Cultural Economics: Empirical Applications in the German Cultural Sector

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Anne-Kathrin Last

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1 Introduction

"It is in our own best interest to make theater possible and to protect it. [...] An open and respectful dialogue between the theater and its responsible body is on behalf of both. This certainly includes questions of financing. Indeed, it concerns the arts, but the fact is that one cannot spend more than available." In speaking to the Deutscher Bühnenverein (German Stage Association), von Weizsäcker (1988), former Federal President of the Federal Republic of Germany, alluded to one of the main problems the highly subsidized German cultural sector has faced for decades: Although national cultural policy aims address such goals as providing a cultural infrastructure and preserving cultural heritage, the mounting pressure on public budgets makes it increasingly difficult to justify continuing current rates of public funding for the cultural sector.

The German cultural sector covers a wide range of cultural institutions and activities: theaters, music activities, music schools, non-scientific and scientific museums and libraries, art academies, measures for the preservation of ancient monuments and buildings, care of cultural heritage, foreign cultural policy, and the administration of cultural affairs. The basic public expenses[1] for cultural institutions and activities in this sector amounted to 8004 million € in 2005, or 0.36 percent of Germany's gross domestic product (GDP).[2] In comparison, the revenues gained by the cultural sector from private households, the private sector and foundations in 2005 amounted to 1030 million € (Statististische Ämter des Bundes und der Länder (Statistical Offices of the Federation and the Länder), 2008).

Against the background of the dependence of cultural institutions on public funding and the increasing pressure on public budgets, this thesis aims to make a contribution to the economic analysis of the German cultural sector. For this purpose, three empirical studies focusing on the German cultural sector are conducted, using different methods to

[1] In this context the concept of basic public cultural expenses equals the total public cultural expenses less the revenues (for example ticket sales revenues) (Statististische Ämter des Bundes und der Länder (Statistical Offices of the Federation and the Länder), 2008).

[2] Due to the federal structure of German cultural policy, the Länder (German Federal States) and the local authorities bear nearly 90 percent of the financial burden (Statististische Ämter des Bundes und der Länder (Statistical Offices of the Federation and the Länder), 2008).

quantify the analyzed effects.[3] Two different theoretical approaches are used to describe the cultural sector: the demand side of the sector and consumer preferences for cultural goods, and the supply side of the sector and the production of cultural goods.

Chapter 2 describes an application of the contingent valuation method (CVM) for assessing public approval of the amount of subsidies spent on cultural facilities. Cultural subsidies are spent to increase the supply of cultural goods to meet the people's demand but also in response to non-use values like existence, option, bequest, education and prestige. These non-use values are not reflected in direct or actual demand (e.g., in the number of museum entrance tickets purchased), so it cannot be internalized by the competitive market and can lead to market failure. In order to determine the economically optimal amount of subsidy needed for cultural goods, the public authorities need to know the magnitude of non-use values. The CVM, originally developed in the scope of environmental economics, can capture the use value as well as the non-use values, so it has been used in cultural economics for more than twenty years (Navrud and Ready, 2002). The basic idea behind the method is to present a hypothetical scenario of a quantity or quality change in a public good and then to ask individuals directly what they are willing to pay for the scenario to be realized. For our analysis, we conducted a contingent valuation study to capture the willingness to pay (WTP) for the municipal cultural supply in Lüneburg, Germany.[4] To identify the factors associated with the respondents' WTP, we supplemented an ordinary least squares (OLS) and a Tobit regression model with a quantile regression (QR) model. The findings suggest the existence of non-use values: On the one hand self-selected non-users showed a positive mean WTP for the municipal supply, and on the other hand the peoples' acceptance levels in response to statements that dealt with possible non-use demand attributed to the supply of the town's cultural facilities was high. The results of the OLS regression that were predominantly validated by the Tobit regression are in accordance with the literature on cultural economics: Higher education and higher income lead to a higher WTP for the municipal cultural supply. Since the QR analyzes the coefficients at different points of the distribution of the dependent variable (in contrast to the other two models), it accounts for the heterogeneity of preferences. For example, the QR reveals that, for our analyses, a higher WTP for the municipal supply is less a question of education than of income. Overall, the results indicate that the QR can provide useful information in deriving implications for cultural policy.

[3] The data are available on request from the author.

[4] The survey was part of a research project financed by the Ministry of Science and Culture of Lower Saxony between 2006 and 2008.

In contrast to the consumption-oriented approach of Chapter 2, Chapters 3 and 4 focus on the production of cultural goods in Germany - specifically, the production of performing arts in public theaters. Data were taken from the theater reports published by the Deutscher Bühnenverein (German Stage Association) from 1993 to 2007. These reports contain technical data (for example, number of seats and number of productions), as well as accounting data (for example, salary expenses and amount of subsidies) for all public theaters in Germany. For the analyses, an unbalanced panel data set of 174 theaters for the 1991/1992 to 2005/2006 seasons was used.

Chapter 3 uses a stochastic frontier analysis approach to analyze the efficiency of German public theaters. In contrast to other studies on efficiency measurement in the performing arts that have used the non-parametric data envelopment analysis method, the stochastic frontier analysis approach has the advantage of separating statistical noise from inefficiency, so it provides a more careful measure of the theaters' performance. However, a shortcoming of the parametric stochastic frontier approach is that it requires a functional specification of the production frontier; therefore, we applied an input distance function that needs no further assumptions on the behavior, like cost-minimizing or profit-maximizing, in order to specify the functional form as flexibly as possible. According to Niskanen's model of bureaucracy (1971), at least partial information asymmetry between theater managers and public authorities can be assumed, where only the theater managers are fully aware of the minimum costs for theater productions. Against this theoretical background, whether the assumption of cost-minimizing behavior is reliable in the case of public theaters is of particular interest. Thus, in addition to the input distance function model, we employ a cost function model in order to evaluate whether the cost-minimizing behavior can be maintained. We also applied several panel data models that differ in their ability to account for unobserved heterogeneity to evaluate the impact of unobserved heterogeneity on the efficiency estimates. The results indicate that the cost-minimizing assumption cannot be maintained. Consequently, an efficiency analysis based on a cost function approach seems inappropriate in the case of German public theaters. We also find a considerable unobserved heterogeneity across the theaters that causes a significant variation in the models' efficiency estimates. This finding suggests that failing to account for unobserved heterogeneity leads to biased efficiency values. Taken together, our results suggest that there is still space for improvement in the employment of resources in the area of performing arts production in Germany.

The third study, presented in Chapter 4, discusses the development and sources of productivity in German public theaters. In the context of the live performing arts, the opportunity for major technological progress that would lead to productivity growth is limited: The number of required actors, singers and orchestra members, as well as the length of a piece, cannot easily be changed. As labor costs increase, productivity decreases over time; this phenomenon is referred to as “Baumol’s cost-disease” (Baumol and Bowen, 1965) and has been broadly discussed in the literature on cultural economics. However, productivity is not influenced only by technological change; technical efficiency and scale efficiency also play a role. Thus, which of the three factors - technological change, technical efficiency, or scale efficiency - are positive or negative drivers for productivity change in the case of German public theaters is of particular interest. Using a stochastic distance frontier approach to decompose the total factor productivity into the three different sources of productivity, 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 offset by efficiency gains. The findings indicate that there is no significant technological progress that can countervail the negative productivity trend caused by increasing wages and, thus, support the cost-disease hypothesis. Furthermore, the finding of increasing returns to scale for the majority of theaters implies that significant productivity-promoting scale efficiency gains can be realized by the exploitation of scale economies. Nevertheless, since technical efficiency remained almost stable and scale inefficiency increased over the sample period we observe an overall decrease in average productivity of about 8 percent. Thus, the analysis shows that while the exploitation of scale economies presents an opportunity for countering the negative productivity trend caused by the cost-disease effect, the theaters did not take advantage of this opportunity in the sample period.

Chapter 5 summarizes the main results of the three empirical analyses. This is followed by concluding remarks on the need for further research.

2 The Monetary Value of Cultural Goods: A Contingent Valuation Study of the Municipal Supply of Cultural Goods in Lüneburg, Germany

2.1 Introduction

During the 2004/2005 season, nearly 44 percent of the 390 theaters and about 60 percent of the 6155 museums in Germany were run partially or completely by public authorities (Deutscher Bühnenverein (German Stage Association), 2006; Institut für Museumsforschung (Institute for Museum Research), 2006)[1]. These figures reveal the major role of public authorities in the provision of cultural goods in Germany. Since German cultural policy is organized locally, the Länder (German Federal States) and the local authorities bear nearly 90 percent of the financial burden (Statististische Ämter des Bundes und der Länder (Statistical Offices of the Federation and the Länder), 2006). During the annual hearings on the municipal budgets, the amount spent on cultural goods is discussed and determined, depending principally on the financial burden of the previous year and necessary investments for the next year. However, the question of whether the amount of cultural goods provided by public authorities is economically optimal takes a back seat. This could be because of rent-seeking behavior of local politicians who do not want to diminish their available budget or because of missing information about the preferences of the population for cultural goods.

The latter point refers particularly to the so-called non-use values of a good which are not directly connected with its usage, like existence, option, bequest, education or

[1] The total number of theaters and museums is derived from those which are recorded by the German Stage Association and the Institute for Museum Research.

prestige. These positive externalities generated by cultural goods cannot be internalized by the competitive market, for example, via entrance fees. From the economic point of view, non-use values justify intervention into the market in the form of paying subsidies to increase supply according to the total demand of the people.

This study addresses the lack of information about the population's preferences regarding cultural facilities provided by municipalities. It describes an application of the contingent valuation method (CVM) that can capture the use value generated by the publicly provided cultural facilities, as well as possible non-use values. The basic idea of the method is to present a hypothetical scenario of a quantity or quality change in a public good and asks individuals directly what they are willing to pay for the scenario to be realized.

The CVM has been applied to cultural goods for more than 20 years (Navrud and Ready, 2002). Comparable studies dealing with subsidies for the municipal cultural supply have found that, in most cases, the affected population approved of the amount of subsidies (see, for example, Morrsion and West (1986) or Bille Hansen (1997)) or even supported higher amounts (Throsby and Withers, 1983).

In order to validate the results obtained by the CVM and to explore the factors associated with preferences for the cultural facilities, the results of different regression models, namely an ordinary least squares (OLS) and a Tobit regression, are analyzed. What is new is the supplementary use of a quantile regression (QR) model in the context of a cultural valuation study. In contrast to traditional regression models like OLS or Tobit which are conditional on the mean, QR allows for the estimation of coefficients for any quantile along the distribution of the dependent variable. Thus, it provides the opportunity to compare the estimates at different points of interest. To our knowledge, in the context of valuation studies QR only has been applied in the field of environmental economics for analyses on the introduction of less polluting public transport (O'Garra and Mourato, 2007) and the improvement of water resources (Belluzzo, 2004).

Concerning contingent valuation (CV) studies, the QR gives a more detailed view on which factors drive the dependent variable at different points of the distribution than has heretofore been available, and therefore allows for the heterogeneity of preferences. Beyond that, O'Garra and Mourato (2007) suggested that "there are numerous policy-related purposes for using QR on CV data." For example, in the field of cultural economics, information about which factors are associated with different levels of willingness to pay (WTP) could be used in order to develop appropriate price differentiation mechanisms with respect to entrance fees (Frey, 2003). It would also be possible to offer special events and performances which could attract people with higher WTP. Overall, QR results can be used in order to adopt policy measures in a more efficient way.

The paper is organized as follows. Section 2.2 discusses the theoretical foundations of applying the CVM to cultural goods by presenting the WTP as a measure for utility. The methodology of the survey is described in Section 2.3, followed by details of the empirical model in Section 2.4, and the descriptive results in Section 2.5. Multivariate results of the empirical analysis are presented in Section 2.6. Section 2.7 concludes the paper.

2.2 The WTP as a measure for utility

The utility attributed to cultural goods arises from the direct use - for example, the experience of a concert or a painting - and the indirect use - for example, the prestige for a city or a region, generated by the uniqueness of a work of art. Stated preference methods like the CVM capture the WTP as a measure of utility by means of the analytical relationship between WTP and utility (see, for example, Perman et al. (2003), or Nicholson (2005)).

The utility can be described by the indirect utility function

$$U = V(p_y, I, q_x), \tag{2.1}$$

where p_y is a vector of prices for all private goods y,I is the income, and q_x is an indicator for the quantity of the public good x. Expenditure functions in the form of

$$E = E(p_y, U, q_x) \tag{2.2}$$

are used to analyze the WTP by describing the minimal expenditures necessary to achieve a specific utility level U. As can be seen, the expenditure function is the inverse of the indirect utility function. The WTP for a quantity change of a specific public good can be measured by the difference between the minimal expenditures for the good before and after the quantity change (from q_x^0 at point t^0 to q_x^1 at point t^1). In the case of an assumed reduction of the provided public good, for example the reduction of opening hours of a museum, the equivalent surplus (ES) measures the WTP for avoiding the change. The reference utility level is U^1, which refers to point t^1 and thus reflects the utility after the change:

$$ES = E(p_y, U^1, q_x^1) - E(p_y, U^1, q_x^0). \tag{2.3}$$

Therefore, the ES is the amount which an individual is willing to pay to avoid the loss in utility resulting from a reduction in the publicly provided good.

This is illustrated in Figure 2.1[2], where an individual is initially able to consume the quantity q_x^0 of the public good x. E_0 reflects the individual's budget constraint, which equals the minimal expenditure to achieve the utility level U^0 when q_x is q_x^0. If, because of a policy measure, the quantity of the public good x decreases from q_x^0 to q_x^1 which equals a price increase of x, the budget constraint turns inwards, given by E_1 and the individual's utility decreases to the level U^1. To analyze how much the individual would be willing to pay to avoid the policy measure and the corresponding utility decrease, a new expenditure level E_2 must be drawn parallel to the initial level E_0 which intersects the new utility level U^1, where q_x is q_x^1. The distance between the two expenditure levels E_0 and E_2 equals the amount of money the individual would have to spend to achieve the initial utility level U^0 after the policy change, so it represents the ES.

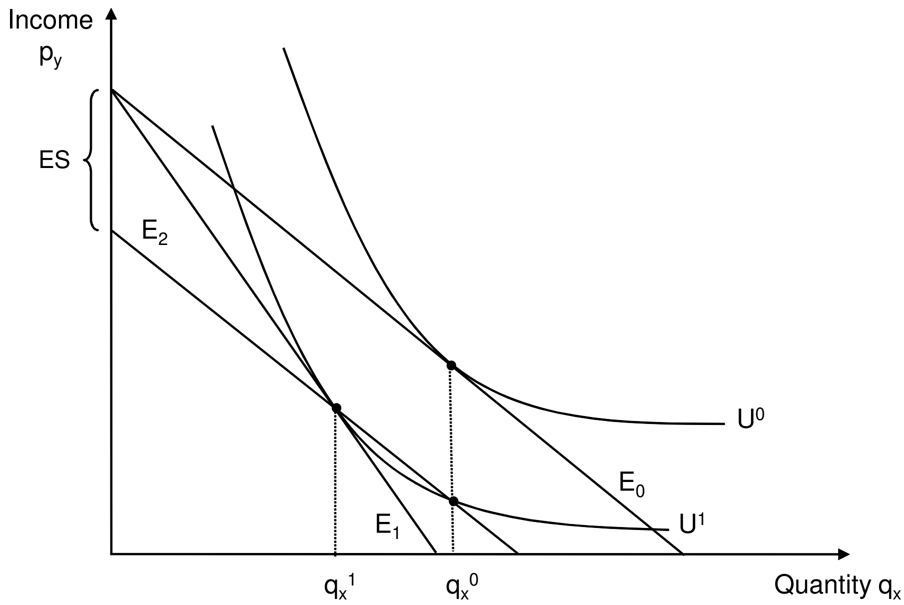

Figure 2.1: The equivalent surplus to avoid a quantity reduction of the public good

When designing a CV study, it is important to consider whether the marginal or the total WTP is captured. The marginal WTP for a quantity change of a public good can be found by differentiating the expenditure function so it equals the Hicksian compensated inverse demand function (Pommerehne, 1987):

$$ES = \frac{\partial E}{\partial q_x} = E_{q_x}(p_y, U^1, q_x). \tag{2.4}$$

[2] Figure 2.1 and its description follow Perman et al. (2003).

In this study the total WTP, which equals the sum of the marginal WTPs, is of interest. It can be shown by the path-dependent integral

$$ES = \int_{q_x^0}^{q_x^1} E(p_y, U^1, q_x) dq_x. \tag{2.5}$$

The functional connections show that the WTP captured in CV studies can serve as a measure for utility.

2.3 Survey and methodology

The aim of the survey was to determine respondents' WTP for the municipal supply of cultural goods in Lüneburg. The supply includes a theater, three museums, a music school, two libraries, an education center for experimental music, a town museum, a center for the promotion of literature, a series of classical concerts and temporary art exhibitions, a center for cultural performances, and measures for the preservation of ancient monuments and buildings. Since the town is comparatively small (about 71.000 inhabitants), it can be assumed that most of the cultural facilities presented in the questionnaire are well known to the respondents. The population of this survey included all inhabitants of the city of Lüneburg who were 18 years old or older. Questionnaires containing a CVM scenario were sent to a random sample of 5,000 people provided by the registration office. Out of the 4,696 letters which could be delivered, about 30 percent (1,447) were filled out and returned.

The scenario includes the implementation of a monthly contribution paid to the town. The amount of this hypothetical contribution will be calculated as the average of all stated WTP amounts so that it is independent of the respondents' income level. It displaces the part of taxes which had been expended for cultural goods, which results in a decreasing individual tax burden. Thus, if the average WTP of all respondents were equal to or lower than the actual tax burden for these goods, the contribution does not imply an additional financial burden.

The chosen elicitation method is a set of presented € amounts. The respondents were asked to mark the amount they would be willing to pay for the supply of cultural goods in Lüneburg (see Appendix 2.A). The NOAA panel argued that this elicitation method "is likely to create anchoring and other forms of bias" (Arrow et al., 2005) so, to reduce those effects, the € amounts were widely ranged in order to avoid giving a clue about what could be the expected or socially acceptable value. Moreover, the set of € amounts was followed by an open ended question to grant the respondents an option to specify their previously stated amount. However, only 3 percent of the respondents answered the follow-up question.

To avoid establishing false incentives, the survey informed respondents that the supply of cultural goods would be restricted if the average WTP were lower than the actual amount spent on cultural goods. Thus, the amount the respondents would have to pay is contingent on the stated WTP, which offers incentives to behave strategically. Nevertheless, the impact of a single stated WTP amount on the amount of the contribution is comparatively small, so that the incentives should be "weak to moderate" (Mitchell and Carson, 1990). However, it implies that respondents need information about how much is paid at the moment (4.70 € per month and capita of the population), although providing this information can cause a strong anchoring bias.

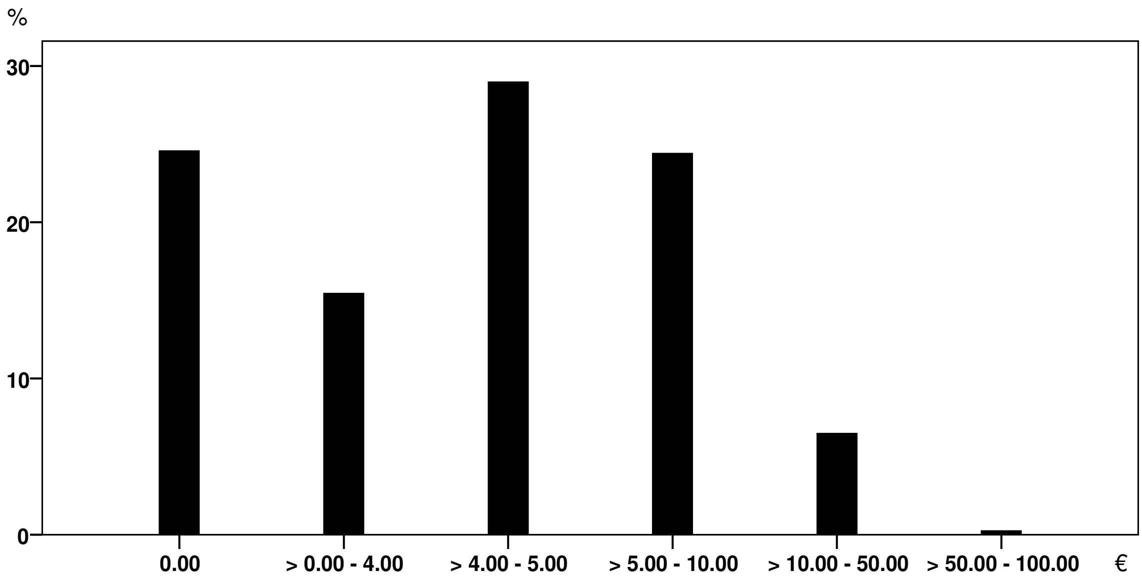

Figure 2.2: Distribution of the stated WTP € amounts (in percent)

Figure 2.2 shows the distribution of the stated WTP amounts. It is apparent that there is a strong anchoring bias since more than 27 percent of all respondents stated a WTP value that range between 4.00 and 5.00 €, which is very close to 4.70 €. Nevertheless, it is important to provide the status quo in order to enable respondents to consider whether they prefer to spend more or less for this good. Moreover, similar information is given in comparable non-hypothetic situations, such as public referenda (see, for example, Frey and Pommerehne (1990) or Schulze and Ursprung (2000)).[3]

[3] For a more detailed discussion, see, for example, Bille Hansen (1997).

2.4 The empirical model

Since the idea is to explore the factors associated with the respondents' preferences for the cultural municipal supply in Lüneburg, the dependent variable in the empirical model is the stated WTP. The first group of independent variables in the model refers to the use value and the non-use values. A dummy variable, *indicator use value*, which divides the respondents into users and non-users, captures the use value generated by cultural goods. The non-user group is defined as respondents who have not visited one of the museums, the theater, one of the libraries, an art exhibition or a concert within a year from the date of the survey. Non-users also do not participate actively in the town's cultural life, for example, in a development association of a museum or in a choir.[4]

In order to capture the all-over acceptance of the non-use concept, the respondents were given four statements concerning possible non-use values attributed to the supply of cultural goods and were asked to state their level of agreement with these statements on a given scale; then the four values were averaged for each respondent. This variable is included in the model as an indicator of the non-use values attributed to the municipal supply of cultural goods.

Further, since Hamburg is easily accessible from Lüneburg and offers a wide range of high quality cultural facilities, its cultural supply presents an alternative to the supply of Lüneburg. This substitutive relationship can decrease the use value related to cultural goods in Lüneburg, so a dummy for using cultural facilities in Hamburg is included.

The second group of independent variables contains dummies for the general interest for culture (medium interest, high/very high interest). The last group of independent variables in this model consists of socio-economic and socio-demographic variables, namely, the respondents' sex, age group, employment status, highest educational achievement, income level and household size. Non-response to required questions relevant to the model's variables reduced the number of qualified surveys to 1,062.

2.5 Descriptive results

The fraction of zero-bids of all respondents who stated a WTP amount is presented in Table 2.1. One-fourth of the 1,316 WTP amounts stated in the survey were zero-bids. If

[4] Representing the "indicator use value" by a dummy variable implicates that the frequency of use is not considered. In other words, the respondents defined as users range from a person who only visited one art exhibition during the period of reference to the theater subscriber and regular user of the library. However, the purpose of this variable is to separate the non-users in order to focus on their stated WTP as an indicator for the existence of positive non-use values.

the respondents stated a WTP equal to zero, they were asked for the reason in a follow up question. 14 percent of them answered that they were generally not interested in cultural goods, while nearly 70 percent reported that they are already paying enough taxes and other contributions. Regarding the latter group of respondents, it is not certain that they have a WTP equal to zero; their WTP may be positive but, because of the payment vehicle offered in the scenario, they stated a zero-bid. Thus, the fraction of zero bids could decrease if, for example, voluntary donations instead of a contribution were proposed[5].

Table 2.1: Zero-bids

Fraction of zero-bids	No. of observations (percent of all stated WTP amounts)
$WTP > 0$	993 (0.75)
$WTP = 0$	323 (0.25)
Reasons for a $WTP = 0$	No. of observations (percent of all zero-bids)
Generally no interest	46 (0.14)
Already paying enough taxes and contributions	225 (0.70)

Table 2.2 presents some basic descriptive results for the variables used in the model. The mean of the WTP regarding the complete sample is 5.63 €, which is significantly higher than the 4.70 € amount given for subsidies, but which is the product of a wide spread of response, from 0 € to 100 €. Only one respondent stated a WTP greater than 100 €. As the amount was not specified in the follow-up question, the answer is not considered for further analysis.

Nearly 84 percent of all respondents were users of cultural goods, which means that they either attended one of the listed cultural goods at least one time during the previous year or they participated actively in the town's cultural life in the previous year.[6] The remaining 16 percent of the respondents could consume private cultural goods, like CDs, books, private theater attendance or other public cultural goods, such as the municipal supply of other cities, for example Hamburg. Nevertheless, they did not report using the goods which should be valuated in this study so, in the context of this study, they are defined as non-users.

[5] The guideline proposed by Bateman et al. (2002) says that a payment vehicle should be used "which is likely to be employed in a real world decision"; therefore, in this survey, a coercive contribution was chosen. Although it is not compatible with the German municipal law, the contribution approximates the taxes spent on cultural subsidies.

[6] Between 36 percent (art exhibition) and 59 percent (theater) of the respondents used cultural goods at least once, and 14 percent participated actively in the town's cultural life.

Table 2.2: Descriptive statistics, complete sample

Variables	N^o of obs.	Mean	Std. Dev.	Minimum	Maximum
WTP in €	1316	5.63	7.2858	0	100
User (1 = yes)	1447	0.8397	0.3670	0	1
Female (1 = yes)	1439	0.5650	0.4959	0	1
26 - 35 years old (1 = yes)	1441	0.1867	0.3898	0	1
36 - 55 years old (1 = yes)	1441	0.2302	0.4802	0	1
56 years and older (1 = yes)	1441	0.3400	0.4739	0	1
Self-employed (1 = yes)	1413	0.0849	0.2789	0	1
Civil servant (1 = yes)	1413	0.0913	0.2881	0	1
Employee (1 = yes)	1447	0.3386	0.4734	0	1
Trainee/Student (1 = yes)	1447	0.1285	0.3348	0	1
Housewife/Househusband (1 = yes)	1413	0.0665	0.2493	0	1
Pensioner (1 = yes)	1413	0.2435	0.4293	0	1
Unemployed (1 = yes)	1447	0.0346	0.1827	0	1
Lower education (1 = yes)	1386	0.3939	0.4888	0	1
Higher sec. schooling (1 = yes)	1386	0.2330	0.4229	0	1
University degree (1 = yes)	1386	0.3716	0.4834	0	1
Income < 1999 € (1 = yes)	1244	0.5338	0.4991	0	1
Income 2000 - 2999 € (1 = yes)	1244	0.2211	0.4151	0	1
Income 3000 - 3999 € (1 = yes)	1244	0.1463	0.3536	0	1
Income > 4000 (1 = yes)	1244	0.0989	0.2986	0	1

To explain the WTP in more detail, the differences between the means of the users and the non-users of the municipal supply of cultural goods in Lüneburg are presented in Table 2.3. Although, the self-selected non-users stated that they did not use one of the listed cultural facilities and did not participate actively in the cultural life, 55 percent of them stated a positive WTP. This result strongly suggests the existence of non-use values. The mean WTP of the non-users was 3.14 €, which is significantly lower than the mean WTP of the users. However, if the users had non-use values of the same size, the non-use values would constitute over 50 percent of the users' total mean WTP.

The user group was made up of significantly more civil servants and employees than the non-user group, a finding which may be related to the relatively stable income situation of these two occupational categories. By contrast, the proportion of housewives and househusbands was significantly smaller in the user group. The two groups also differ in educational and income levels; 53 percent of the non-users reported no or low educational achievement, which is significantly less education than that reported by the user group, and a significantly lower proportion of non-users reported having a university degree. These findings suggest a lower level of cultural education in the non-user group, leading to

Table 2.3: Descriptive statistics, compared for users and non-users

Variables	Mean users	Mean non-users	P-value
WTP in €	6.08	3.14	0.0000
Female (1 = yes)	0.5742	0.5209	0.1514
26 - 35 years old (1 = yes)	0.1957	0.1495	0.0878
36 - 55 years old (1 = yes)	0.3724	0.3084	0.0650
56 years and older (1 = yes)	0.3287	0.3692	0.2577
Self-employed (1 = yes)	0.0879	0.0725	0.4359
Civil servant (1 = yes)	0.0980	0.0580	0.0305
Employee (1 = yes)	0.3528	0.2837	0.0413
Trainee/Student (1 = yes)	0.1253	0.1535	0.2869
Housewife/Househusband (1 = yes)	0.0595	0.1063	0.0388
Pensioner (1 = yes)	0.2353	0.2609	0.4394
Unemployed (1 = yes)	0.0330	0.0465	0.3766
Lower education (1 = yes)	0.3701	0.5327	0.0000
Higher sec. schooling (1 = yes)	0.2326	0.2312	0.9645
University degree (1 = yes)	0.3964	0.2312	0.0000
Income < 1999 € (1 = yes)	0.5146	0.6529	0.0006
Income 2000 - 2999 € (1 = yes)	0.2263	0.1941	0.3309
Income 3000 - 3999 € (1 = yes)	0.1549	0.0882	0.0069
Income > 4000 (1 = yes)	0.1042	0.0647	0.0624

a lower level of cultural use. Similar results on income levels may also explain lower levels of cultural use. At the same time the non-users have a significantly higher proportion of respondents with an income level less than 2000 € and a lower proportion in the two highest income groups compared to the users. These results confirm the current hypotheses in cultural economics that a lower income level, as well as a lower education level, is negatively correlated with the use of (and, therefore, the WTP for) cultural goods (see, for example, Frey and Pommerehne (1990), Withers (1980), or Dickenson (1997)).

2.6 Multivariate results

This Section presents the results of the multivariate analysis. The empirical model presented in Section 2.4 is first estimated by OLS, followed by a Tobit regression. In a last step, a QR is applied and the results are compared with those of the other methods. The intention of the multivariate analysis is to identify factors associated with the respondents' WTP. All regression estimates are based on 1,062 observations.

To create an initial benchmark for the assessment of the QR results, an OLS regression model[7] is estimated. The results presented in Table 2.4 show that only a few variables have a significant influence on the WTP. In accordance with the theory of cultural economics, the results show that higher indicators for individual use value, as well as for non-use values, ceteris paribus lead to a higher WTP for the municipal supply in Lüneburg.

Table 2.4: Results for different regression models of the WTP for cultural goods in Lüneburg[a,b]

	Model 1 OLS regression	Model 2 Tobit regression	Model 3 Median regression
Indicator use value	1.080 (0.041)	1.598 (0.048)	1.125 (0.017)
Indicator non-use values	0.761 (0.000)	1.328 (0.000)	0.685 (0.000)
Attendance at cultural activities in Hamburg	0.311 (0.151)	0.462 (0.142)	0.040 (0.890)
Medium interest	0.600 (0.312)	1.323 (0.066)	1.107 (0.026)
High/very high interest	1.124 (0.098)	1.828 (0.025)	1.416 (0.008)
Female	0.374 (0.404)	0.580 (0.273)	-0.084 (0.771)
26 - 35 years old	1.905 (0.146)	2.018 (0.051)	0.060 (0.914)
36 - 55 years old	1.489 (0.225)	1.459 (0.193)	-0.597 (0.343)
56 years and older	1.433 (0.248)	1.191 (0.352)	-0.717 (0.316)
Self-employed	1.534 (0.066)	1.602 (0.093)	1.324 (0.062)
Civil servant	-0.132 (0.823)	-0.289 (0.742)	0.002 (0.997)
Trainee/student	1.823 (0.087)	2.141 (0.040)	-0.332 (0.543)
Housewife/househusband	-0.190 (0.830)	-0.012 (0.992)	0.506 (0.414)
Pensioner	0.382 (0.545)	0.286 (0.758)	-0.051 (0.913)
Unemployed	-0.691 (0.342)	-1.425 (0.305)	-1.094 (0.071)
Higher secondary schooling	0.760 (0.122)	1.129 (0.136)	0.399 (0.353)
University degree	1.191 (0.010)	1.829 (0.004)	0.668 (0.032)
Income 2000 - 2999 €	1.201 (0.026)	1.624 (0.018)	0.913 (0.026)
Income 3000 - 3999 €	1.108 (0.059)	1.676 (0.030)	0.994 (0.026)
Income > 4000 €	1.883 (0.012)	2.002 (0.032)	1.694 (0.017)
N^o adults living in household	0.181 (0.595)	0.181 (0.513)	0.220 (0.160)
N^o children living in household	0.274 (0.363)	0.299 (0.221)	0.050 (0.735)
Constant	-4.139 (0.020)	-10.205 (0.000)	-1.996 (0.048)
N^o of observations	1062	1062	1062
R^2	0.0907		
Pseudo R^2		0.0222	0.0560

[a]P-values are reported in parentheses behind the coefficient estimate. [b]All model estimates are obtained by using Stata 10.0.

[7] The OLS regression model was estimated with robust standard errors.

In the survey, non-use values are captured on an ordinal scale, which makes it difficult to reveal their correct scope. Still, compared to those respondents who have no educational achievement or have not completed higher secondary schooling (Abitur), the respondents with a university degree have a significantly higher WTP. The results also show a significant impact on the stated WTP amounts by the three income levels above 2000 €, compared to those with lower income levels.

Since the payment vehicle in this study is a set of presented WTP amounts censored down to zero, additionally a Tobit regression can be applied (see, for example, Santagata and Signorello (2000)). Although the magnitude of coefficients cannot be interpreted in the same way as the OLS estimates, the pattern of signs and the level of significance of the coefficients can be compared between both models (McDonald/Moffitt, 1980). For this reason, a Tobit regression is applied to validate these two dimensions of the OLS estimates.

All signs of coefficients of the OLS model are validated by the Tobit model, and all significant coefficients estimated by the OLS regression are confirmed. Moreover, the Tobit regression shows a significant impact on the WTP for those respondents who stated to have high or very high interest in culture in general, compared with those who stated to have low or no interest in culture. Although these results may appear trivial, they validate the respondents' self assessment regarding their preferences for culture and cultural goods. Finally, the Tobit model indicates a significantly higher WTP for trainees and students compared to employees, all other factors remaining the same, which may be explained by the fact that trainees and students normally have more leisure time than other workers. To sum up, the results of the Tobit regression validate the OLS estimates, which can be used as a benchmark for further analysis.

The third model used in the multivariate analysis is a QR model, which produces a "more focused view of the application than could be achieved by looking exclusively at conditional mean models" like OLS or Tobit (Koenker, 2005). Hence, in this study the model can provide more detailed information about the respondents' WTP and can thereby account for the heterogeneity of preferences. While the OLS and the Tobit regression models include the squared residuals, the coefficients for the QR are obtained by minimizing the sum of residuals, which makes the model less sensitive to outliers Fahrmeir et al. (2007). Therefore, the QR is particularly suitable for this analysis, as nearly 94 percent of all results in the study's data set lie between 0 € and 10 €, although the total range is 100 € (cp. Figure 2.2). The QR provides the opportunity to compare the coefficients at different points of the distribution. In addition to the quartiles (0.25, 0.50, 0.75), the 0.90 quantile is analyzed because the coefficients' impact on higher

WTP amounts is of particular interest. Table 2.5 shows the different quantiles and the corresponding WTP amounts.

Table 2.5: Distribution of the WTP over the quantiles

Quantile	0.25	0.50	0.75	0.90
WTP in €	1.00	5.00	7.50	10.00

When the results of the median regression (at the 0.50 point of the distribution) are contrasted with the OLS estimations listed in Table 2.4, all significant coefficients have the same sign, and nearly all are similar in magnitude. The only exception is the dummy for having a university degree, which has a lower impact at the median of the QR model. As Table 2.5 shows, this comes about because having a university degree has an impact on WTP not exceeding 2 €, which is significant on the 1 percent level; hence, the OLS estimate for this variable is influenced strongly by respondents who stated lower WTP amounts. Given that more than 24 percent of the respondents stated a WTP of zero, the 0.25 quantile can be interpreted as the critical point in the decision for or against a positive WTP. Therefore, having completed higher secondary schooling seems to have an impact on the decision for a positive WTP, but no relevant impact on the amount of the WTP.

In comparing the results over the different quantiles presented in Table 2.6, only the coefficient for the variable "high or very high interest for culture in general," compared to those who have no or a low interest, is statistically significant over all analyzed quantiles. Although the coefficients are rising over the quantiles for all but the 0.50 quantile, the relative impact on the WTP amount decreases. The coefficient for the medium-interest variable is significant only for the 0.25 and 0.50 quantile, which is consistent with the previous results since it can explore only factors associated with lower WTP amounts. The indicator for the use value has an impact on the WTP up to the 0.50 quantile. Compared to this, the estimated coefficients for the indicator of non-use values are significant at an error level of 0 percent for the 0.25, 0.50 and 0.75 quantiles, which points out that the non-use values can be associated with the respondents' WTP up to 7.50 €. However, the significant coefficients of the non-use value indicator are comparatively small and clearly lower than the use value estimates. Beyond that, the estimated coefficients for both indicators are constant in absolute magnitude over the quantiles, which suggests a decreasing relative impact on the WTP.

Among those in the income class of 2000-2999 €, there is an impact on the stated WTP for the 0.50 and the 0.75 quantiles, compared to the base category of income un-

Table 2.6: Results for the QR of the WTP for cultural goods in Lüneburg[a]

	Quantile regression			
	0.25	0.50	0.75	0.90
Indicator use value	1.1109 (0.007)	1.125 (0.017)	1.0415 (0.135)	-0.1875 (0.893)
Indicator non-use values	0.7262 (0.000)	0.685 (0.000)	0.8168 (0.000)	0.175 (0.657)
Attendance at cultural activities in Hamburg	0.0653 (0.654)	0.040 (0.890)	0.6306 (0.134)	0.375 (0.619)
Medium interest	0.8678 (0.027)	1.107 (0.026)	1.0525 (0.065)	0.4875 (0.596)
High/very high interest	1.4755 (0.002)	1.416 (0.008)	1.9315 (0.010)	2.225 (0.044)
Female	0.1360 (0.681)	-0.084 (0.771)	-0.3778 (0.346)	-0.1938 (0.805)
26 - 35 years old	0.4778 (0.407)	0.060 (0.914)	1.2543 (0.098)	2.6375 (0.054)
36 - 55 years old	0.4846 (0.435)	-0.597 (0.343)	0.5743 (0.485)	2.4563 (0.062)
56 years and older	0.4005 (0.545)	-0.717 (0.316)	0.4808 (0.634)	2.5438 (0.179)
Self-employed	0.4206 (0.509)	1.324 (0.062)	0.6433 (0.330)	1.35 (0.645)
Civil servant	-0.1996 (0.641)	0.002 (0.997)	-0.1751 (0.792)	-0.0438 (0.972)
Trainee/student	0.2816 (0.605)	-0.332 (0.543)	0.4501 (0.610)	2.9125 (0.099)
Housewife/househusband	-0.6622 (0.343)	0.506 (0.414)	-0.0384 (0.962)	-0.0875 (0.957)
Pensioner	-0.8979 (0.055)	-0.051 (0.913)	0.1130 (0.889)	0.1813 (0.911)
Unemployed	-0.7032 (0.213)	-1.094 (0.071)	-0.5200 (0.676)	-0.5875 (0.810)
Higher secondary schooling	0.8004 (0.066)	0.399 (0.353)	0.7422 (0.207)	0.0188 (0.984)
University degree	1.2008 (0.001)	0.668 (0.032)	0.7878 (0.114)	0.2563 (0.783)
Income 2000 - 2999 €	0.8768 (0.054)	0.913 (0.026)	1.4939 (0.003)	1.8313 (0.077)
Income 3000 - 3999 €	1.2336 (0.003)	0.994 (0.026)	1.9722 (0.001)	1.8438 (0.064)
Income > 4000 €	1.0317 (0.049)	1.694 (0.017)	2.0774 (0.002)	4.7875 (0.082)
N^o adults living in household	0.1730 (0.311)	0.220 (0.160)	0.0470 (0.830)	-0.1063 (0.858)
N^o child. living in household	-0.0176 (0.904)	0.050 (0.735)	0.0494 (0.807)	0.4063 (0.634)
Constant	-5.1556 (0.000)	-1.996 (0.048)	-1.4577 (0.362)	4.2063 (0.172)
N^o of observations	1062	1062	1062	1062
Pseudo R^2	0.1277	0.0560	0.0857	0.0200

[a] P-values are reported in parentheses behind the coefficient estimate.

der 2000 €. For the income classes of 3000-3999 € and 4000 € and more, there are significant coefficients for all but the 0.90 quantile, compared with the base category. For every quantile, the magnitude of the significant coefficients increases with higher incomes, which shows the meaningful impact of income level on WTP for cultural goods.

Overall, the findings suggest that, the higher the WTP, the less well the QR model is able to explore influencing factors. This is reflected in the decreasing number of significant coefficients and in the coefficients' decreasing relative impact on the WTP amounts. Therefore, as most of the variables included in the model refer to socio-economic and socio-demographic characteristics, they have a bearing on zero bids and on low WTP amounts, but almost none on higher WTP amounts. However, the very low R^2 values indicate that only a small fraction of the WTP's sample variation can be explained by the econometric model. Therefore, the results should be interpreted with caution.

2.7 Conclusion

This analysis studied the WTP for cultural goods using the example of the municipal supply of cultural goods in Lüneburg, Germany. For this purpose, a dataset of 1,447 questionnaires was analyzed using descriptive statistics, as well as OLS, Tobit and QR models.

First, the results of the survey, particularly the means, suggest that the population of Lüneburg agrees with the amount spent on the municipal supply of cultural goods by the public authorities. Moreover, non-use values are detected because the mean WTP of the non-users is positive and because the acceptance levels of statements concerning possible non-use values attributed to the supply of the town's cultural facilities was high. These results indicate the existence of positive external or non-use effects, which can legitimate economically the subsidies paid by the public authorities. However, the results must be considered carefully because of the strong anchoring bias that results from revealing the actual tax amount spent on the town's cultural facilities.

The multivariate analysis focuses on the QR model, which is applied in order to take the heterogeneity of responses into account. As a benchmark, an OLS model, which is conditional on the mean, is first estimated, and then compared with the results of the QR model. For example, for the dummy for having a university degree, the OLS shows the expected significant impact on the stated WTP. By comparison, the QR model reveals that the variable has a decreasing impact on WTP up to 5.00 €, but no impact for higher stated WTP amounts; at the same time, there is a significant impact of higher income on higher WTP amounts up to 7.50 €. In this study, the results point out that higher WTP amounts for the supply of cultural goods are less a question of education than of income, suggesting that it would make sense to concentrate on internalizing the demand of people with lower incomes, for example, via reduced entrance fees.

Moreover, as only the variable "high/very high interest" for culture in general shows a significantly positive influence over all analyzed quantiles of the WTP distribution, one who wanted to encourage additional spending on culture could aim to promote cultural education in schools to arouse the interest in and increase the WTP for culture. The only variable which had ceteris paribus a significant impact only at the 0.90 quantile, which corresponds to a WTP of 10 €, is the dummy for age 26-35. Hence, policymakers could consider offering more events and performances targeted to this age group in order to reap additional benefits.

Overall, the results of the multivariate analysis show that the QR provides more detailed information useful with regard to implications for cultural policy, compared to traditionally applied methods for valuation data like OLS or Tobit. Especially in the absence of a market, as is the case, to a large extent, in the German example, such information can be useful in accounting for the people's preferences.

2.A The valuation question presented in the questionnaire

Imagine that the municipality of Lüneburg plans to implement a mandatory contribution to finance the cost of cultural facilities. Every citizen 18 years or older has to pay the contribution, which is the same for everyone. In order to determine the amount of the contribution, the public authorities need to know the citizens' preferences regarding how much should be spent on cultural facilities, and the contribution will be calculated as the average of all amounts stated on the survey. If the average is lower than or equal to the amount currently spent in the form of taxes (4.70 €), the supply of cultural events/facilities must be restricted.

Please mark the € amount which you are willing to pay monthly for the municipal supply of cultural goods in Lüneburg in the form of the described contribution:

0.00 €	☐	7.50 €	☐	40.00 €	☐
1.00 €	☐	10.00 €	☐	50.00 €	☐
2.00 €	☐	12.50 €	☐	75.00 €	☐
3.00 €	☐	15.00 €	☐	100.00 €	☐
4.00 €	☐	20.00 €	☐	> 100.00 €	☐
5.00 €	☐	30.00 €	☐	n.a.	☐

If the amount you are willing to pay monthly is not listed above, please specify your answer here: __________ €[8].

[8] The complete questionnaire in German is available on request from the author.

3 The Efficiency of German Public Theaters: A Stochastic Frontier Analysis Approach

3.1 Introduction

Like in most other European countries, the amount of public funding of cultural institutions in Germany is relatively high. This is due to national cultural policy aims such as providing a cultural infrastructure and preserving cultural heritage. In particular, performing arts institutions with cost-intensive production processes and relatively low revenues rely heavily on public funding; on average, 81 percent of the income of German public theaters comes from subsidies granted by local, federal or European public authorities (Deutscher Bühnenverein (German Stage Association), 2008).

Given this high level of public funding and the increasing cost-pressure on public budgets, the economic performance or efficiency of German public theaters has become an interesting economic issue. In particular, public authorities who decide on the distribution of public budgets need reliable performance indicators in order to promote an optimal, cost-minimizing employment of resources. In this context, the application of benchmarking methods in public non-profit sectors such as higher education, health care or cultural services has become more important in recent years. Benchmarking or efficiency analysis methods compare the economic performance of an individual firm to a reference set of firms; that is, they detect the "best-practice" firms and provide clues to the management of non-profit institutions as well as for public authorities for a more efficient use of resources.

This paper gives further insights on the employment of resources for performing arts productions. In contrast to other studies in this area that have used the non-parametric data envelopment analysis method, we use the parametric stochastic frontier analysis approach to evaluate the efficiency of public theaters in Germany. Compared to non-parametric methods, parametric approaches have the advantage of accounting for statistical noise. Further, in the case of panel data, a variety of model specifications allows to account for observed and unobserved heterogeneity.

To model the production technology, we employ an input distance function that requires no specific behavior assumptions, such as cost-minimization or profit-maximization, and estimates the degree to which a theater could reduce its use of inputs to produce a certain level of output. Further, in order to compare our findings to those of previous studies that have utilized a cost function approach and, in particular, to test their assumption of cost-minimizing behavior, we also employ a cost function approach. To our knowledge, this is the first study on performing arts institutions that applies both an input distance function and a cost function model.

Moreover, since several studies have shown that failing to account for unobserved firm-specific heterogeneity in performance measurement can result in overestimated inefficiency values (see, for example Farsi et al., 2005; Greene, 2005*a*,*b*), several panel data models that differ in their ability to account for unobserved heterogeneity are applied in order to evaluate the impact of unobserved heterogeneity on the efficiency estimates. In particular, we compare the estimation results of four different stochastic frontier models for panel data: the fixed effects model of Schmidt and Sickles (1984), the random effects model of Pitt and Lee (1981), the true random effects model proposed by Greene (2005*a*,*b*), and the true random effects model with a Mundlak (1978) adjustment, as suggested by Farsi et al. (2005). The panel data set employed consists of 174 German public theaters and covers the 1991/1992 season through the 2005/2006 season.

The paper is organized as follows. Section 3.2 discusses theoretical aspects of the financing of German public theaters and summarizes previous research on the economic performance measurement of theaters. Specifications of the applied models are introduced in Section 3.3, followed by a presentation of the estimation approach in Section 3.4, and a description of the data in Section 3.5. Estimation results of the empirical analysis are presented in Section 3.6, and Section 3.7 concludes the paper.

3.2 Theoretical background and previous research

The current analysis investigates the efficiency of public theaters in Germany that are funded by public authorities. Agreements between the public authorities and the theaters set the amount of funds granted to the theaters for periods of time that can span several seasons, so theaters can plan the number of new productions and performances and the corresponding factor input for the coming seasons.

According to Niskanen's model of bureaucracy (1971), and its further development by Migué and Bélanger (1974), managers of organizations in the public sector try to maximize either the quantity of output or the resources granted by public authorities because these two parameters are positively correlated with the arguments in their utility functions. As Taalas proposed (1997), such arguments can be ”desire for large audiences, high quality of productions, or large budgets.” Thus, according to Niskanen’s model, a higher output or a higher amount of available resources increases managers’ utility.

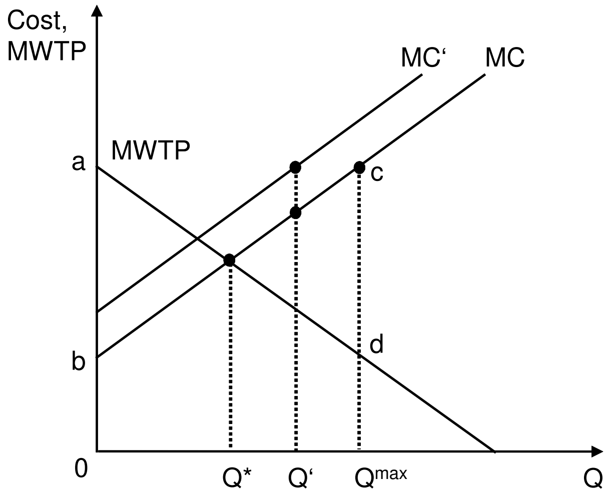

Figure 3.1: Budget maximization

In Figure 3.1 Q^* denotes the optimal level of output that results if no information asymmetry exists. That is, the marginal willingness to pay (MWTP) equals the real marginal costs (MC). However, if it is assumed that only the theater managers are fully aware of the minimum costs, this information asymmetry enables them to maximize their budget and to extend the output beyond the market equilibrium. This results in the output level Q^{max} where the utility - given by the area under the peoples’ MWTP curve ($0adQ^{max}$) - equals total cost - given by the area under the MC curve ($0bcQ^{max}$). Since for any output higher than Q^{max} the net utility is negative, any output right of Q^{max} would not be accepted by the public authorities. Further, if the theater managers are interested in extending their available funds for a specific output level, for example, to hire famous actors or to indulge in complex and expensive stage designs they could claim higher than the minimum costs. By representing the claimed higher minimum costs with the marginal cost curve MC’ this results in the budget maximizing output level Q'.

Following the model of bureaucracy and its further development, in the case of German public theaters, where the amount of funds is fixed by the agreements between the theaters and the public authorities that fund them, theater managers can utilize the information asymmetry regarding the minimum costs in order to maximize their utility. However, one might argue that the assumption of information asymmetry between theater managers and public authorities cannot be sustained. The German stage association (Deutscher Bühnenverein) publishes annual statistics that provide information on the revenues and expenditures of all German public theaters. Although, these statistics provide a general overview on the production structure of the theaters they do not allow to gain comprehensive theater-specific information about the cost-minimizing input employment without a detailed and time-consuming cost structure analysis. Assuming that budget and time constraints do not allow such a detailed analysis by the public authorities in each single case, at least a partial information asymmetry remains.

Referring to the subsidy system, the promotion of a cost-minimizing employment of the granted resources is intended by the possibility to transfer unspent public funds from one season to the next and, thus, to increase the budget for the next season. However, the possibility for a higher budget in a subsequent season is a rather weak incentive for spending less than the available funds in the current season because the theater managers must fear that the subsidies will be reduced in case of recurrent savings and transfers. Altogether, considering the theoretical explanations and the actual subsidy system of public theaters in Germany, it is likely that the assumption of cost-minimizing behavior is violated.

Several empirical studies have been conducted on the cost structure of performing arts productions to assess potential economies of scale (see, for example, Throsby, 1977; Globerman and Book, 1974).[1] These studies have all estimated a cost function, which implies that the assumption of cost-minimizing behavior holds. Moreover, most newer studies have used panel data sets to gain further information and to consider technical progress. For example, Fazioli and Filippini (1997) used a dataset of 28 Italian theaters during the period 1991-1993; to estimate a short-run cost function, they assumed that theater managements minimize the variable costs for the production of performances and found economies of scale and scope within the production process. Therefore, they suggested that established productions should be performed more often in different theaters in order to take advantage of the size effects and that, because of the economies of scope in different theater activities, theater groups should avoid specializing in particular types of performances.

Taalas (1997) was among the first to address possible inefficiencies regarding the employment of inputs in performing arts productions. She analyzed the cost structure of

[1] For a detailed overview, see Marco-Serrano (2006).

37 Finnish theaters during 1985-1993 and found, as in the other studies, that the cost function estimates indicated economies of scale in production. In order to test for allocative efficiency, Taalas compared the estimated shadow prices with the market prices and found significant differences, so she rejected the assumption of allocative efficiency with respect to the use of inputs. Her estimation results showed that, on average, the observed total costs exceeded the minimum costs by nearly 5 percent. Taalas also suggested that the violation of the cost-minimizing behavior may have been caused either by the restrictions implied through public subsidies or by rent-seeking by theater managers. Therefore, as Taalas noted, "a need for a detailed analysis of the extent of technical inefficiencies is accentuated. A full blown examination of both allocative and technical efficiencies in the production of cultural services, however, necessitates the application of cost or production frontiers."

So far, only a few studies have used frontier techniques to identify possible sources of inefficiencies in the production process of performing arts. Marco-Serrano (2006) measured the technical efficiency of an unbalanced panel of Spanish theaters organized in a network in the Valencia region during 1995-1999. His results, obtained by means of data envelopment analysis, showed a decrease in the efficiency scores over the analyzed period, over which the network expanded continuously because of the incorporation of new theaters.

Another study that applied data envelopment analysis was conducted by Tobias (2003), who analyzed the cost efficiency of German Public Theaters for the seasons 1995/96-1998/99 using the same data source as in the present article. His overall findings reported average cost inefficiencies of about 11 percent.

Overall, previous studies on the cost structure of public theaters have focused on economies of scale and scope, although more recent work has concentrated on possible inefficiencies in production as a result of the finding that the assumption of cost-minimizing behavior is likely to be violated. Thus far, data envelopment analysis has been applied to measure the inefficiencies in the context of performing arts productions, but the current study uses a stochastic frontier analysis approach for panel data that accounts for stochastic influences within the data.

3.3 Model specification

In order to analyze the economic performance of German public theaters, we apply an input distance function approach. Compared to a cost function approach, the input distance function approach requires no preimposed behavioral assumption, such as cost-minimization, which is likely to be violated in the case of the highly subsidized German public theater sector. Nevertheless, in order to compare our findings to previous studies that have utilized a cost function approach and in order to test their assumption of cost-minimizing behavior, we also employ a cost function approach. If our hypothesis that German public theaters do not show a cost-minimizing behavior is supported, the coefficient estimates of both functions must differ because the linkage between the cost and the distance function, based on the duality theory, would be lost.

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:

$$D_I(x, y) = \max\{\theta : (x/\theta) \in L(y)\}, \tag{3.1}$$

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 (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[2], which can be calculated by the reciprocal of the input distance function:

$$TE(x, y) = 1/D_I(x, y) \leq 1. \tag{3.2}$$

Technical efficiency values equal to one identify efficient firms using an input vector located on the production frontier. Technical efficiency values between zero and one belong to inefficient firms using 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 (Coelli et al., 2005).

[2] Note that the presented efficiency analysis is based solely on a technical view of production and does not account for quality aspects due to lack of data.

The translog input distance function for K (k=1,...,K) inputs and M (m=1,...,M) outputs can be written as

$$\begin{aligned} ln\, D_{it}^{I} \;=\;& \alpha + \sum_{m=1}^{M} \alpha_m \, ln\, y_{mit} + \frac{1}{2} \sum_{m=1}^{M} \sum_{n=1}^{M} \alpha_{mn} \, ln\, y_{mit} \, ln\, y_{nit} + \sum_{k=1}^{K} \beta_k \, ln\, x_{kit} \\ & + \frac{1}{2} \sum_{k=1}^{K} \sum_{l=1}^{K} \beta_{kl} \, ln\, x_{kit} \, ln\, x_{lit} + \sum_{k=1}^{K} \sum_{m=1}^{M} \gamma_{km} \, ln\, x_{kit} \, ln\, y_{mit} \\ & + \theta_t \, t + \frac{1}{2} \theta_{tt} \, t^2 + \sum_{k=1}^{K} \lambda_{kt} \, ln\, x_{kit} \, t + \sum_{m=1}^{M} \phi_{mt} \, ln\, y_{mit} \, t + \sum_{s=1}^{S} \psi_s \, z_{sit}, \end{aligned} \tag{3.3}$$

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

$$\alpha_{mn} = \alpha_{nm}, \quad (m, n = 1, 2, ..., M) \quad \text{and} \quad \beta_{kl} = \beta_{lk}, \quad (k, l = 1, 2, ..., K), \tag{3.4}$$

and linear homogeneity in inputs is given if

$$\sum_{k=1}^{K} \beta_k = 1, \quad \sum_{l=1}^{K} \beta_{kl} = 0, \quad \sum_{k=1}^{K} \gamma_{km} = 0, \quad \text{and} \quad \sum_{k=1}^{K} \lambda_{kt} = 0. \tag{3.5}$$

Imposing the homogeneity restrictions by normalizing the distance term and the inputs in Equation 3.3 by one of the inputs (Lovell et al., 1994), and replacing the negative log of the distance term $-ln\, D_{it}^{I}$ with an error term ε_{it}, yields the estimable form of the translog input distance function.[3] The function can be written as

$$\begin{aligned} -\, ln\, x_{Kit} \;=\;& \alpha + \sum_{m=1}^{M} \alpha_m \, ln\, y_{mit} + \frac{1}{2} \sum_{m=1}^{M} \sum_{n=1}^{M} \alpha_{mn} \, ln\, y_{mit} \, ln\, y_{nit} + \sum_{k=1}^{K-1} \beta_k \, ln\, x_{kit}^{*} \\ & + \frac{1}{2} \sum_{k=1}^{K-1} \sum_{l=1}^{K-1} \beta_{kl} \, ln\, x_{kit}^{*} \, ln\, x_{lit}^{*} + \sum_{k=1}^{K-1} \sum_{m=1}^{M} \gamma_{km} \, ln\, x_{kit}^{*} \, ln\, y_{mit} \\ & + \theta_t \, t + \frac{1}{2} \theta_{tt} \, t^2 + \sum_{k=1}^{K-1} \lambda_{kt} \, ln\, x_{kit}^{*} \, t + \sum_{m=1}^{M} \phi_{mt} \, ln\, y_{mit} \, t + \sum_{s=1}^{S} \psi_s \, z_{sit} + \varepsilon_{it}, \end{aligned} \tag{3.6}$$

[3] The symmetry restrictions in Equation 3.4 are imposed during estimation.

where $x^*_{kit} = (x_{kit}/x_{Kit})$.

If it is assumed that the firms follow a cost-minimization behavior and that they take input prices as given, economic theory implies duality between the input distance function and the cost function approach. Following Shephard (1953), the dual cost function can be defined as:

$$C(x,y) = \min_x \{w'x : x \in L(y)\} = \min_x \{w'x : D_I(x,y) \geq 1\}, \tag{3.7}$$

where $L(y)$, x and y are as defined above; and w' is a strictly positive input price vector, $w = (w_1, ..., w_K)' \in \mathbb{R}^K_{++}$. The function is non-negative and homogenous of degree one in input prices and satisfies the economic regularity conditions of monotonicity and concavity, that is, the function is non-decreasing and concave in input prices and non-decreasing in outputs (Färe and Primont, 1995).

Using a translog functional form, the cost function in Equation 3.7 can be written as:

$$\begin{aligned} ln\, C_{it} &= \alpha + \sum_{m=1}^{M} \alpha_m \, ln\, y_{mit} + \frac{1}{2} \sum_{m=1}^{M} \sum_{n=1}^{M} \alpha_{mn} \, ln\, y_{mit} \, ln\, y_{nit} + \sum_{k=1}^{K} \beta_k \, ln\, w_{kit} \\ &+ \frac{1}{2} \sum_{k=1}^{K} \sum_{l=1}^{K} \beta_{kl} \, ln\, w_{kit} \, ln\, w_{lit} + \sum_{k=1}^{K} \sum_{m=1}^{M} \gamma_{km} \, ln\, w_{kit} \, ln\, y_{mit} \\ &+ \theta_t \, t + \frac{1}{2} \theta_{tt} \, t^2 + \sum_{k=1}^{K} \lambda_{kt} \, ln\, w_{kit} \, t + \sum_{m=1}^{M} \phi_{mt} \, ln\, y_{mit} \, t + \sum_{s=1}^{S} \psi_s \, z_{sit}, \end{aligned} \tag{3.8}$$

where C_{it} are the total costs; w_k denotes the k-th input price (k=1,...,K); and all other variables and parameters are as defined above.

Just as for the input distance function, the restrictions defined in Equation 3.4 and 3.5 must be valid in order to guarantee symmetry and linear homogeneity in input prices of the cost function. Imposing the homogeneity restrictions by normalizing total costs and the input prices in Equation 3.8 by one of the input prices, and adding an error term ε_{it}, yields the estimable form of the translog cost function. The function can be written as:

$$\begin{aligned} -\, ln\, C^*_{it} &= \alpha + \sum_{m=1}^{M} \alpha_m \, ln\, y_{mit} + \frac{1}{2} \sum_{m=1}^{M} \sum_{n=1}^{M} \alpha_{mn} \, ln\, y_{mit} \, ln\, y_{nit} + \sum_{k=1}^{K-1} \beta_k \, ln\, w^*_{kit} \\ &+ \frac{1}{2} \sum_{k=1}^{K-1} \sum_{l=1}^{K-1} \beta_{kl} \, ln\, w^*_{kit} \, ln\, w^*_{lit} + \sum_{k=1}^{K-1} \sum_{m=1}^{M} \gamma_{km} \, ln\, w^*_{kit} \, ln\, y_{mit} \\ &+ \theta_t \, t + \frac{1}{2} \theta_{tt} \, t^2 + \sum_{k=1}^{K-1} \lambda_{kt} \, ln\, w^*_{kit} \, t + \sum_{m=1}^{M} \phi_{mt} \, ln\, y_{mit} \, t + \sum_{s=1}^{S} \psi_s \, z_{sit} + \varepsilon_{it}, \end{aligned} \tag{3.9}$$

where $C_{it}^{*} = (C_{it}/w_{Kit})$ and $w_{kit}^{*} = (w_{kit}/w_{Kit})$.[4]

In addition to the homogeneity and symmetry restrictions, the input distance function and the cost function must satisfy the regularity conditions of monotonicity and concavity. If these conditions are violated, the estimated parameters are not consistent with economic theory and, hence, are not reliable (Sauer et al., 2006). For example, a monotonicity-violating input distance function will provide incorrectly signed elasticity estimates and implies the economically absurd result that, for fixed outputs, an increase in inputs will improve economic performance (O'Donnell and Coelli, 2005). Further, cost function estimates that violate the regularity conditions give reason to question the assumption of cost-minimizing behavior; duality theory fails and the elasticities of the cost function with respect to input prices are not equal to the corresponding input cost shares (Rungsuriyawiboon and Coelli, 2006).

For the purpose of securing theoretical consistency, monotonicity and concavity can either be imposed ex ante on the estimated function or tested after the estimation. As Kuenzle (2005) argued, the advantage of an after-estimation test is that it provides further insight into the empirical model and the industry; that is, after-estimation tests can provide hints about whether the functional form, the variables and the assumed behavior of the firms provide an appropriate image of the industry under consideration. Since we want to investigate whether a translog cost function approach with a cost-minimizing assumption is appropriate in the case of German public theaters, we follow this argument and test the regularity conditions ex post.[5]

To be monotone, the input distance function must be non-decreasing in inputs and non-increasing in outputs at each data point. For the translog case, this condition is equivalent to the restrictions:

$$\varepsilon_k = \frac{\partial lnD}{\partial lnx_k} = \beta_k + \sum_{l=1}^{K} \beta_{kl}\, ln\, x_k + \sum_{m=1}^{M} \gamma_{km}\, ln\, y_m + \lambda_{kt}\, t \geq 0 \tag{3.10}$$

and

$$\varepsilon_m = \frac{\partial lnD}{\partial lny_m} = \alpha_m + \sum_{n=1}^{M} \alpha_{mn}\, ln\, y_m + \sum_{k=1}^{K} \gamma_{km}\, ln\, x_k + \phi_{mt}\, t \leq 0; \tag{3.11}$$

that is, the elasticity of D with respect to x_k is non-negative, and the elasticity of D with respect to y_m is non-positive for all inputs and outputs.

[4] Alternative model specifications for the input distance and the cost function, such as a Cobb-Douglas functional form, a translog functional form with no technical change and a translog functional form with Hicks neutral technical change, have been tested and rejected by likelihood-ratio tests.

[5] For a method to impose regularity conditions ex ante on the estimated function, see O'Donnell and Coelli (2005).

Similarly, for the cost function, monotonicity holds if the function is non-decreasing in input prices and non-decreasing in outputs at each data point. For the translog case, this condition is equivalent to the restrictions:

$$\varepsilon_k = \frac{\partial lnC}{\partial lnw_k} = \beta_k + \sum_{l=1}^{K} \beta_{kl}\, ln\, w_k + \sum_{m=1}^{M} \gamma_{km}\, ln\, y_m + \lambda_{kt}\, t \geq 0 \tag{3.12}$$

and

$$\varepsilon_m = \frac{\partial lnC}{\partial lny_m} = \alpha_m + \sum_{n=1}^{M} \alpha_{mn}\, ln\, y_m + \sum_{k=1}^{K} \gamma_{km}\, ln\, x_k + \phi_{mt}\, t \geq 0; \tag{3.13}$$

that is, both the elasticity of C with respect to x_k and the elasticity of C with respect to y_m are non-negative for all input prices and outputs.

Satisfying the concavity condition requires that the input distance function be concave in inputs and the cost function be concave in input prices. For the input distance function, this requires that the Hessian matrix of the second-order derivatives of D with respect to x_k be negative semi-definite; that is, all leading principle minors of the matrix must alternate in sign, beginning with negative. Similarly, the cost function is concave in input prices if negative semi-definiteness holds for the Hessian matrix of the second-order derivatives of C with respect to w_k.

Following Diewert and Wales (1987), it can be shown that the Hessian matrix of the translog input distance function with respect to the inputs – or the translog cost function with respect to the input prices – is negative semi-definite if, and only if, the matrix $\hat{H}$ is negative semi-definite. $\hat{H}$ is defined as:

$$\hat{H} = \begin{bmatrix} \beta_{11} & \cdots & \beta_{1l} \\ \vdots & \ddots & \vdots \\ \beta_{k1} & \cdots & \beta_{kk} \end{bmatrix} - \begin{bmatrix} e_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & e_k \end{bmatrix} + \begin{bmatrix} e_1 e_1 & \cdots & e_1 e_l \\ \vdots & \ddots & \vdots \\ e_n e_1 & \cdots & e_k e_k \end{bmatrix} \tag{3.14}$$

where, for the input distance function case, β_{kl} are the second-order coefficients of the inputs and e_k are the input elasticities, and, for the cost function case, β_{kl} are the second-order coefficients of the input prices and e_k are the input price elasticities.

3.4 Estimation approach

In order to estimate the technical and cost efficiency of German public theaters and to investigate the influence of unobserved heterogeneity on the estimation results, we follow Farsi et al. (2005) and apply four different stochastic frontier models for panel data. Following Greene (2005*a*), a general stochastic frontier model for panel data can be expressed as:

$$d_{it} = \alpha + \beta' r_{it} + v_{it} + S u_i, \tag{3.15}$$

where d_{it} and r_{it} stand either for the dependent and independent variables in the distance function model, as specified in Equation 3.6, or for the dependent and independent variables in the cost function model, as specified in Equation 3.8. Furthermore, v_{it} and u_i are the two parts of a composed random error, $\varepsilon_{it} = v_{it} + Su_i$, where v_{it} represents a random error term that captures noise as well as any firm and time-specific unobserved heterogeneity; and u_i is a non-negative time-invariant firm-specific inefficiency term. S equals -1 in the case of a distance function and 1 in the case of a cost function. Finally, α is a constant and β' is a vector of coefficients to be estimated.

The four models differ in their assumptions about the distribution of the two error components, as well as in their estimation approach for the inefficiency indicators and, therefore, in their efficiency scores. Given Farrell's measure of technical efficiency and given the definition of cost efficiency as the ratio of optimal costs to observed costs, the efficiency scores range between zero and one, where a value equal to one indicates efficiency. A summary of the econometric specifications of the models is given in Table 3.1.

Table 3.1: Econometric specifications[a]

	Model I Fixed effects	Model II Random Effects	Model III True random effects	Model IV True random effects with Mundlak formulation
Firm-specific component	fixed	$u_i \sim iidN^+(0,\sigma_u^2)$	$\alpha_i \sim iidN(0,\sigma_\alpha^2)$	$\alpha_i = \gamma\bar{x}_i + \delta_i$ $\bar{x}_i = \frac{1}{T_i}\sum_{t=1}^{T_i} x_{it}$ $\delta_i \sim N(0,\sigma_\delta^2)$
Random error ε_{it}	$\varepsilon_{it} = v_{it}$ $v_{it} \sim iid(0,\sigma_v^2)$	$\varepsilon_{it} = v_{it} + Su_i$ $v_{it} \sim iidN(0,\sigma_v^2)$ $u_i \sim iidN^+(0,\sigma_u^2)$	$\varepsilon_{it} = v_{it} + Su_{it}$ $v_{it} \sim iidN(0,\sigma_v^2)$ $u_{it} \sim iidN^+(0,\sigma_u^2)$	$\varepsilon_{it} = v_{it} + Su_{it}$ $v_{it} \sim iidN(0,\sigma_v^2)$ $u_{it} \sim iidN^+(0,\sigma_u^2)$
Inefficiency	$max\{\hat{\alpha}_i^d\} - \hat{\alpha}_i^d$ $\hat{\alpha}_i^c - min\{\hat{\alpha}_i^c\}$	$E[u_i \vert \bar{\varepsilon}_i]$	$E[u_{it} \vert \hat{w}_{it}]$ $w_{it} = \alpha_i + \varepsilon_{it}$	$E[u_{it} \vert \hat{w}_{it}]$ $w_{it} = \delta_i + \varepsilon_{it}$
Relative efficiency	$e^{-(max\{\hat{\alpha}_i^d\} - \hat{\alpha}_i^d)}$ $e^{-(\hat{\alpha}_i^c - min\{\hat{\alpha}_i^c\})}$	$E[e^{-u_i} \vert \bar{\varepsilon}_i]$	$E[e^{-u_{it}} \vert \hat{w}_{it}]$ $w_{it} = \alpha_i + \varepsilon_{it}$	$E[e^{-u_{it}} \vert \hat{w}_{it}]$ $w_{it} = \delta_i + \varepsilon_{it}$

[a]The superscripts *d* and *c* stand for the distance function and the cost function, respectively.

Model I is a fixed effects model as proposed by Schmidt and Sickles (1984). Apart from the assumption that v_{it} is independent and identically distributed (iid) with zero mean and constant variance and is uncorrelated with the explanatory variables no further distributional assumptions are required. In particular, the firm-specific inefficiency term u_i and, hence, the firm-specific fixed effects $\alpha_i = \alpha + Su_i$ are allowed to correlate with the explanatory variables or with v_{it}. In case of an input distance function, the firm's inefficiency is estimated by the deviation from the firm-specific intercept $\hat{\alpha}_i^d$ to the maximum intercept in the sample, that is $\hat{u}_i^d = max\{\hat{\alpha}_i^d\} - \hat{\alpha}_i^d$, and in the case of a cost function by the deviation from the firm-specific intercept $\hat{\alpha}_i^c$ to the minimum intercept in the sample, that is $\hat{u}_i^c = \hat{\alpha}_i^c - min\{\hat{\alpha}_i^c\}$.

Model II is a random effects model as proposed by Pitt and Lee (1981). In this model the firm-specific inefficiency term u_i is an iid half-normally distributed random effect which is independently distributed from the iid normally distributed random error term v_{it}. Further, both error components are assumed to be uncorrelated with the explanatory variables and each other. The model estimates are obtained by maximum likelihood estimation, and, as proposed by Jondrow et al. (1982), the firm's inefficiency is estimated by the conditional mean of the inefficiency term $\hat{u}_i = E[u_i|\bar{\varepsilon}_i]$, where $\bar{\varepsilon}_i = \frac{1}{T_i}\sum_{t=1}^{T_i}\hat{\varepsilon}_{it}$ (Farsi et al., 2005).

Both models have assets and drawbacks. Since the fixed effects model identifies at least one firm as 100 percent efficient, the inefficiency of the other firms can only be measured relative to the best-practice firm(s) in the sample. That is, the inefficiency estimates are sensitive to sample selection and outliers (Kuenzle, 2005; Farsi and Filippini, 2004). Further, since the fixed effects estimator does not allow to include any time-invariant variables in the estimation, it cannot account for any observed time-invariant heterogeneity. Both problems can be solved by the random effects model. However, the main advantage of the fixed effects model is that the estimated coefficients are not affected by any correlation between the firm-specific effects and the explanatory variables. In contrast, the estimates of the random effects model will be biased in this case.

Moreover, the fixed and random effects models have two additional shortcomings in common. First, both models assume constant inefficiency over time which is rather unrealistic in relatively long panels. Second, any time-invariant firm-specific unobserved heterogeneity is included in the firm-specific component and thus in the inefficiency estimates. In other words, if any time-invariant firm-specific unobserved heterogeneity is existent, the conventional fixed and random effects models tend to overestimate the inefficiency (Greene, 2005*a*; Farsi et al., 2005).

Model III is the true random effects model proposed by Greene (2005*a*,*b*). This model accounts for the shortcomings of the conventional panel data models by adding a firm-specific random term α_i. The model can be expressed as

$$d_{it} = \alpha + \alpha_i + \beta' r_{it} + v_{it} + S u_{it}, \tag{3.16}$$

where α_i represents time-invariant firm-specific unobserved heterogeneity and u_{it} represents time-varying firm-specific inefficiency. All other notation is as defined before. The error components v_{it} and u_{it} are distributed as in the random effects model and the unobserved heterogeneity component α_i is iid normally distributed. Further, v_{it}, u_{it} and α_i are assumed to be uncorrelated with the explanatory variables and each other. As in the random effects model, the firm's inefficiency is estimated by the conditional mean of the inefficiency term $\hat{u}_{it} = E[u_i|\hat{w}_{it}]$, where $w_{it} = \alpha_i + \varepsilon_{it}$.

This specification separates time-invariant unobserved heterogeneity from time-varying inefficiency and therefore relaxes the main limitations of the conventional panel data models. However, since all time-invariant effects are treated as unobserved heterogeneity and are captured by the firm-specific constant any persistent inefficiency is not included in the inefficiency term. Consequently, as the conventional fixed and random effects models tend to overestimate the inefficiency, the true random effects model tends to underestimate it (Farsi et al., 2006).

Model IV is an extension to Model III. As suggested by Farsi et al. (2005), it uses Mundlak's (1978) formulation to overcome the possible bias problem in the true random effects model that results if any correlation between the unobserved heterogeneity component α_i and the explanatory variables r_{it} is existent. Mundlak's formulation accounts for these correlations with an auxiliary regression that can be written as:

$$\alpha_i = \gamma' \bar{r}_i + \delta_i, \quad \bar{r}_i = \frac{1}{T_i} \sum_{t=1}^{T_i} r_{it}, \quad \delta_i \sim N(0, \sigma_\delta^2), \tag{3.17}$$

where $\bar{r}_i$ represents a vector of the group means of the explanatory variables r_{it}; 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 Equation 3.16 the auxiliary coefficients γ_x 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).

3.5 Data

The utilized 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 less than four observations are excluded from the estimation. For the input distance function model this procedure leaves a total of 1433 observations from 126 theaters and for the cost function model a total of 1413 observations from 124 theaters, respectively. For both models, 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. Therefore, in order to account for the differences in size, we measure the output using the variable *number of supplied tickets*, calculated as the number of performances per season multiplied by the number of seats.[6] According to Throsby (1994) this output variable measures the produced output in contrast to sold output, which would reflect the actual number of visitors per season. The latter output concept refers to the cultural experience of the visitors as the final product. However as we do not consider demand in our analysis the produced output is chosen here. For the distance function model, the total salary expenses and the *operating expenses* per season are used as monetary measures for the quantities of labor and capital.[7] The salary expenses are divided into *salary expenses for artistic staff* and *salary expenses for administrative and technical staff*. This division allows for a more detailed identification of possible sources of inefficiency. The operating expenses include, among other things, administration costs, leasing and fire service expenditures.

In addition, to account for observed heterogeneity three firm characteristic variables are taken into account. First, as described in Section 3.2, the theaters are aware of the amount of subsidies when they plan productions for upcoming seasons. In this sense subsidies present a financial framework for the production process finally set and granted in advance by the public authorities. Given this allocation system we consider the amount

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

[7] 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 €.

of subsidies as an exogenous operating characteristic rather than as an input. Therefore, in order to control for the impact of public funding on efficiency we include a variable reflecting the *amount of subsidies* in the model. We assume that this variable has a negative impact on efficiency. Further, the production technology of the theaters differs significantly by 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*, 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 large audiences. However, producing plays is cost-intensive and is expected to have a negative impact on efficiency, while re-runs of an established production 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, is included in order to control for the impact on input requirements.

For the cost function model, in addition to the *total costs*, given as the sum of total salary expenses and operating expenses, the input variables must be included in terms of prices. Therefore, to calculate the prices for labor, the two salary expense variables are divided by the appropriate number of employees in order to get the *price for artistic staff* and the *price for administrative and technical staff*. Accordingly, following Taalas (1997), the *price for capital* is given by the operating expenses divided by the number of seats, which is used as a proxy for the capital stock. Finally, the same output and firm characteristic variables as in the input distance function model are included.

Tables 3.2 and 3.3 report the summary statistics of the output variable, the input variables and the firm characteristic variables of the input distance function model and the cost function model. The descriptive statistics show significant variance regarding all variables. For example, the largest theater in terms of output supplies 97 times more tickets than the smallest theater in the data set.[8] This variance results from the different auditorium sizes and number of stages run by each theater.

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

Table 3.2: Input distance function – summary 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)

Table 3.3: Cost function – summary statistics

Variable description	Variable	Mean	Median	Std. Dev.	Min	Max
Number of supplied tickets (10^3)	Y	175	163	110	6	596
Total annual costs (10^3 €)	TC	14600	12400	10800	326	61100
Price for artistic staff (10^3 €/employee)	P_{Lart}	54	51	17	13	138
Price for administrative and technical staff (10^3 €/employee)	P_{Lad}	37	37	9	8	76
Price for capital (€/seat)	P_C	1861	1534	1215	93	9851
Amount of subsidies (10^3 €)	SUB	13300	12000	9814	218	56000
Number of stages	ST	4	4	2	1	13
Number of productions	$PROD$	30	27	14	2	90
Number of observations			1413			

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

Table 3.4 presents the fraction of within variation of the overall variation for the variables included in the two models. The figures indicate that the variables show a significant fraction of within variation. Altogether, the descriptive statistics indicate that the used variables show a reasonable between and within variation, which finding supports the use of panel data models and the use of fixed effects models in particular.

Table 3.4: Fraction of within variation[a]

Input distance function model		Cost function model	
Variable	Fraction of within variation	Variable	Fraction of within variation
$-ln\,(X_C)$	0.20	$ln\,(TC/P_C)$	0.32
$ln\,Y$	0.17	$ln\,Y$	0.17
$ln\,(X_{Lart}/X_C)$	0.39	$ln\,(P_{Lart}/P_C)$	0.55
$ln\,(X_{Lad}/X_C)$	0.47	$ln\,(P_{Lad}/P_C)$	0.51
$ln\,SUB$	0.11	$ln\,SUB$	0.10
$ln\,ST$	0.51	$ln\,ST$	0.53
$ln\,PROD$	0.43	$ln\,PROD$	0.45

[a] Within variation represents the standard deviation of theater observations from the theater's average $(X_{it} - \bar{X}_i)$. The fraction of within variation is defined as the ratio of within to overall standard deviation (Farsi et al., 2005).

3.6 Results

The parameter estimates of the input distance and the cost function for all models are presented in Table 3.5. As each variable is in natural logarithm and is normalized by its sample median, the first-order coefficients can be interpreted as distance and cost elasticities at the sample median firm, respectively.

Considering the different model specifications a Hausman test conducted on both functions indicates that the firm-specific effects are correlated with the explanatory variables. This suggests that the estimated coefficients of Models II and III, which do not account for this correlation, are biased. In contrast, since our data set shows a reasonable within variation and covers a sufficient long time period of 15 years, the results of the fixed effects model can be considered as unbiased parameter estimates.[9]

First, focusing on the distance function estimates, the results show that all first-order coefficients are statistically significant at the 1 percent level and have the expected signs across all models. In other words, at the sample median firm, the estimated input distance function is decreasing in outputs and increasing in inputs. The magnitude of the coefficients differs slightly across the models, indicating slightly biased estimation results for Models II and III. The smallest difference among the models' coefficients is observed between Models I and IV. In conjunction with the statistical significance of 17 out of the 20 Mundlak terms in Model IV this suggests that the applied Mundlak formulation is able to account for correlations between the firm-specific effects and the explanatory

[9] In short panels the so called 'incidental parameter' problem arises, yielding inconsistent parameter estimates.

Table 3.5: Parameter estimates[a,b,c]

		Input distance function						Cost function			
Variable	Parameter	Model I	Model II	Model III	Model IV	Variable	Parameter	Model I	Model II	Model III	Model IV
Y	α_1	−0.121(−8.6)	−0.167(−13.6)	−0.166(−34.6)	−0.122(−10.5)	Y	α_1	0.211(10.6)	0.277(18.1)	0.245(37.9)	0.210(13.0)
Y^2	α_{11}	−0.032(−2.5)	−0.006(−0.7)	−0.023(−6.4)	−0.034(−3.0)	Y^2	α_{11}	−0.002(−0.1)	0.002(0.1)	0.001(0.2)	0.006(0.4)
X_{Lart}	β_1	0.490(43.0)	0.493(44.4)	0.495(117.4)	0.494(60.6)	P_{Lart}	β_1	0.399(30.7)	0.400(42.0)	0.399(60.4)	0.399(49.2)
X_{Lad}	β_2	0.372(29.5)	0.353(28.6)	0.358(58.8)	0.366(37.3)	P_{Lad}	β_2	0.451(32.2)	0.451(32.2)	0.449(68.4)	0.447(43.5)
X_C	β_3	0.138	0.154	0.147	0.140	P_C	β_3	0.150	0.149	0.152	0.154
X_{Lart}^2	β_{11}	0.165(11.3)	0.201(14.7)	0.185(24.6)	0.170(17.5)	P_{Lart}^2	β_{11}	0.242(8.0)	0.230(12.3)	0.192(13.3)	0.187(12.1)
X_{Lad}^2	β_{22}	0.118(10.5)	0.116(9.1)	0.116(15.5)	0.117(8.2)	P_{Lad}^2	β_{22}	0.120(3.7)	0.126(4.6)	0.111(5.9)	0.103(4.9)
X_C^2	β_{33}	0.037	0.069	0.047	0.035	P_C^2	β_{33}	0.074	0.076	0.085	0.086
$X_{Lart}X_{Lad}$	β_{12}	−0.123(−12.5)	−0.124(−13.9)	−0.127(−17.9)	−0.126(−13.9)	$P_{Lart}P_{Lad}$	β_{12}	−0.144(−5.1)	−0.140(−6.1)	−0.109(−6.7)	−0.102(−5.8)
$X_{Lart}X_C$	β_{13}	−0.042	−0.077	−0.058	−0.044	$P_{Lart}P_C$	β_{13}	−0.098	−0.090	−0.083	−0.085
$X_{Lad}X_C$	β_{23}	0.005	0.008	0.011	0.009	$P_{Lad}P_C$	β_{23}	0.024	0.014	−0.002	−0.001
$X_{Lart}Y$	γ_{11}	−0.027(−3.2)	−0.001(−0.1)	−0.012(−3.0)	−0.026(−2.9)	$P_{Lart}Y$	γ_{11}	0.022(1.8)	0.016(2.2)	0.017(3.0)	0.012(1.9)
$X_{Lad}Y$	γ_{21}	0.049(4.9)	0.036(3.4)	0.040(6.5)	0.047(5.0)	$P_{Lad}Y$	γ_{21}	0.017(1.3)	0.013(1.2)	0.020(2.7)	0.022(2.1)
X_CY	γ_{31}	−0.022	−0.035	−0.028	−0.021	P_CY	γ_{31}	−0.039	−0.013	−0.037	−0.034
T	θ_t	−0.004(−6.8)	−0.005(−10.1)	−0.004(−12.4)	−0.004(−9.6)	T	θ_t	−0.005(−7.3)	−0.004(−8.9)	−0.005(−12.0)	−0.005(−11.6)
T^2	θ_{tt}	0.000(−1.2)	−0.001(−2.6)	0.000(−2.5)	0.000(−1.2)	T^2	θ_{tt}	0.003(7.5)	0.003(9.5)	0.002(7.5)	0.002(5.7)
$X_{Lart}T$	λ_{1t}	−0.004(−3.9)	−0.003(−3.5)	−0.004(−5.5)	−0.004(−5.8)	$P_{Lart}T$	λ_{1t}	0.005(2.4)	0.004(2.7)	0.003(2.7)	0.003(2.3)
$X_{Lad}T$	λ_{2t}	0.008(6.8)	0.006(5.4)	0.007(8.5)	0.008(8.4)	$P_{Lad}T$	λ_{2t}	0.000(0.1)	0.001(0.4)	0.001(0.5)	0.001(0.8)
X_CT	λ_{3t}	−0.004	−0.003	−0.003	−0.004	P_CT	λ_{3t}	−0.005	−0.005	−0.004	−0.004
YT	ϕ_{1t}	0.000(−0.4)	0.001(1.7)	0.000(1.4)	0.000(−0.3)	YT	ϕ_{1t}	0.003(4.6)	0.003(6.2)	0.002(6.6)	0.003(6.05)
SUB	ψ_1	−0.622(−40.3)	−0.783(−123.6)	−0.731(−192.2)	−0.617(−68.1)	SUB	ψ_1	0.364(15.3)	0.523(36.7)	0.408(78.2)	0.313(23.3)
ST	ψ_2	−0.006(−1.0)	0.002(0.2)	−0.002(−0.5)	−0.009(−1.4)	ST	ψ_2	0.106(9.3)	0.107(11.8)	0.111(19.2)	0.119(13.4)
$PROD$	ψ_3	−0.026(−3.6)	−0.016(−1.9)	−0.017(−4.0)	−0.025(−3.7)	$PROD$	ψ_3	0.026(2.4)	0.022(2.3)	0.028(4.9)	0.033(3.4)
Constant	α	–	0.317(21.4)	0.053(15.0)	−0.036(−9.1)	Constant	α	–	−0.464(−22.5)	−0.084(−19.5)	0.000(−0.1)
Sigma	$\sqrt{\sigma_u^2+\sigma_v^2}$	–	0.364(9.5)	0.840(11.2)	0.963(8.7)	Sigma	$\sqrt{\sigma_u^2+\sigma_v^2}$	–	0.516(13.6)	1.810(12.3)	2.217(11.5)
Lambda	σ_u/σ_v	–	6.090(3.9)	0.067(51.3)	0.067(37.3)	Lambda	σ_u/σ_v	–	6.164(5.5)	0.114(43.2)	0.119(44.2)

[a] All variables are in natural logarithm and are normalized by their sample median. [b] T-ratios are reported in parenthesis. [c] All model estimates are obtained by using Limdep 9.0.

variables, and, thus, to reduce the resulting bias.[10]

Given the unbiased estimates of Model I, the estimated input elasticities for salary expenses for artistic staff (β_1) and for salary expenses for administrative and technical staff (β_2) are found to be equal to 0.490 and 0.372, respectively. The input elasticity for operating expenses (β_3) is calculated via the homogeneity restriction presented in Equation 3.5 and equals 0.138. Interpreted as shadow shares, the input elasticities indicate that expenses for artistic staff account for 49.0 percent, expenses for administrative and technical staff account for 37.2 percent, and operating expenses account for 13.8 percent of total costs at the sample median firm. These values are similar to the observed cost shares at the sample median firm that account for 48.3, 34.7, and 17.0 percent, respectively.

The first-order coefficient of time (θ_t) is -0.004. Independent of the negative sign that implies regressive technical change, the fairly low magnitude suggests almost no technical change for the sample median firm in the mid year of the sample. This result can be explained by the very limited possibilities of the performing arts to benefit from labor or capital-saving technological improvements compared to other sectors (Fazioli and Filippini, 1997).

Referring to the firms' characteristics, two out of the three coefficients are significantly different from zero at the 1 percent level. First, the statistically significant and negative coefficient of subsidies (ψ_1) implies that a 1 percent increase in the amount of subsidies will increase the input requirements by 0.62 percent at the sample median firm. This result is consistent with previous research (Bishop and Brand, 2003) and confirms our expectation that public funding has a negative impact on efficiency. Furthermore, it corroborates the hypothesis that the assumption of cost-minimizing behavior is violated in the highly subsidized German public theater sector. Second, the statistically significant and negative coefficient of the number of productions (ψ_3) suggests an increase of input requirements of 2.6 percent for an additional production at the sample median firm. This result shows that the aim of cultural diversity comes at some costs.

As for the distance function estimates, the first-order coefficients of the cost function estimates are all statistically significant at the 1 percent level and have the expected signs across all models. In other words, at the sample median firm, the estimated cost function is increasing in outputs and in input prices. Again, the magnitude of the coefficients differs slightly across the models indicating slightly biased estimation results of Models II and III. However, the unbiased estimates of Model I are rather different than

[10] The Mundlak terms of Model IV are not reported to conserve space. For both functions 17 out of the 20 Mundlak coefficients are statistically different from zero at the 5 percent level.

the estimates of the corresponding input distance function model. In particular, the cost elasticities with respect to input prices that can be interpreted as shadow shares differ significantly from the input distance function estimates. Summarized, the cost function estimates indicate that expenses for artistic staff (β_1) account for 39.9 percent, expenses for administrative and technical staff (β_2) account for 45.1 percent, and operating expenses (β_3) account for 15.0 percent of total costs at the sample median firm. Except for the operating expenses estimate, these values are quite different from the observed cost shares as well as from the distance function shadow shares.

As noted by Rungsuriyawiboon and Coelli (2006), one possible - and in our case the most likely - reason for this difference is the violation of the cost-minimization assumption.[11] This conclusion is further supported by the posteriori test results on the violations of the regularity conditions. While the monotonicity condition is violated in less than 1 percent of the observations in both the distance and the cost function, the violation rate of the curvature condition is rather high in the cost function compared to the distance function. While the curvature condition across all estimated models is violated at the maximum of about 20 percent of the observations in the distance function, the violation rate in the cost function differs from as high as 94 percent in Model I to at least 25 percent in Model IV.[12] To sum up, these results suggest that the cost-minimizing assumption is violated; thus, the cost function estimates are rather unreliable. Consequently, an efficiency analysis based on a translog cost function approach seems to be inappropriate in the case of German public theaters.

The summary statistics of the estimated technical efficiency scores are reported in Table 3.6.[13] As expected, the results differ considerably across the four models. In particular, the efficiency estimates of the conventional fixed and random effects models (Models I and II) are rather low compared to the efficiency estimates of the true random effects models (Models III and IV).

For Model I, the mean efficiency value of 0.367 implies that on average, the same output quantity could have been produced despite reducing the input usage by more than 63 percent. Model II shows a much higher mean efficiency value of 0.724, indicating a possible input reduction of about 28 percent on average. Further, the minimum efficiency values of Model I and Model II, 0.213 and 0.331, suggest an input saving potential of

[11] Other possible reasons noted by Rungsuriyawiboon and Coelli (2006) are measurement errors in either the input quantities or prices or an endogenous regressor problem in the distance function model. See Rungsuriyawiboon and Coelli (2006) for a further discussion.

[12] The violation rate of the curvature condition in the distance (cost) function is 20 (94) percent in Model I, 18 (67) percent in Model II, 19 (26) percent in Model III, and 20 (25) percent in Model IV.

[13] Since the cost function estimates are considered less reliable the estimated cost efficiency scores are not reported to conserve space. The results are available on request from the authors.

Table 3.6: Summary statistics of technical efficiency scores

	Model I	Model II	Model III	Model IV
Minimum	0.213	0.331	0.826	0.822
Maximum	1.000	0.994	0.993	0.992
Mean	0.367	0.724	0.967	0.964
Median	0.336	0.715	0.968	0.966
5 percentile	0.239	0.617	0.951	0.944

about 67 to 79 percent, respectively, for the most inefficient observations. These results, particularly the mean efficiency value of Model I, seem rather unrealistic and can be explained by the fact that both models assume constant inefficiency over time and do not separate firm-specific unobserved heterogeneity from inefficiency. That is, any unobserved heterogeneity that influences the firm-specific production structure is included in the efficiency scores. Moreover, since Model I identifies at least one observation as 100 percent efficient, its efficiency estimates are sensitive to sample selection and outliers that could result in highly downward biased efficiency values.

Turning to Models III and IV that account for the shortcomings of Models I and II by assuming time-varying inefficiency and distinguishing unobserved heterogeneity from inefficiency, the mean efficiency values of 0.967 and 0.964, respectively, indicate a possible input reduction of about 3 percent on average. Combined with the minimum efficiency values of 0.826 and 0.822, respectively, that suggest an input saving potential of about 17 percent for the most inefficient observations, and the 5th percentile values of 0.951 and 0.944, respectively, which suggest that in only 5 percent of all observations the input saving potential is higher than approximately 5 percent, these results seem to be more reasonable. Further, the nearly identical efficiency results of Models III and IV indicate that the efficiency estimates are not influenced considerably by a bias resulting from any correlation between the firm-specific effects and the explanatory variables.

3.7 Conclusions

In this study, we analyzed the efficiency of German public theaters for the seasons 1991/1992 to 2005/2006. Based on a stochastic frontier analysis approach, we tested whether the assumption of cost-minimizing behavior is reliable and thus, whether an efficiency analysis via a cost function approach is appropriate in this sector. In addition, several panel data models that differ in their ability to account for unobserved heterogeneity were applied to evaluate the impact of unobserved heterogeneity on the efficiency estimates.

With regard to the cost-minimizing behavior, both the differences between the estimated cost function's shadow shares and the observed cost shares as well as the high violation rate of the regularity conditions in the cost function approach suggest that the assumption of cost-minimizing behavior cannot be maintained. This conclusion is supported by the theoretically consistent result that higher subsidies lead ceteris paribus to relatively higher input requirements. Consequently, an efficiency analysis based on a cost function approach that presumes a cost-minimizing behavior may provide biased efficiency estimates and, hence, seems inappropriate in the case of German public theaters.

Referring to the impact of unobserved heterogeneity on the efficiency estimates, our results are consistent with previous research (see, for example, Farsi and Filippini, 2004; Farsi et al., 2005). We observe considerably differences between the conventional fixed effects and random effects models that do not separate firm-specific unobserved heterogeneity from inefficiency and the two true random effects models that do. Hence, our results imply that the German public theater sector is characterized by considerably unobserved heterogeneity across the theaters, which influences the theater-specific production structure. Given the rather unrealistic efficiency estimates of the conventional models, it can be assumed that these models, particularly the fixed effects model, underestimate the efficiency. Alternatively, the true random effects models treat all time-invariant effects as unobserved heterogeneity, including any persistent inefficiency; hence, they may overestimate the efficiency to a certain degree. Nevertheless, the results of the true random effects models seem to be more realistic. Both models indicate an input saving potential of about 3 percent on average and a maximum input saving potential of about 5 percent for 95 percent of all observations.

Overall, our results suggest that there is still space for improvement in the employment of resources in the German public theater sector. In particular, given the doubts about the existence of cost-minimizing behavior in the presence of the actual subsidy system, public authorities should carefully reassess the system with a particular focus on the implementation of cost-minimizing incentives.

In this context, it should be noted that our efficiency results are solely based on a technical view of performing arts production. Due to the lack of data we were not able to include any quality aspects into our analysis and, therefore, the results provide no information on the relationship between efficiency and quality. Consequently, the judgement whether the measured technical inefficiency of an individual theater is due to poor employment of the resources or to higher input requirements as a result of a higher quality level remains with the public authorities. While budget cuts are appropriate in case of a theater that reveals both a high technical inefficiency level and a poor quality level, a certain degree of technical inefficiency might be acceptable in case of a theater that provides a high quality level and, hence, should not result in budget cuts.

To sum up, our analysis provides information on one side of the story - technical efficiency - which connected with the other side of the story - quality - can help public authorities to identify the best-performing theaters and to derive the best-practice production strategies. As suggested by Farsi et al. (2005), the results of such an analysis can be used to predict an interval of necessary costs for each theater and, thus, can reduce the information asymmetry regarding minimum costs in the context of negotiations between theater managers and public authorities.

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

4.1 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 4.2 presents the theoretical foundations of the cost-disease effect in the performing arts and the decomposition of the total factor productivity change. Section 4.3 discusses the estimation methodology and is followed by a description of the data set in Section 4.4. Estimation results of the empirical analysis are presented in Section 4.5. Section 4.6 summarizes and presents conclusions.

4.2 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 4.1 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_A^t can be realized using at least the input level x_A^t. 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_A^{t+1} equals y_A^t) can only be produced with a higher input level (x_A^{t+1}). Further, since TFP is defined as the ratio of the outputs to 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

[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).

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.

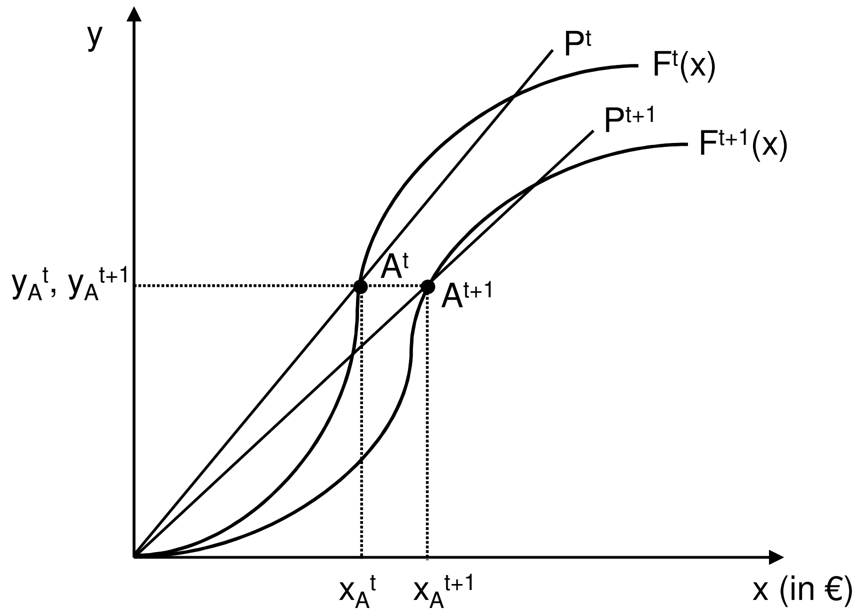

Figure 4.1: Increasing wages, lack of technological progress and productivity

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 4.2. 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

[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

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.

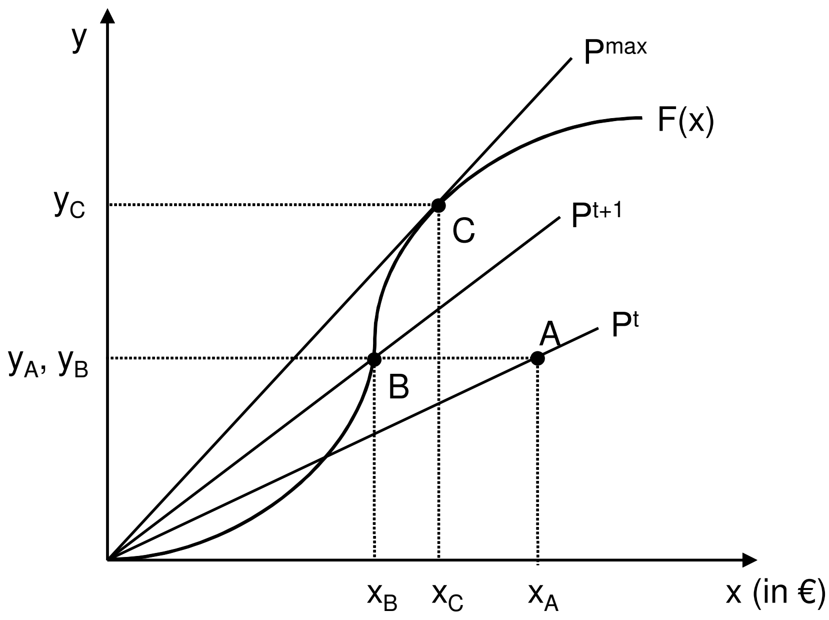

Figure 4.2: Technical efficiency, scale efficiency and productivity

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

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.

4.3 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:

$$D_I\left(x,y\right) = \max\{\theta : (x/\theta) \in L\left(y\right)\}, \tag{4.1}$$

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:

$$TE(x,y) = 1/D_I\left(x,y\right) \leq 1. \tag{4.2}$$

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

$$\begin{aligned} ln\, D^I_{it} \;=\;& \alpha + \sum_{m=1}^{M} \alpha_m \, ln\, y_{mit} + \frac{1}{2} \sum_{m=1}^{M} \sum_{n=1}^{M} \alpha_{mn} \, ln\, y_{mit} \, ln\, y_{nit} + \sum_{k=1}^{K} \beta_k \, ln\, x_{kit} \\ & + \frac{1}{2} \sum_{k=1}^{K} \sum_{l=1}^{K} \beta_{kl} \, ln\, x_{kit} \, ln\, x_{lit} + \sum_{k=1}^{K} \sum_{m=1}^{M} \gamma_{km} \, ln\, x_{kit} \, ln\, y_{mit} \\ & + \theta_t \, t + \frac{1}{2} \theta_{tt} \, t^2 + \sum_{k=1}^{K} \lambda_{kt} \, ln\, x_{kit} \, t + \sum_{m=1}^{M} \phi_{mt} \, ln\, y_{mit} \, t + \sum_{s=1}^{S} \psi_s \, z_{sit}, \end{aligned} \tag{4.3}$$

where the subscripts i and t denote the firm and year, respectively; D^I_{it} 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

$$\alpha_{mn} = \alpha_{nm}, \quad (m, n = 1, 2, ..., M) \quad \text{and} \quad \beta_{kl} = \beta_{lk}, \quad (k, l = 1, 2, ..., K), \tag{4.4}$$

and linear homogeneity in inputs is given if

$$\sum_{k=1}^{K} \beta_k = 1, \quad \sum_{l=1}^{K} \beta_{kl} = 0, \quad \sum_{k=1}^{K} \gamma_{km} = 0, \quad \text{and} \quad \sum_{k=1}^{K} \lambda_{kt} = 0. \tag{4.5}$$

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:

$$\alpha_i = \gamma' \bar{r}_i + \delta_i, \quad \bar{r}_i = \frac{1}{T_i} \sum_{t=1}^{T_i} r_{it}, \quad \delta_i \sim N(0, \sigma_\delta^2), \tag{4.6}$$

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 4.5 must be imposed. Thus, the distance term and the inputs in Equation 4.3 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

$$\begin{aligned} -\,ln\, x_{Kit} \;=\; & \alpha_0 + \sum_{m=1}^{M} \alpha_m\, ln\, y_{mit} + \frac{1}{2} \sum_{m=1}^{M} \sum_{n=1}^{M} \alpha_{mn}\, ln\, y_{mit}\, ln\, y_{nit} + \sum_{k=1}^{K-1} \beta_k\, ln\, x_{kit}^* \\ & + \frac{1}{2} \sum_{k=1}^{K-1} \sum_{l=1}^{K-1} \beta_{kl}\, ln\, x_{kit}^*\, ln\, x_{lit}^* + \sum_{k=1}^{K-1} \sum_{m=1}^{M} \gamma_{km}\, ln\, x_{kit}^*\, ln\, y_{mit} \\ & + \theta_t\, t + \frac{1}{2} \theta_{tt}\, t^2 + \sum_{k=1}^{K-1} \lambda_{kt}\, ln\, x_{kit}^*\, t + \sum_{m=1}^{M} \phi_{mt}\, ln\, y_{mit}\, t + \sum_{s=1}^{S} \psi_s\, z_{sit} \\ & + \alpha_i + v_{it} - u_{it}, \end{aligned} \tag{4.7}$$

where $x_{kit}^* = (x_{kit}/x_{Kit})$. The unknown parameters of Equation 4.6 and 4.7 are jointly estimated by simulated maximum likelihood, and the firm's inefficiency is estimated by using the conditional mean of the inefficiency term $\hat{u}_{it} = E\left[u_{it}|\hat{\omega}_{it}\right]$, 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 4.7 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:

$$\begin{aligned} ln\left(TFP_{it+1}/TFP_{it}\right) &= ln\left(TE_{it+1}/TE_{it}\right) \\ &+0.5\left[\left(\partial\, ln\, D_{it+1}/\partial\, t\right) + \left(\partial\, ln\, D_{it}/\partial\, t\right)\right] \\ &+0.5\sum_{m=1}^{M}\left[\left(SF_{it+1}\,\varepsilon_{mit+1} + SF_{it}\,\varepsilon_{mit}\right)\left(ln\, y_{mit+1} - ln\, y_{mit}\right)\right], \end{aligned} \tag{4.8}$$

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 4.3, the i-th firm's technological change in the t-th period is:

$$\partial\, ln\, D_{it}/\partial\, t = \theta_t + \theta_{tt}t + \sum_{k=1}^{K}\lambda_{kt}\, ln\, x_{kit} + \sum_{m=1}^{M}\phi_{mt}\, ln\, y_{mit}. \tag{4.9}$$

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 4.3, the i-th firm's output elasticity for each output in the t-th period is:

$$\varepsilon_{mit} = \partial\, ln\, D_{it}/\partial\, ln\, y_{mit} = \alpha_m + \sum_{m=1}^{M}\alpha_{mn}\, ln\, y_{mit} + \sum_{k=1}^{K}\gamma_{km}\, ln\, x_{kit} + \phi_{mt}t. \tag{4.10}$$

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):

$$RTS_{it} = -\left(1\Big/\sum_{m=1}^{M}\varepsilon_{mit}\right), \tag{4.11}$$

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

$$SF_{it} = \left(\sum_{m=1}^{M} \varepsilon_{mit} + 1 \right) \Big/ \sum_{m=1}^{M} \varepsilon_{mit} = 1 - RTS_{it}. \quad (4.12)$$

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.

4.4 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,

[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 €.

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 4.1 show significant variance regarding all variables. For example, the largest theater in terms of output supplies 97 times more 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.

[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.

Table 4.1: 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:

$$\begin{aligned}
-\ln X_{C_{it}} &= \alpha_0 + \alpha_1 \ln Y_{it} + \frac{1}{2}\alpha_{11}(\ln Y_{it})^2 \\
&+ \beta_1 \ln(X_{Lart_{it}}/X_{C_{it}}) + \beta_2 \ln(X_{Lad_{it}}/X_{C_{it}}) \\
&+ \frac{1}{2}\beta_{11}(\ln(X_{Lart_{it}}/X_{C_{it}}))^2 + \frac{1}{2}\beta_{22}(\ln(X_{Lad_{it}}/X_{C_{it}}))^2 \\
&+ \beta_{12}\ln(X_{Lart_{it}}/X_{C_{it}})\ln(X_{Lad_{it}}/X_{C_{it}}) \\
&+ \gamma_{11}\ln(X_{Lart_{it}}/X_{C_{it}})\ln Y_{it} + \gamma_{21}\ln(X_{Lad_{it}}/X_{C_{it}})\ln Y_{it} \\
&+ \theta_t T + \frac{1}{2}\theta_{tt}T^2 + \lambda_{1t}\ln(X_{Lart_{it}}/X_{C_{it}})T + \lambda_{2t}\ln(X_{Lad_{it}}/X_{C_{it}})T \\
&+ \phi_{1t}\ln Y_{it}T + \psi_1 \ln SUB_{it} + \psi_2 \ln ST_{it} + \psi_3 \ln PROD_{it} \\
&+ \alpha_i + v_{it} - u_{it}.
\end{aligned} \tag{4.13}$$

4.5 Results

The parameter estimates of Equation 4.13 are presented in Table 4.2. To conserve space, the jointly estimated Mundlak terms of the auxiliary regression (Equation 4.6) 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 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 4.5 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

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 4.2: 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.

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 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 4.3 and Figure 4.3. According to Equation 4.8, 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 4.3, 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

Table 4.3: 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

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.

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

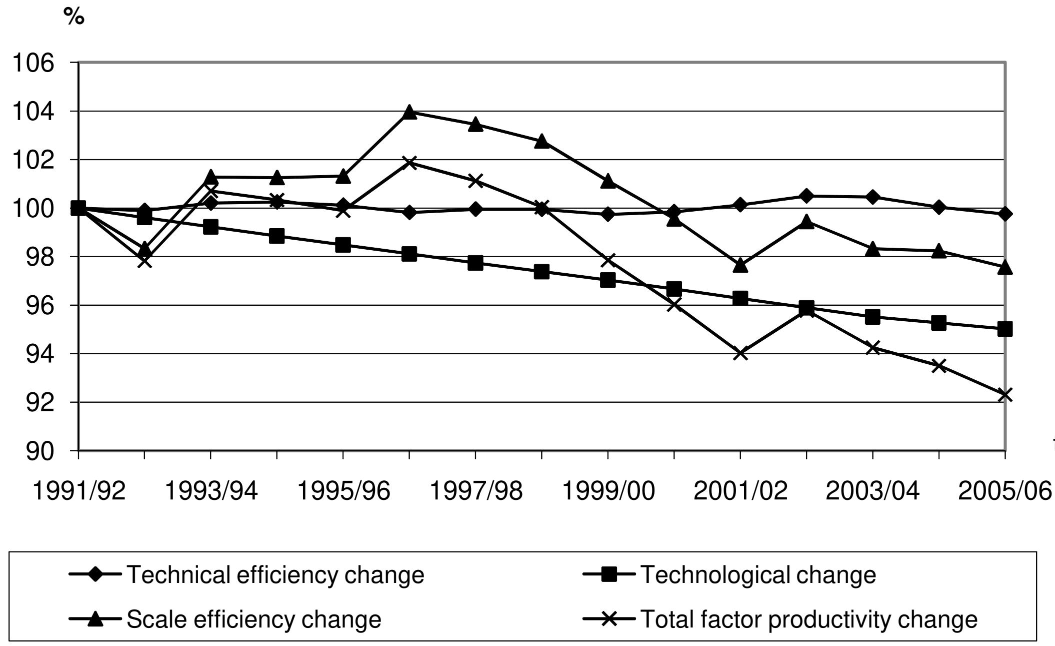

Figure 4.3: Cumulative indices of average TFP change and its components

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.

4.6 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 them, 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.

5 Summary and Conclusions

Against the background of the dependence of cultural institutions on public funding and the increasing cost-pressure on public budgets, this thesis contributes to the economic analysis of the German cultural sector. For this purpose, we conducted three empirical studies focusing on the German cultural sector using different methods to quantify the analyzed effects.

Chapter 2 described an application of the CVM to assess public approval for the amount spent on the supply of publicly provided cultural facilities. For our analysis, we used data from a CV survey that captures the WTP for the municipal cultural supply in Lüneburg, Germany. An OLS and a Tobit regression model were supplemented by a QR model to analyze the results. The results show, first, that the population of Lüneburg agrees with the amount spent on the municipal supply of cultural goods by the public authorities. However, this finding must be considered carefully because of the anchoring bias that results from revealing the actual tax amount spent for the municipal supply of cultural facilities. Second, in terms of the non-use values attributed to cultural goods, the results suggest the existence of these external effects. Furthermore, comparing the estimates of the different multivariate regression models shows that the QR model provides more detailed information than traditional methods like OLS and Tobit, so it allows for the heterogeneity of preferences.

Chapter 3 presented an analysis of the efficiency of German public theaters for the 1991/1992 to 2005/2006 seasons. Using a stochastic frontier analysis approach, we tested to determine whether the assumption of cost-minimizing behavior is reliable in this sector. We also applied several panel data models that differ in their ability to account for unobserved heterogeneity to evaluate the impact of unobserved heterogeneity on the efficiency estimates. The results of the analysis suggest that cost-minimizing behavior is violated in the case of German public theaters, so an efficiency analysis based on a cost function approach seems inappropriate. Further, comparing the results of the different panel data models shows that the German public theater sector is characterized by considerably unobserved heterogeneity across the theaters. Taken together, the efficiency results suggest that there is still room for improvement in the employment of resources in the German public theater sector. Thus, public authorities should carefully reassess the system with a particular focus on the implementation of cost-minimizing incentives.

Chapter 4 investigated the development and sources of the TFP of German public theaters using a stochastic distance frontier approach that allows the decomposition of total factor productivity change into technological change, technical efficiency change and scale efficiency change. The findings indicate that there is no significant technological progress that can countervail the negative productivity trend caused by increasing wages and, thus, support the cost-disease hypothesis. Furthermore, the majority of the theaters reveal increasing returns to scale, which implies that significant efficiency gains can be realized by the exploitation of scale economies. Nevertheless, since technical efficiency remained almost stable and scale inefficiency increased over the sample period we observe an overall decrease in average productivity of about 8 percent.

Several central conclusions can be drawn from the three studies presented in this thesis. As shown in the example of the municipal cultural supply in Lüneburg, the German public appears to approve public funding of the arts in order to provide a cultural infrastructure and preserve cultural heritage. However, the actual subsidy system needs careful reassessment in order to improve efficiency in employing the publicly provided resources. To reach the desired economic effects, cost-minimizing incentives should be implemented, and the exploitation of scale economies should be promoted. Since the three empirical studies are subject to limitations in time and space, further research in the form of comparable studies is necessary before these implications can be transferred to other areas of the German cultural sector.

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