the expected signs and are statistically significant at the 1 percent level. Thus, the estimated input distance function for the sample median firm is decreasing in output and increasing in inputs.

The estimated input elasticities for salary expenses for artistic staff (β_1) and for administrative and technical staff (β_2) are 0.494 and 0.366, respectively. The homogeneity restriction for inputs presented in Equation 5 is employed to calculate the 0.140 input elasticity for operating expenses (β_3). Since these elasticities can be interpreted as shadow shares, the results demonstrate that the expenses for artistic staff account for about 49 percent of overall expenses, expenses for administrative and technical staff account for about 37 percent, and operating expenses account for about 14 percent at the sample median firm. These values are similar to the cost percentages observed at the sample median firm of about 48, 35 and 17 percent, respectively. This close correlation of values suggests a good fit of the model.

The first-order coefficient of time (θ_t) amounts to -0.004. Independent of the negative sign, which implies regressive technological change, the fairly low size of the coefficient suggests almost no technological change for the sample median firm in the mid-year of the sample. This result supports the hypothesis that the production process of German public theaters is characterized by very limited opportunities to benefit from technological improvements and suggests that the cost-disease effect is at play in this sector. Nevertheless, as noted by Saal et al. (2007), this technological change estimate is for a non-existent hypothetical sample median firm with unchanging characteristics. Hence, it does not account for changes in inputs and outputs and should be interpreted with caution.

Regarding the firm characteristics, the coefficients of the amount of subsidies (ψ_1) as well as of the number of productions (ψ_3) are statistically signifcant and negative. Thus, for the sample median firm, the input requirements increase by 0.62 percent if the subsidies increase by 1 percent and by 2.5 percent if there is an additional production per season. Moreover, since the negative of the inverse of the first-order output coefficient (α_1) amounts to 8.197, significantly increasing returns to scale can be observed for the sample median firm. Further, more than 99 percent of the observations show increasing returns to scale, and the median value of returns to scale is 8.403. This result is in line

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[6] Using the same data set as is used in the current study, Last and Wetzel (2010) showed that the distance function estimates of a conventional fixed effects model with unbiased parameter estimates are very similar to the distance function estimates of the true random effects model with Mundlak formulation. However, since, in contrast to the true random effects model, the conventional fixed effects model identifies at least one observation as 100 percent efficient and assumes - at least for long panels - a somewhat unrealistic constant efficiency over time, its efficiency estimates are sensitive to outliers and are, in all likelihood, very downward biased. See Last and Wetzel (2010) for more details.

Table 2: Estimation results of the input distance function[a,b]

Variable	Parameter	Coefficient	T-ratio	Variable	Parameter	Coefficient	T-ratio
Y	α_1	-0.122	-10.46	T	θ_t	-0.004	-9.55
Y^2	α_{11}	-0.034	-2.95	T^2	θ_{tt}	0.000	-1.16
X_{Lart}	β_1	0.494	60.58	$X_{Lart}T$	λ_{1t}	-0.004	-5.81
X_{Lad}	β_2	0.366	37.28	$X_{Lad}T$	λ_{2t}	0.008	8.43
X_C	β_3	0.140		X_CT	λ_{3t}	-0.004	
X_{Lart}^2	β_{11}	0.170	17.51	YT	$\phi 1t$	0.000	-0.25
X_{Lad}^2	β_{22}	0.117	8.24	SUB	ψ_1	-0.617	-68.07
X_C^2	β_{33}	0.035		ST	ψ_2	-0.009	-1.41
$X_{Lart}X_{Lad}$	β_{12}	-0.126	-13.94	$PROD$	ψ_3	-0.025	-3.73
$X_{Lart}X_C$	β_{13}	-0.044					
$X_{Lad}X_C$	β_{23}	0.009					
$X_{Lart}Y$	γ_{11}	-0.026	-2.87	Constant	α_0	-0.036	-9.05
$X_{Lad}Y$	γ_{21}	0.047	5.00	Sigma	$\sqrt{\sigma_u^2 + \sigma_v^2}$	0.963	8.68
X_CY	γ_{31}	-0.021		Lambda	σ_u/σ_v	0.067	37.34

[a] All variables are in natural logarithm and are normalized by their sample median. [b] All model estimates are obtained by using Limdep 9.0.

with earlier studies on the performing arts that also found increasing returns to scale (see, for example Taalas, 1997; Fazioli and Filippini, 1997).

The results of the TFP change decomposition computed from the input distance function estimates are presented in Table 3 and Figure 3. According to Equation 8, the annual TFP change is equal to the sum of the technical efficiency change, the technological change and the scale efficiency change. The development of the average technical efficiency change in the observed period is comparatively volatile, and the maximum absolute average efficiency change from one year to the next is less than 0.5 percent. Together, as shown in Figure 3, these results lead to an overall negative technical efficiency change of 0.25 percent on average, which is therefore economically insignificant.

In contrast, the average technological change is negative in all seasons. Although the annual change rates are small (-0.25 to -0.39 percent), this trend sums to a negative technological change of about 5 percent on average. That is, we observe an increase in the minimum input level necessary for every output level or, in graphic terms, a downward shift of the production frontier. In fact, since salary expenses and operating expenses are used as monetary measures for labor and capital input, and total salary expenses account for more than 80 percent of the costs, this result indicates an increase in real unit labor costs as a result of rising wages. In other words, this result reflects an increase of the monetary value of the necessary minimum input level that cannot be countervailed by any significant technological progress reducing the input requirements in physical terms. Thus, the negative development of technological change is expected and supports Baumol's cost-disease hypothesis.

Table 3: Average change rates of TFP and its components (in percent)

	Technical efficiency change	Technological change	Scale efficiency change	TFP change
1991/92 - 1992/93	−0.11	−0.39	−1.67	−2.18
1992/93 - 1993/94	0.31	−0.38	2.95	2.88
1993/94 - 1994/95	0.04	−0.38	−0.03	−0.37
1994/95 - 1995/96	−0.13	−0.37	0.06	−0.44
1995/96 - 1996/97	−0.30	−0.37	2.64	1.97
1996/97 - 1997/98	0.14	−0.37	−0.50	−0.74
1997/98 - 1998/99	−0.01	−0.36	−0.70	−1.08
1998/99 - 1999/00	−0.20	−0.35	−1.64	−2.19
1999/00 - 2000/01	0.10	−0.36	−1.56	−1.82
2000/01 - 2001/02	0.29	−0.39	−1.90	−2.00
2001/02 - 2002/03	0.36	−0.39	1.79	1.75
2002/03 - 2003/04	−0.04	−0.37	−1.12	−1.53
2003/04 - 2004/05	−0.42	−0.25	−0.08	−0.75
2004/05 - 2005/06	−0.28	−0.25	−0.67	−1.19
Cumulative	−0.25	−4.98	−2.43	−7.69

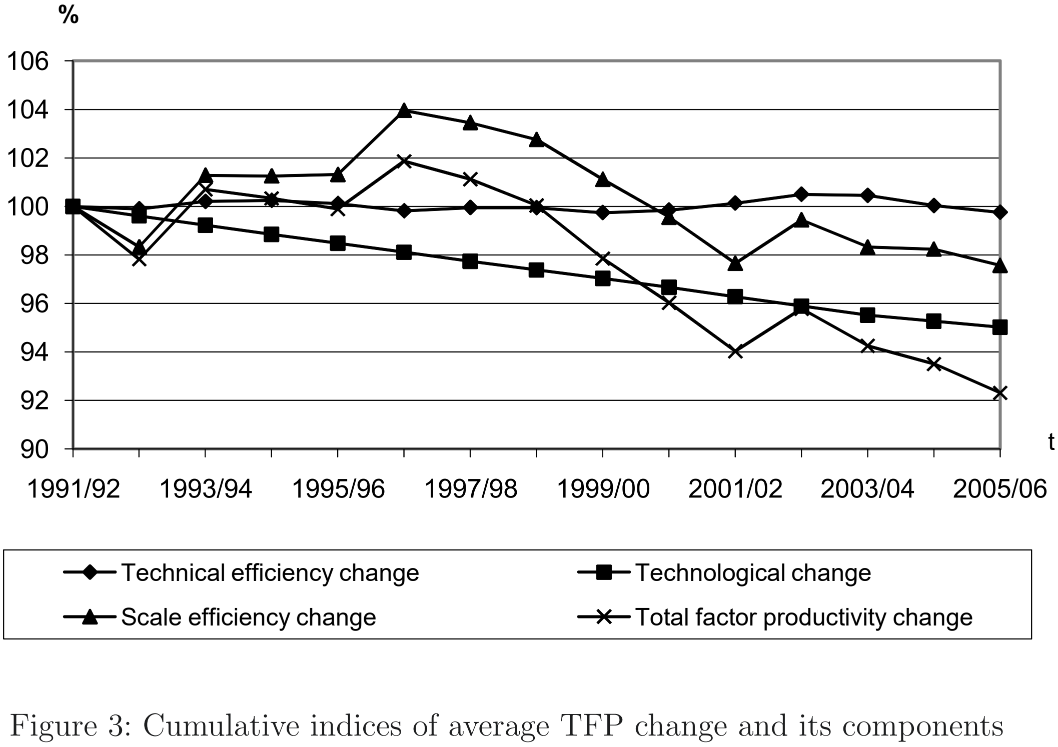

Figure 3: Cumulative indices of average TFP change and its components

Finally, the annual scale efficiency change is volatile. While in the 1992/93-1996/97 period, the cumulative average scale efficiency change index increased, it almost exclusively decreased afterwards, and it finally indicates an overall negative scale efficiency change of about -2.4 percent on average. Considering the increasing returns to scale for the majority of the theaters, this result shows that, in the 1992/93-1996/97 period, the theaters were able to create scale efficiency gains by increasing the scale of their operations. Furthermore, since we observe a positive development of average TFP in this sub-period, the positive influence of scale efficiency gains on productivity not only compensated for the contemporaneous negative influence of technological change - or, in other words, of increasing real unit labor cost - it outperformed it. Nevertheless, after the peak in 1996/97, the almost exclusive decrease in average scale efficiency indicates a steady downsizing of the scale of operations. That is, after the 1996/97 season, we observe increasing scale efficiency losses, which have a negative influence on TFP change.

Altogether, average TFP decreased by almost 8 percent over the observed period. This development is primarily driven by the increase in real unit labor cost reflected in the negative technological change and the almost continuous increase in scale inefficiency after the 1996/97 season. However, average TFP is essentially unaffected by any change in technical efficiency.

6 Conclusions

Our analysis of the productivity development in the German public theater sector for the 1991/1992-2005/2006 season is the first stochastic distance frontier approach to address the relationship between the cost-disease effect and efficiency changes in the German performing arts sector. Based on a true random effects model for panel data and a generalized Malmquist productivity index, we estimated a translog input distance function and decomposed TFP into three sources: technological change, technical efficiency change and scale efficiency change. The aim was to examine (a) whether Baumol's cost-disease hypothesis is valid in this sector and (b) if so, whether its negative influence on productivity can be compensated for by efficiency gains.

Our findings indicate that, in fact, the German public theater sector is affected by the cost-disease effect. Based on our model specification, the estimated negative development of technological change can be interpreted as an indicator for increasing real unit labor costs as a result of increasing wages. Thus, in line with the cost-disease hypothesis, we observe a decrease in productivity caused by a combination of increasing labor cost and no (or very limited) opportunities to benefit from technological improvements.

We obtain different results concerning whether any efficiency gains can counteract the negative impact of the cost-disease effect on productivity. First, we do not find any significant impact, positive or negative, on productivity from technical efficiency change. From a purely technical perspective, this result suggests that, on average, the low performers were not able to catch up to the best-practice frontier, and the high performers did not suffer from any significant efficiency losses over time. In other words, the firm-specific technical efficiency scores remained almost stable.

In contrast, the increasing returns to scale for the majority of the theaters suggest that the majority of theaters do not operate on an optimal scale of operations and, therefore, can realize significant efficiency gains by exploiting scale economies. As the positive development of productivity in the mid-1990s shows, these gains in scale efficiency can even outperform the negative influence of the cost-disease effect on productivity. However, over the whole period, the decrease in average scale efficiency indicates that the theaters did not increase their scale of operations but decreased it, resulting in efficiency losses that reinforced the negative productivity development caused by the cost-disease effect. Since the theaters rely heavily on public funding, this development is likely to have resulted from increasing budget cuts that forced theater managers to downsize their scale of operations. Therefore, before the budget of an individual theater is cut, a careful assessment of potential productivity losses is advised.

Overall, our results suggest that there is space for efficiency gains and productivity improvements in the German public theater sector. For example, cooperation among theaters in form of additional external performances can improve the scale of operation and reduce the relative costs of stage designs and rehearsal. Such arrangements should be promoted by the subsidy system since they can counter the existing cost-disease effect.

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