Four Essays on Efficiency and Productivity of Cultural Institutions

- Empirical Analyses of Orchestras,Theatres and Museums

Mervi A.Taalas

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University of Warwick
Department of Economics

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Summary

This thesis builds on the research tradition of Cultural Economics, particularly of its empirical strand. The thesis includes four articles that each analyse empirically a different facet of production of cultural services. Together they contribute to the two main themes of the thesis: features of production technology and applicability of different empirical methods in analysing production of cultural services.

The four articles proceed in "chronological" order. The first article deals with problems shared by the subsequent studies - measurement of inputs, output(s) and quality of production - and employs neo-classical single-output cost functions and Structural Equation Modeling approach together with a cross-sectional data set of museums. The second article follows the earliest strand of cultural economics and examines, in a context of Baumol's cost disease, the assumption of stagnant productivity growth. The analysis utilises two index number approaches, Törnqvist Approximated and Generalised Divisia Indices, and a panel data set of orchestras. The third article looks at the scale properties of production as well as tests the assumption of allocative efficiency by using non-linear single-output cost functions with a panel data set of theatres. The fourth article focuses on cost-efficiency of museums and utilises non-parametric Free Disposal Hull method and a cross-sectional data set of museums.

The main findings of the thesis indicate, first, that production technologies of museums, orchestras and theatres vary substantially. The production technology of museums is shown, in a single-output setting, to exhibit homotheticity and homogeneity with respect to output as well as substantial increasing/decreasing scale economies, depending on the output measure. Analysis in a multiple output context reveals that on average a quarter of museums are cost-inefficient and private museums are more likely to be inefficient than the publicly owned ones. The production technologies of orchestras and theatres are alike with respect to single-output production as well as non-homotheticity and non-homogeneity of production technology. They differ as to the scale properties - orchestras exhibit diseconomies while theatres are characterised by scale economies - as well as relative usage of labour input. Production in orchestras is characterised by stagnant productivity that is a result of scale effect cancelling out technical change. Theatres are shown to be moderately allocatively inefficient. As to the methodology, the thesis suggests that particularities of cultural institutions have to be taken into account. These particularities involve problems related to measurement of inputs, output(s) and quality of production, definition of production technology as well as problems arising form data. Methods employed in price-quantity space, allowing in-efficiencies of production and not imposing a priori assumptions on production technology are argued to be most applicable ones.

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Declaration

Parts of this thesis have been published previously.

II Measurement of Inputs, Output(s) and Quality in Production of Cultural Services

A more extensive version of the cost function analysis of the article has appeared as Taalas M. (1998) "Cost Functions of Finnish Museums - Existence of Scale Economies in Cultural Institutions", in *Art Museums and Markets* (Uusitalo L. and Ahola E-K. eds.), Helsinki School of Economics, Helsinki.

III Total Factor Productivity in Production of Cultural Services

An earlier version of the article has been published as Taalas M. (1998) "Let's Face the Music! - Productivity Growth in Symphony Orchestras in the Presence of Non-constant Returns to Size and Technological Change", *Economics of Artists and Arts Policy - Selection of Papers* (Heikkinen M. and Koskinen T. eds.), Research Reports of the Arts Council of Finland 22, Helsinki.

IV Generalised Cost functions for Producers of Performing Arts

The article has been published as Taalas M. (1997) "Generalised Cost Functions for Producers of Performing Arts - Allocative Inefficiencies and Scale Economies in Theatres", *Journal of Cultural Economics* 21: 335-353.

I Introduction

1 Background

Since the seminal study by Baumol and Bowen (1966) "Performing Arts - The Economic Dilemma: A Study of Problems common to Theater, Opera, Music and Dance" there has been increased interest in analysing production and consumption of arts.[1] According to Throsby (1994) this interest, labelled often as cultural economics, breaks down into four main research traditions:[2] studies on *markets of arts works*, *labour markets for artists*, *public subsidies to the arts* and *markets of performing arts*.[3]

The studies on *markets of arts works* are generally based on a notion, that works of art differ from other commodities.[4] Each work of art, moreover, differs form every other arts work: Throsby (1994) points out, that the "original art objects (paintings, pieces of sculpture, and other artifacts) are ...an extreme case of a heterogeneous commodity."[5] Because of this, the demand for arts works is generally conditioned, besides the price, consumer income, financial market characteristics, to aesthetic quality, while the supply is determined by prices and costs of production.[6] In the markets the motives of buyers are generally assumed to range from "demand for art purely as decoration to demand for art as pure [financial] asset" (ibid.), that finalise either in decentralised primary markets or concentrated secondary markets, that are dominated by international auction houses.[7]

The secondary markets, and particularly the rate of return of arts works as a financial investment, have inspired a great variety of empirical analyses. The focal point in these analyses has generally been to compare the rate of return of arts works and other investment goods such as real estate, bonds or shares. The comparisons have most often been based on the data set, or its extensions, by Reitlinger (1961) on secondary market transactions of arts works in major auction houses from 1760 till 1961 and data on given local markets for other investment goods.[8]

The analyses have generally found great variability in the rate of return.[9] For example Baumol (1986) concludes in his study, that investing in most arts works, in most time periods, leads to losses rather than profits, due to "the fickleness of taste whose meanderings defy prediction."[10] This view is supported also e.g. by Frey and Pommerehne (1988), who bluntly conclude, that "it is no easier to make speculative financial profits in art than anywhere else".[11] The few studies that find art as a lucrative financial asset include e.g. Bryan (1985) who utilise the Shotheby's Art Index for the period 1970-1984. The observation by Bryan (1985) that "the returns in the art market were lucrative for the pure art speculator" are not, however, surprising given the extraordinary rise in art prices during the 1980's.

The peculiarity of markets is also the starting point of the studies on *labour markets for artists*. Throsby (1994) points out that "the popular image of the artist, whether actor, musician, painter, or poet, as a flamboyant bohemian devoted only to realizing a creative dream and oblivious to financial concerns is a portrayal far removed from the philistine economic man who lies at the heart of conventional economic models of labour market behaviour". Thus, the studies, rather than employing rigorous economic models, center mainly on describing the determinants of supply as well as income levels and distribution across the artistic labour force.

The studies on labour supply generally suggest, that labour supply in the arts is characterised by multiple job holding, and that "pursuit of art at the expense of income is widespread" (ibid.). The studies on income levels and their distribution, in turn, reveal according to Throsby (1994), first, that mean earnings among artists are lower than "other workers of similar educational and professional standing", second, that "age-earnings profiles are steeper for artists than for workers", and third, that "artists' incomes are more variable than those of other groups, both across time for an individual artist, and across artists at a given point in time".

Of the determinants of income level and employment, training and talent have been regarded as the most important ones. For example Frey and Pommerehne (1989) as well as Wassall and Alper (1992) have emphasised the importance of training, whereas Towse (1992) sees education to serve "as an insurance policy". The role of talent in determining success in an artistic career was underlined by Rosen (1981), who noted that differences in talent result in differences in earnings.[12] This result, together with the notion that consumption of arts is often characterised by scale economies, suggests that few talented artists - "superstars" - dominate the markets and receive the highest earnings.[13]

The early studies on *public subsidies for the arts* rely on the well established economic theories. The seminal study by Baumol and Bowen (1966) on performing arts bases the need for public subsidies, or private donations, on market failure argument as well as on the idea of "cost disease" that plague performing arts institutions. The market failure arguments suggest, that due to positive externalities, public good characteristics, and production having natural monopoly characteristics, arts should be subsidised, since the markets do not produce optimal allocation of resources.

The cost disease - or alternatively Baumol's disease, B-B thesis, income gap or earnings gap - in turn, suggests, that performing arts is prone to an ever increasing gap between costs and revenues. This argument is based on the idea of a two-sector unbalanced growth model, in which the performing arts sector is characterised by labour intensity and price elastic demand that prevents increasing ticket prices.[14] These two characteristics, combined with the notion that the productivity growth of performing arts sector lags behind the other sector of economy (due to lack of technical progress), yields a situation in which performing arts institutions face an increasing gap between costs and revenues. Baumol and Bowen (1966) argue, that "the economic pressures which beset the arts are not temporary - they are chronic...[and] if things are left to themselves deficits are likely to grow".

The market failure arguments as well as the cost disease have both inspired a vast number of studies.[15] Most of the studies have elaborated the different market failure arguments together with the B-B thesis and discussed their applicability in different markets. The findings of these studies have generally supported the relevance of both - market failure arguments and cost disease - as to legitimise public subsidies. The relevance of the market failure arguments has been, furthermore, underlined in so called impact studies that have focused on demonstrating the positive externalities of production and consumption of arts. These studies have centered either on local level activities - e.g. Myerscough (1988) as well as O'Hagan et al. (1989) - or positive externalities at country level. An example of the latter is Seamann (1992), who went as far as to argue that in 1991 the US cultural sector constituted six per cent of the GNP and employed more than two and a half per cent of the US labour force.[16] Moreover, Seamann (1992) found various positive non-monetary externalities that were mainly based on the idea of production and consumption of arts being as such meritious.[17]

Besides the market failure arguments, also the ideas of government failure and information asymmetries have been put forward as to legitimise public subsidies.[18] These two arguments have been employed mainly to explain existence of non-profit producers of performing arts.[19] The former suggests that a government fails to provide adequate level of arts with the prevailing tax rate, and thus, publicly subsidised non-profits emerge to satisfy the excess demand. The latter argues that since information asymmetries between producers and consumers of arts are likely, non-profits should be subsidised in order to secure high quality provision to consumers. For example Hansmann (1980) has argued that since "a for-profit firm has both the incentive and the opportunity to take advantage of customers by providing less service to them than was promised and paid for, the non-profit firms emerge to provide services in the amount and quality agreed on." Of these two - government failure argument and information asymmetries - only the government failure argument has been empirically examined. The government failure has been examined mainly in terms of the so called willingness to pay studies that aim to assess the public's willingness to pay for the external benefits of the arts contrary to taxpayers liability. Examples of such studies are e.g. Throsby and Withers (1986) as well as Morrison and West (1986).[20]

The research tradition on the *markets of performing arts* has conventionally been based on the notion that demand for performing arts resembles demand for arts works, since aesthetic judgement is an essential element of any production. Demand is, however, assumed to differ dramatically from arts works, since performing arts does not materialise as artefacts to be sold in secondary markets. An exception to this are recordings of live performances, enabled by recent technological advances, that have created a mass market for such products.[21] Notwithstanding these mass markets, performing arts productions remain a transient phenomenon: even the most elaborate recording cannot reproduce a live performance. The demand for a given live performance is, thus, conditioned to the quality of the given artistic experience. Besides this, demand is generally conditioned to ticket prices, and income.

The empirical studies on demand have centered mainly on price and income elasticities and have been based on the assumption that output of performing arts institutions is best measured by attendance (tickets sold). The empirical studies on price elasticities, e.g. by Moore (1968) and Felton (1994), suggest - contrary to Baumol and Bowen (1966) - that demand for performing arts is relatively inelastic. Cross-elasticities between different types of performing arts - theatres, symphony orchestras, dance groups and opera - are, however, significant e.g. according to Gapinski's (1986) study on London West End in 1970's. The studies on income-elasticities, e.g. by Withers (1980), in turn, show - rather expectedly - that demand for artistic experiences increases with income.[22] The sole application in which quality is examined as a determinant of demand is by Throsby and Withers (1982): the study found demand to be inelastic with respect to ticket price, but "strongly responsive to variations in quality" measured by standard of script, acting and production.

The supply of performing arts is generally defined, as any other production, in terms of a producer transforming labour and capital inputs into outputs. The producer is characterised, according to theoretical models on market structures of performing arts, most often as a monopolistic non-profit producer that cannot finance its activities with own revenues.[23] This is the case e.g. in the two most referred to models on non-profit producers of performing arts by Hansmann (1981) and Holtman (1983). Hansmann (1981) portrays performing arts institutions as monopolistic non-profit producers that maximise attendance, quality or budget. The producers, furthermore, charge an admission fee for their services - production of which require relatively high fixed costs - as well as do not increase their ticket prices due to relatively high demand elasticity and restricted demand of "high culture". Basing on this, Hansmann (1981) concludes that producers of performing arts must acquire private donations - that are depicted in the model as voluntary relinquishes of a part of consumer surplus - as well as to be entitled to public subsidies.

Holtman (1983) assumes in his public utility pricing model that demand for performing arts is stochastic, implying that producers decide both capacity and price prior to knowing the actual demand. The non-profit producers that operate in the markets are assumed to pursue a social objective that maximises the expected consumers' willingness to pay minus total costs. This leads the non-profit producers to set a socially optimal price that covers operating costs, but no capital costs. This resulting low price (admission fee) necessitates rationing that is operationalised by different types of non-profits in rationing rules that reflect their ethical norms. In addition to the host of different non-profits, for-profit enterprises may also enter the markets. The for-profits set prices and capacity as to maximise profit and remain in the industry only if the consumers are ready to pay a higher price for the assured availability of the service. Thus, the model envisages co-existence of different types of producers in the same market.[24]

The more detailed analyses on supply of performing arts have concentrated on empirical assessments of production. Throsby's (1994) categorisation of research traditions acknowledges merely the few studies on "production and cost relationships", and calls for "more carefully articulated models" as well as more detailed empirical assessments of production of performing arts. Actually - even if Throsby (1994) rightly laments the lack of empirical research on production of performing arts - an undercurrent of empirical studies on production of cultural services has slowly emerged. These studies, however, refer with production of cultural services to both performing arts institutions - orchestras, theatres, dance companies, and opera - and institutions connected to visual arts - museums and galleries.[25] These empirical studies, moreover, fall into three main categories. First, studies that stem directly from the B-B thesis and focus on *the growth of costs and stagnant productivity*, second, studies that look at *features of technology and particularly scale economies*, and third, studies that *examine efficiency of production*.

As already noted, the B-B thesis has stimulated a wealth of empirical studies in relation to legitimisations of public subsidies. In terms of more detailed analyses of production, comparisons between *growth rates of production costs* in production of cultural services and general price level have attracted most attention. This line of inquiry has been followed e.g. by Netzer (1978), Throsby and Withers (1979), Peacock et al. (1982), Baumol and Baumol (1980, 1984) as well as Schwartz (1986), who all suggest that costs in performing arts rise with a faster rate than in the rest of the economy, thus, implying a continuously increasing earnings gap. The assumption of *stagnant productivity* - that is the driving force of the B-B thesis - has been empirically addressed by Felton (1994), who devices a rudimentary measure for labour input productivity in US orchestras. Controversially, the study gives preliminary evidence that productivity of labour input in performing arts institutions fluctuated considerably from 1972 till 1992.

The *scale properties of production* of cultural services have been analysed mainly by using the cost function approach. The cost function approach has become widely used, since it does not require detailed information on technical aspects of production, but employ information on economic aspects - in the case of cultural services data on economic aspects has been more often available and more reliable, than data on technical aspects. Globerman and Book (1974), who examined scale properties of US symphony orchestras and theatre groups, were first to employ cost functions to production of cultural services. Thorsby (1977) followed suit, and assessed Australian performing arts institutions. The mid 1980's brought about some more theoretically sound estimations of cost functions: Lange et al. (1985) estimated cost flexibilities for different size of US symphony orchestras, Jackson (1988) compared cost flexibilities of different types of US museums, and Paulus (1993) examined scale economies of French museums. All these applications found different degrees of increasing scale economies, notwithstanding the producer type.

The third area of empirical analysis of production - *efficiency* - emerged only in the early 1990's and utilised new methodological innovations. Most importantly, non-parametric mathematical programming methods - Data Envelopment Analysis (DEA) and

Free Disposal Hull (FDH) - were taken into the methodological repertoire. The path of efficiency analysis was, however, blazed by Gapinski (1979), who already in the late 1970's estimated for US performing arts institutions time series transcendental production functions that allowed a variety of configurations for marginal products of inputs. The estimated production functions - that captured both technical change and divergences from the doctrine of positive but declining marginal products of inputs (technical efficiency) - suggested, first, that performing arts institutions generally exhibit decreasing scale economies, and second, that artistic personnel is over utilised together with the capital input.

The pioneering application of non-parametric methods is by Ek (1991a, 1991b, 1994), who assessed productivity growth and technical efficiency of Swedish theatres. A subsequent study by Paulus (1995) examined technical efficiency of French museums, and Mairesse (1997) assessed technical efficiency of Belgian museums. All these three latest studies have applied DEA and found substantial technical inefficiencies.[26]

By and large, the three empirical traditions to look at the production of cultural services - studies on productivity, scale economies and efficiency - have two distinctive characteristics. First, the early studies in each tradition have a tendency to treat different types of producers similarly, particularly different types of performing arts institutions. Even if the studies cover a wide range of producers from dance companies to museums, similar approaches have been applied across the board: for example Jackson (1988) and

Lange et al. (1985) use similar single-output cost functions with similar functional form for museums and symphony orchestras, respectively. Moreover, in all three traditions the results appear to be relatively similar across different institution types: cost disease is argued to plague both performing arts institutions as well as museums, both performing arts institutions and museums exhibit scale economies, and production seems to be technically inefficient in both performing arts institutions and museums. Notwithstanding this, there are grounds to suspect that production technology varies significantly between different kinds of producers: staging an opera piece by Wagner is likely to differ radically from setting up an exhibition of water colors by Turner.

Second, the previous studies scarcely discuss about the methodological issues and explicitly argue for the methodological choices. This is partly due to the fact that the research has been to a great extend driven by policy concerns: the research topics, rather than methodologies have dominated the discussion.[27] The proliferation of methodological tools has, however, instigated a need to discuss the applicability and relative performance of different (econometric) methods in more detail. In the case of cultural services three main points are of particular interest - besides the main stay arguments for the usage of particular methodologies - as to the choice of methodology: caveats deriving from available data sets, conceptual and measurement problems related to inputs, output(s) and quality, as well as level of a priori knowledge on the production technology.

This thesis builds on the three empirical traditions - productivity, scale properties and efficiency - as to analyse production of cultural services. The two over-arching themes of the thesis are the differences and similarities of production amongst different types of producers of cultural services, as well as factors affecting the methodological choices. This thesis endeavours to demonstrate, with respect to the three research traditions, that features of production differ significantly across different types of producers, as well as advocates discussion on methodological choices.

2 Definitions of the basic concepts

Representation of production presupposes an *input* bundle, *output* bundle, and illustration of the input and output correspondences, i.e. *production technology*, that indicate how inputs are turned into output(s). The production technology can be approached either from the perspective of inputs or output(s). The former perspective defines production technology in terms of minimisation of inputs at a given output level, while the latter determines production technology in terms of maximisation of output(s) with given inputs. Moreover, the production technology, either input or output oriented, can be modeled either in a quantity or price space. This means, that input and output bundles can be defined either in terms of quantities or prices, and hence, the production technology - correspondence between input and output - can be defined in terms of quantities, prices or a combination of thereof.[28]

Traditionally, the correspondence between inputs and output has been modelled as a *production function.*[29] The production function is an output oriented representation of technology: production technology can be modeled in a quantity space as a transformation of a n-dimensional vector of non-negative inputs x into a (m-n)-dimensional vector of non-negative output, i.e. $y = f(x)$. The production function is generally assumed to represent the maximum output for given inputs, and some additional properties are generally posed in order $f(x)$ to represent a well behaving production function that depicts the economic behaviour presupposed in neoclassical economic theory.[30]

A *cost function,* in turn, is an input oriented representation of technology in a quantity-price space which represents the minimum inputs required to produce a given output(s).[31] Assuming a vector of strictly positive input prices p, the cost function can be written as a following minimisation problem:

$$c(p,y) = \min_x [p \cdot x : x \in V(y)]$$

in which $V(y)$ is the input requirement set that has to be non-empty and closed in order the cost function $c(p,y)$ to exist. In this definition the input requirement set $V(y)$ and the producible output set Y^* define the input output correspondence: the input requirement set $V(y)$, contains all the input bundles x that can produce output level y, i.e. $V(y) = \{x : (x,y) \in Y\}$, whereas Y^* includes all output bundles that appear in the production possibility set Y, that includes those pairs of input and output bundles (x,y) with which y can be produced by using x, i.e. $Y^* = \{y|(x,y) \in Y\}$. Furthermore, a well-behaving cost function has the properties of (1) non-negativity, (2) non-decreasingness in p, (3) non-decreasingness in y, (4) positive linear homogeneity in p, (5) concavity and continuousness in p, and (6) differentiability.[32]

As seminally pointed out by Shephard (1953), cost and production functions can be alternatively used to represent the same input output correspondence.[33] This feature is captured in the theory of production *duality* which implies that under certain conditions it is possible to derive from the cost function the underlying dual production technology.

The starting point of a representation of the dual relationship is that the cost function represents the cost minimising points of all isoquants, in given input prices for all output levels. Hence, the cost function presents all the cost minimising points of the input requirement set V(y) in given factor prices. In order for the cost function to describe also the economically inefficient production possibilities the factor prices p are let to vary over all possible price vectors. This yields V*(y), which is defined as $V^*(y) = \{x: px \geq px(p,y) = c(p,y) \text{ for all } p \geq 0\}$. The focal point of the duality is, thus, under what conditions the input requirement set derived from the cost function V*(y) corresponds the true V(y). It has been proven that V*(y) equals V(y) when V(y) is regular, convex, and monotonic.[34] In case the original technology is convex and monotonic, the cost function can be used to reconstruct completely the underlying production technology.

And vice versa, if the cost function is non-decreasing in both y and p as well as linear homogenous and concave in p, the cost function will accurately describe the production technology. In this sense McFadden (1979) calls the cost function a "sufficient statistic for all the economically relevant characteristics of the underlying technology".[35]

Notwithstanding whether the input-output correspondences are represented in quantity or quantity-price space, the most relevant characteristic of technology has traditionally been the scale economies. The *scale economies* generally refer to the proportional changes in the size of technology. The *elasticity of scale* $\in(y,x)$, that can be derived from the production function, is a measure of output variation associated with a simultaneous change in all inputs in same proportion. Formally, the elasticity of scale can be written as $\in \equiv \partial \ln f(\lambda x)/\partial \ln \lambda \big|_{\lambda=1}$. The alternative measures - *elasticity of size* and *cost flexibility* - are derived from the cost function and measure the effect of output change on costs. The elasticity of size is the reciprocal of the cost flexibility that is defined as the first derivative of the cost function with respect to output. In fact, the concept of cost flexibility $n(p,y)$ measures the elasticity of cost with respect to output, and it can be written as $n(p,y) = [\partial c(p,y)/\partial y]y \,/\, c(p,y) = \partial \ln c(p,y) \,/\, \partial \ln y$. The interpretation of this is that if $n(p,y) > 1$, smaller size production is more cost effective, and if $n(p,y) < 1$, there are cost advantages in larger sized production. As noted, the elasticity of size $\in^*(p,y)$ is the reciprocal of cost flexibility, i.e. $\in^*(p,y) = 1/n(p,y)$.[36] According to this an enterprise exhibits decreasing economies of size if $\in^*(p,y) < 1$, and increasing returns to size if $\in^*(p,y) > 1$.

The focal point to note is that the scale elasticity $\in(p,y)$ and the size elasticity $\in^*(p,y)$ are equivalent only if the production technology, and subsequently both the production and cost functions, exhibit *homotheticity*. The homotheticity - introduced into economics again by Shephard (1953) - indicates that an increase in output does not alter the relative utilisation of inputs, i.e. cost function is separable. In the framework of cost functions this, furthermore, implies that since an increase in output does not alter the relative utilisation of inputs the cost shares of inputs do not alter. In fact, in such a case the cost function can be written as a separable function in output and factor prices, i.e. $c(p,y) = h(y)g(p)$. As is well known, homotheticity is also a pre-requisite of *homogeneity* of production technology *with respect to output*: homogeneous technology with respect to output implies e.g. that the level of scale (dis-)economies does not increase/decrease when the output expands.[37]

Besides the scale properties of production, the performance of a producer in turning inputs into outputs is generally assessed by using the notion of *productivity*. In fact, productivity depicts how well inputs are transformed into outputs: the higher the productivity the less inputs are required to produce more output. Usually, productivity is determined in terms of *total factor productivity* (TFP) that is defined as a ratio of an index of outputs to an index of inputs.[38] The variations of productivity between producers and over time have been of particular interest. Traditionally, productivity has been assumed to vary, pace Solow (1957), solely due to *technical change* that refers to a change in production technology, i.e. input output correspondence. Recently, productivity has been, however, interpreted as a result of a net change in output due to technical change, changes in *efficiency* and environment in which production takes place. The change of productivity in time - *productivity growth* - has generally been defined as a change in TFP in time.

Efficiency can be defined by comparing observed and optimal values of output produced and inputs utilised. Again, this comparison can be either output or input oriented - efficiency can be defined as the ratio of observed to maximum potential output obtainable from the given input, or as the ratio of minimum potential to observed inputs required to produce a given output level.[39] In both of these comparisons optimum is defined in terms of difference between the actual production and optimal feasible production possibilities determined by the production technology. Hence, this type of efficiency is called *technical efficiency*.

Traditionally, technical efficiency is defined either in terms of *Koopmans efficiency* or *Debreu-Farrell efficiency*. As demonstrated by Lovell (1993), according to Koopmans (1951) a production unit (input-output vector) is technically efficient if increasing any output or decreasing any input is possible only by decreasing some other output or increasing some other input - Koopmans definition requires efficiency in all inputs and outputs. The definition pace Debreu (1951) and Farrell (1957) is less stringent: a production unit is Debreu-Farrell -efficient if an equiproportionate increase in all outputs (an equiproportionate decrease in all inputs) is not possible when input usage (output level) remains the same.[40] This definition requires efficiency only in at least one input (or output), and thus, Debreu-Farrell technical efficiency is necessary, but not a sufficient condition for Koopmans technical efficiency.[41]

In addition to technical efficiency, efficiency includes also the notion of *allocative* (or price*) efficiency*. Allocative efficiency- introduced by Farrell (1957) - implies that inputs are employed in optimal proportions in terms of prevailing market prices, and that production process is economically efficient. In more detail, production is allocatively efficient where the ratios of market prices for inputs equal to corresponding marginal rates of technical substitution: allocative efficiency is often defined residually as the ratio of cost efficiency to the Debreu-Farrell input-oriented measure of technical efficiency. *Cost efficiency*, in turn, is generally defined as the ratio of minimum feasible cost - given technical and allocative efficiency - to the observed actual cost. Hence, a producer is cost efficient if and only if it is technically and allocatively efficient: cost efficiency requires that the producer employs, in addition to technical efficiency, an input mix as to minimise the costs, i.e. inputs are combined in optimal proportions in light of prevailing market prices. A cost efficient production unit is, thus, allocatively as well as technically efficient, but allocatively efficient unit is not necessarily cost efficient.

3 Themes of the thesis and research questions

As noted, this thesis builds on the three empirical traditions - productivity, scale properties and efficiency - as to analyse production of cultural services and consists of four articles. Each article forms an independent analysis of a facet of production of cultural services, but contributes to the over-arching themes of the thesis: features of production technology and their variation across different types of producers, as well as choice of methodology.

The four articles proceed in "chronological" order. The first article deals with problems shared by all subsequent studies, namely definition and measurement of inputs, output(s) and quality. The second article focuses on the earliest strand of empirical cultural economics and in the context of B-B thesis examines the assumption of stagnant productivity in Finnish orchestras. The third article takes on the scale economies and looks at the features of production in Finnish theatres, whereas the fourth article addresses the question of efficiency and assesses cost efficiency of Finnish museums.

Notwithstanding the different methodologies, all four articles employ an input (cost) oriented approach that represent production technology in a quantity-price space. The reason for this is twofold: first, data on economic aspects - rather than technical aspects - of production has been available and data reliable, and moreover, information on economic aspects of production are considered to be of more interest as to policy making and management of individual institutions than information on technical aspects of production. It should, however, be noted that each of the four articles is based on different data sets, methodologies, and perspectives, and hence, can be read as a self-contained study. Most of the articles have been published as selfcontained studies.[42]

3.1 The first article

The first article tackles the question that is relevant in each of the three latter articles, namely the measurement of inputs (input prices) and output(s). Besides this, possibilities to capture quality of production in empirical analyses are discussed. The aim of the article is, first, to show how the previous empirical applications have solved the measurement problems - the seminal empirical applications are shown to assume single-output production and to employ relatively similar measures for both inputs (prices) and output, irrespective the type of the institution, whereas the more recent applications use multi-output framework. Furthermore, the article suggests proxies for input prices and output(s) to be employed in the three subsequent empirical articles.

The possible proxies for output(s) and quality are explored by using neo-classical single-output cost functions and Structural Equations Modeling (SEM). The cost functions are employed primarily to underline the fact that the choice of the proxy for output has a significant effect on the results. Altogether four different single-output cost functions are estimated by using four different proxies for output. Besides this, a model with a proxy for quality of output is estimated. SEM, in turn, is utilised to explore possible measures for output in a multi-output setting. SEM approach is employed for two main reasons: the method allows to use latent variables to capture the evasive output, and besides this, the method incorporates means to test each and every relation of a given model. Both applications use a cross-sectional data set of 164 Finnish museums, year 1991.

The article proceeds in four stages. The measures for input (prices), output(s) and quality employed in the previous studies are first discussed. Then the data set of the two subsequent empirical applications is introduced. The application of cost functions is set off by putting forward the parameterisation of the single-output cost function that is followed by the estimates and their interpretation. After this, it is turned towards the multi-output setting and introduction of the SEM approach together with the subsequent results. Lastly, some concluding remarks are made.

3.2 The second article

The second article revisits the B-B thesis, and focuses on productivity growth in orchestras. The aim of the article is to test the assumption of stagnant productivity growth, given cost efficient production pace Baumol and Bowen (1966), as well as to explore possible causes of stagnant productivity growth. The article, moreover, casts some light to the features of the underlying production technology: homotheticity and scale properties of production. The assumption of stagnant productivity, and its possible causes, is examined by using index numbers together with neo-classical cost functions. The analyses utilise a panel data set of 19 Finnish symphony orchestras from 1978 to 1995.

Two different index number approaches are employed: the traditional Törnqvist approximated Divisia index that assumes competitive markets and constant returns to scale, and a generalised Divisia index, that allows to relax the assumption of constant scale economies. Of these, the former approach interpretes productivity growth equal to technical change, while the latter interpretates productivity growth to result both from technical change and scale properties of production. The two indices, that both allow to analyse productivity growth at firm level, are used for two main reasons. The computationally convenient indices are used, first, to demonstrate that the assumption of stagnant productivity holds in the case of symphony orchestras, even if the origins of stagnant productivity differ from the ones put forward by Baumol and Bowen (1966). Second, the two alternative approaches are used as to assess relative performance of the two indices in analysing production of cultural services - whether the more rudimentary Törnqvist index suffices, or whether the more elaborate generalised index is required.

The article proceeds in four stages. The data set of the study is first described, with an emphasis on the existence of an earnings gap and its growth rate in time. Then the concept of productivity growth is introduced. The application of the indices is started by presenting the formulation of the traditional Törnqvist approximated Divisia index together with the calculated indices of productivity growth. After this, it is turned towards the generalised indices. Since the generalised Divisia index necessitates information on scale properties of production, a trans-log formulation of single-output cost function is introduced as well as the estimates of the size elasticities. Then the formulation of the generalised Divisia index is put forward, together with the generalised productivity growth indices. Lastly, the results of the two subsequent calculations are compared and concluding remarks are made.

3.3 The third article

The third article looks at allocative efficiency of theatres. The aim of the article is, first, to test whether theatres combine inputs in optimal proportions in light of prevailing market prices, and moreover, to cast light to the features of the underlying production technology: homotheticity, partial elasticity of substitution between labour and capital, labour intensity of production, as well as scale properties of production. The article employs cost functions, both as to test the allocative efficiency and to examine the underlying production technology, as well as a panel data set of 37 Finnish theatres 1985-1993.

Both neo-classical cost functions as well as non-linear generalised cost functions are employed. The neo-classical cost functions are used first and foremost to produce starting values for the non-linear estimations, but also to act as a reference point. The non-linear generalised cost functions, in turn, are used since they enable to test allocative efficiency - that is modeled by using the notion of shadow input prices - as well as to assess the extend of allocative inefficiency. The generalised cost function is formulated as a flexible trans-log cost function since the trans-log functional form allows to test homotheticity, homogeneity as well as substitutability between inputs.

This article proceeds in four stages. The notion of shadow cost function is first established as a generalisation of a neo-classical cost function. Then the data set is introduced. The estimations are initiated by computation of the neo-classical cost functions as system of equations and this is followed by estimation of a non-linear shadow cost function. After this, the assumption of allocative efficiency is tested, extent of allocative inefficiency is calculated, and features of production technology are outlined. Lastly, some concluding remarks are made.

3.4 The fourth article

The fourth article concentrates on cost efficiency of museums. The aim of the article is to assess relative cost efficiency both across different museum types (art, culture historical, special, nature historical and culture historical museums) and across all museum types. Besides this, a point is made about differences in cost efficiency between privately owned and publicly run museums (museums owned by associations, foundations or funds vs. museums owned by the state, towns or municipality).[43] The article utilises a cross-sectional data set of 129 Finnish museums in 1996, as well as a non-parametric input (cost) oriented Free Disposal Hull (FDH) method that allows usage of multiple outputs.

The FDH method is employed, most importantly, since the method does not necessitate definition of a functional form for the underlying production technology: a museum produces multiple outputs, whence correspondence between inputs and outputs is difficult to define formally.[44] The method enables, moreover, to examine relative performance of institutions that is of interest both to policy makers as well as to the management of the individual institutions - FDH establishes the best practice producers and compares the rest of the producers to this bench mark. The input (cost) oriented approach is chosen, since the orientation provides, besides the institution specific efficiency scores, also information on excess spending in individual institutions.

The article proceeds in four stages. First, the data set is described. After this the FDH method is introduced with an emphasis on showing that FDH and DEA applied in the previous studies are nested. Then, the calculations of efficiency scores across different museum types are carried out. The same calculations are then repeated across all museums due to possible sparsity biases, outliers and existence of efficiency by default in the sample of the museums. The differences in cost efficiency between privately and publicly owned museums are then assessed. Lastly, some concluding remarks are made.

4 Data sets

As noted, each of the four articles is based on a different data set. The first article uses a cross-sectional data set of 164 Finnish museums in 1991, the second article utilises a panel data set of 19 Finnish symphony orchestras from 1978 to 1995, and the third article is based on a panel data set of 37 Finnish theatres 1985-1993, whereas the fourth article utilises a cross-sectional data set of 129 Finnish museums in 1996. Two different cross sectional data sets on museums are used since a more recent data set was available at the time of writing the fourth article.

All four data sets are based on the official annual statistics. The annual reports on museums are published in "Museotilasto 1991, Julius - Suomen Museoliitto Tiedottaa", Suomen Museoliitto (The Finnish Museum Association) and "Museotilasto 1996", Museovirasto (The National Board of Antiquities). The annual reports on orchestras are published yearly in "Toimintakertomus: Tietoja jäsenorkestereista kalenterivuodelta", Suomen Sinfoniaorkesterit ry (The Association of Finnish Symphony Orchestras), while the annual reports on theatres are published in "Teatteritilastot", Suomen Teatterijärjestöjen Keskusliitto (The Finnish Theatre Association). The data set of each article is compiled from these reports - the data is, in each case, inputed into PC and processed into an analysable format by the author.[45] Detailed descriptive statistics and information on how the data set is processed are presented in each article.

Endnotes

1. The Association of Cultural Economics was founded in 1973. The Journal of Cultural Economics has been published since 1977 and the first (bi-annual) conference was held in 1979 in Edinburgh.
2. See Bekemans (1989) for a nuanced classification of different branches of Cultural Economics.
3. It should be noted, that the categorisation by Throsby (1994) omits from the research tradition studies on sports as well as socio-cultural activities which are included in the classification of cultural sector by UNESCO. Actually, UNESCO (STC/Q/883) classifies cultural sector to include cultural heritage, printed matter and literature, music, performing arts, socio-cultural activities, and sports and games. See Heilbrun and Gray (1993) for a convenient working definition of cultural sector for the purposes of economic analysis.
4. In practice the definition of jazz by Louis Amstrong is sufficient also as to the works of art. According to Throsby (1994) Amstrog has allegedly pointed out when asked to define jazz that "if you gotta ask, you ain't never going to know."
5. An exception to this are reproductions and copies of arts works. See e.g. Pommerehne and Granica (1995) for a detailed discussion and an empirical application on the markets of reproductions. See Gary (1983) for discussion of forgeries.
6. See Schneider and Pommerehne (1983) for discussion on the determinants of aesthetic quality of arts works. See McCain (1980) for discussion on information asymmetries related to aesthetic quality judgements.
7. The primary markets are such that unorganized individual artists provide works to galleries, local art fairs and exhibitions, small dealers, and private buyers, while the secondary markets include transactions between established artists, dealers, and public and private collectors. See Jyrämä (1998) for characterisation of the secondary markets in Finland, Sweden, France and UK.
8. See Guerzoni (1995) for fierce criticism of the Reitlinger's series. Guerzoni (1995) argues that the data set, as well as most time series data sets on official auction sales, suffer from significant distortions. These distortions arise, first, from "the absence of data relating to the identify and the profession of the market agents involved in the transactions recorded in time series", and second, from " the criteria of selection adopted to construct the historical series of prices." See Frey and Eichenberger (1995) for more general criticism of the rate of return studies.
9. Besides the great variability in the results on rate of return, the studies also differ in terms of methodologies. Two main methods have been the single sales -method and multiple sales -method. The single sales method assesses price changes of art works basing on average prices of similar kind of works in respective years, while the multiple sales method uses observations of sales of the same piece at different time points. The former approach is problematic since the average prices in one market may fluctuate considerably e.g. due to a sale of a single Van Gogh. The latter approach, that is most generally employed, is problematic due to reduced number of observations as well as the fact that the time period between the sales is not accounted for.

10. For criticism of the treatment see Buelens and Ginsburgh (1993).
11. The seminal studies of the same strand include e.g. Anderson (1974) and Stein (1977).
12. Numerable studies on artists employment have been conducted basing on Finnish data sets. See e.g. Karhunen (1996), Heikkinen (1995) as well as Heikkinen and Karhunen (1996). These studies have assessed the effects of professional training and gender on employments and income levels. Besides this, the studies have looked at effects of direct public support on the economic situation of artists.
13. Alternative presentation of the "superstar" phenomenon has been provided e.g. by Adler (1985) and MacDonald (1988).
14. The B-B thesis is implicitly based on Baumol's more general work on two sector models. See Baumol (1970, first edition 1951) for the seminal formulation of the implicit model.
15. Studies on economic rationales for public subsidies to cultural institutions is by far the most researched topic of Cultural Economics. The topic has inspired, even as late as early 1980's, various volumes of collected articles: examples of this are e.g Blaug (ed.) (1976), Hendon et al. (eds.) (1980), Shanahan et. al. (eds.) (1982), Hendon and Shanahan (eds.) (1983), and Chartland et al. (eds.) (1987). See also the seminal contribution by Netzer (1978) on public subsidies. See Taalas (1993) for discussion and an account of the literature on public subsidies to the arts.
16. The survey by National Endowment for the Arts (1992) on US production and consumption of cultural services revealed that in 1990 $5 billion was spent on admissions to theater, opera, galleries, and other not-for-profit arts events (more than on admissions to spectator sports), $4.1 on movie admissions and $17.6 on books. Some one per cent of US labour force was involved in production of cultural services (theater, music, opera, dance, visual arts, crafts, literature, community and folk arts). Consumption and production of culture was estimated to account for one per cent to 2.5 cent of the GDP depending on the definition of cultural sector.
17. The merit good argument suggests that production and consumption of arts is advantageous by nature, and thus, should be publicly subsidised. The argument has been criticised, most importantly, due to its paternalistic overtones: consumers know well enough what is good for them, and because of this public intervention to the markets is not desirable. The most original merit good argument by far has undoubtedly been put forward by Scitovsky (1972) who argued that production and consumption of arts prevent criminal activities, and hence, arts being meritious.
18. Such a line of inquiry became particularly appealing after the launch of the project "The Program on Non-Profit Organizations" in Yale in 1977. Examples of spill-overs of the program are e.g. Rose-Ackerman (ed.) (1986), Powell (ed.) (1987), and James (ed.) (1989) for the Yale tradition, and others e.g. Bekemans (1989), Gui (1989), and O'Hagan and Purdy (1993).
19. See DiMaggio (1987) for an extensive description of the characteristics of not-for-profit producers of cultural services.
20. Throsby and Withers (1986) suggest that on average the Australian taxpayers willingness to pay exceed the current tax liability as to cultural sector. Morrison and

West (1986), in turn, found out in the Canadian case that the current level of tax expenditure was adequate, and that "The relevant external benefits appear to have been already captured (internalized) via current public expenditures."

21. There is a vast amount of studies on e.g. music and film industries, so to say, production of mass media. As noted, these industries have, however, been excluded form the sphere of this thesis. See for example Heilbrun and Gray (1993) for an over view of the studies on mass media.

22. This finding has been confirmed also in a great variety of surveys of public participation in the arts. See O'Hagan (1996a,1996b) for analyses of effects of income levels and educational attainment to access and participation in the arts, in US and in Ireland and US respectively.

23. The sole theoretical model with a reference to museums is the model of private production of excludable public goods by Brito and Oakland (1981). The model assumes first, that museums (among other similar producers) produce excludable public goods, i.e. public goods for which exclusion by means of pricing is cost-less, second, that underlying production technology exhibits economies of scale, and third, that production is unique due to locational considerations.

24. See Taalas (1995) for an application of a mixed oligopoly model of production of cultural services. In the treatment the model by Bester and Petrakis (1993) is used as a basis of a numerical simulation of incentives for cost reduction in a differentiated industry. This simulation suggests that with the simulated parameter values the profitability of a cost reduction in the social optimum is always higher than in a private oligopoly or a mixed oligopoly. This means, that both private and mixed oligopolies leads to under-investment in a cost reduction relative to the social optimum. Besides this, the profitability of a cost reduction for the private firm is higher in a private duopoly than in a mixed one. In the mixed oligopoly there is highest incentive for a cost reduction for the private firm if the public agency resembles a for-profit firm than when the public agency pursues mainly the consumer surplus. In all these cases the profitability of the cost reduction decreases when the degree of product differentiation increases.

25. Increased interest in museums is reflected in emergence of particular workshops in economics of museums e.g. University of Venice summer school in 1992 and conference in Economics of Museums in University of Durham spring 1997 as well as publications by Pearce (ed.) (1991) and Feldstein (1991).

26. Since the non-parametric methods provide information on relative performance as well as level of excess spending, they are clearly public policy oriented. This is reflected in the fact, that all applications on production of cultural services have been done in European countries in which public subsidies are of great importance. The new tradition appears as the first European driven line of inquiry.

27. This is demonstrated partly by the fact that receptiveness of new methodologies has been relatively low in Cultural Economics.

28. See Färe et al. (1994) for a detailed description of possible representations of the production technology in quantity or price space, or a combination of thereof.

29. The formulation and estimation of production functions was introduced to Economics in the seminal paper "A Theory of Production" by Cobb and Douglas in 1928. See Fuss and McFadden (1979) as well as Chambers (1989) for more detailed accounts of the introduction of production functions.
30. As is well known, a bare production function yields the maximum obtainable output from a given input vector, but does not as such provide a sufficient basis to support the neoclassical economic theory. See Fuss and McFadden (1979) or Chambers (1989) for a detailed account of the properties of a well behaving production function.
31. As pointed out by Chambers (1989), Nerlove was first to utilise in 1963 cost functions instead of production functions in empirical analysis. The pioneering study centered on estimation of returns to scale in electricity supply.
32. The non-negativity of cost function ($c(p,y) > 0$, $p > 0$ and $y > 0$) implies, that if input prices p are strictly positive and y is non-zero, the cost of producing a positive output is positive. The non-decreasingness in input prices p indicates, that increasing any input price must not decrease cost when the producible output bundle is fixed. (if $p' \geq p$, then $c(p',y) \geq c(p,y)$) The non-decreasingness in terms of output y suggests, that an increase in output cannot decrease costs. (if $y \geq y'$, then $c(p,y) \geq c(p,y')$) The property, that the cost function is positively linearly homogeneous in input prices p in turn indicates, that if an input bundle x is cost minimising at a strictly positive price vector p, and if all prices are multiplied by a positive scalar θ, then x is the cost minimising bundle and the level of minimum cost is multiplied by θ ($c(\theta p,y) = \theta c(p,y)$, $\theta > 0$). The property of concavity and continuousness suggests, that $c(\theta p + (1 - \theta)p',y) \geq \theta c(p,y) + (1 - \theta)c(p',y)$, for $0 \leq \theta \leq 1$ and $c(p,y)$ is continuous as a function of p, for $p \gg 0$. The differentiablity in p pre-requests a unique vector of cost minimising demands, that equals gradient of cost function $c(p,y)$ in p. This property, known as Shepard's lemma, implies that it is possible to derive cost minimising demands of all inputs from a well-behaving cost function. Using Shephard's lemma yields $x_i (p,y) = \partial c(p,y)/\partial p_i$. Hence, the vector of derivatives of cost function with respect to prices gives the vector of cost minimising input demands. For proof see Chambers (1989). See e.g. Shephard (1970), Diewert (1974), McFadden (1979) or Chambers (1989) for presentations of the properties and their relation to production function.
33. McFadden (1979) points out that the theory of production duality has its beginnings in the work by Hotelling in 1932, Roy in 1942, Hicks in 1946 and Samuelson in 1947. The pioneering study by Shephard (1953), however, was the first inclusive treatment of the subject as well as exhibition of the formal proof of the duality of cost and production.
34. For the proof see McFadden (1979).
35. See Färe et al. (1994) for a detailed proof the theory of production duality in a more general setting.
36. In general the latter concept, elasticity of size is used rather than the concept of cost flexibility. This is because the interpretation of the elasticity of size is analogous to the elasticities of scale, whereas interpretation of cost flexibility is vice versa. This means that when the elasticity of size is greater than one there is increasing returns to size, whereas cost flexibility greater than one implies diseconomies of size.

37. See Chambers (1989) for a detailed presentation of homotheticity and homogeneity with respect to output, and their implications to scale economies.
38. As noted by Kendrick and Vaccara (1980), prior to World War II all productivity estimates were of the simple output-per-worker or per-hour form. The first empirical attempt to measure total factor productivity was made by Tinbergen in 1942, and the concept of TFP was further elaborated by Kendrick in 1951. Solow (1957) was, however, the first to employ a production function framework, and thus, to establish TFP as an operational concept. See Kendrick and Vaccara (1980) for a more detailed account.
39. See Färe et al. (1994) for a general presentation of the concept of efficiency.
40. The original Debreu (1951) measure of technical efficiency, the so called "coefficient of resource utilization", was the first measure of productive efficiency. It is defined as one minus the maximum equiproportionate reduction in all inputs that still allows continued production of given outputs. Thus, a score of one implies technical efficiency because no equiproportionate input reduction is feasible, while a score less than unity describes the level of technical inefficiency.
41. This means that the radial Debrau-Farrell efficiency may suggest a production unit to be efficient when achieving the maximum feasible input savings or output expansion, even if there might be a slack in outputs or inputs. This means that a production unit (input-output vector) determined efficient on the basis of Debreu's radial measure may be technically inefficient on the basis of Koopmans' definition because it may lie on the boundary of the production possibilities set, but not on the efficient subset of the boundary. See Lovell (1993) for a more detailed account.
42. The cost function analysis of the first article on musems is published in Uusitalo and Ahola (eds.) (1998) as Taalas (1998a), the second article on orchestras is published in Heikkinen and Koskinen (eds.) (1998) as Taalas (1998b), and the third article on theatres is published in Journal of Cultural Economics as Taalas (1997). Besides this, two related studies - one on a mixed oligopoly models of production of performing arts and one on objectives of museums - in Benhamouet al. (ed.) (1995) as Taalas (1995) and in Uusitalo and Ahola (eds.) (1998) as Taalas and Uusitalo (1998), respectively.
43. This is to say that the study participates in the discussion about the relative efficiency of the public and private producers where two diverging views have been presented. The popular press has maintained that public enterprises are less efficient than their private counterparts whereas the empirical evidence as well as theoretical analyses have not supported this view.
44. The FDH method is employed, since FDH necessitates even fever a priori assumptions on the underlying production technology than DEA method employed in the previous studies.
45. The kind help of The Finnish Museum Association, The Association of Finnish Symphony Orchestras, The Finnish Theatre Association, and the National Board of Antiquities in providing the annual reports is acklowledged.

II Measurement of Inputs, Output(s) and Quality in Production of Cultural Services - Applications of Trans-log Cost Functions and Structural Equation Models

1 Introduction

The relative growth of service sector since 1960's has instigated a wealth of studies on production of services.[1] These studies have centered on economic performance, most importantly productivity and efficiency, of a great variety of producers (e.g. banking, transport, education, health care and culture) analyses of which involve problems connected to output measurement.[2] According to Griliches (1992) such measurement problems derive from lack of data as well as conceptual problems. The lack of data actualises in the fact that generally much more data has been collected on agriculture and manufacturing than on services. Conceptual problems "arise because in many service sectors it is not exactly clear what is being transacted, what is the output, and what services correspond to the payments made to the providers", and moreover, because production of services generally incorporate an aspect of quality. As to cultural services, both lack of data and conceptual unclarity contribute to the problems connected to measurement of inputs, output(s) and quality of production.

The data sets employed in the pioneering studies on production of cultural services reveal the caveats related to data.[3] The studies have generally utilised cross-sectional data sets including relatively few variables, thus, leading to analyses incorporating a single measure for output and innovative measures for inputs (prices). This is the case for example in the analysis by Globerman and Book (1974) who used a data set on 33 US symphony orchestras and 27 theatre groups year 1971, in a study by Throsby (1977) who pooled cross-sections of variable number of Australian performing arts institutions in seasons 1971-1972 and 1974-1975, as well as in the study by Jackson (1988) who employed a data set of US museums in 1979 (the number of observations is unclear).[4] The more recent analyses by Ek (1991a,199b,1994) are good examples of cases in which availability of high quality panel data enables analyses with multiple outputs.[5]

Irrespective the quality of data, both the pioneering studies as well as the more recent applications have discussed the conceptual problems related to output measurement. Most often the problem is solved by stating that the outputs of cultural institutions are artistic experiences that include an aspect of quality. The early studies generally operationalise these artistic experiences by using either the number of performances or attendance to proxy the output, and in some cases this single proxy is accompanied by a proxy for quality. The more contemporary studies, in turn, generally employ multiple proxies for output, but use no specific measures for the quality aspect of production. Neither the early studies nor the more contemporary treatments, however, discuss the problems related to measurement of inputs (prices).

This article concentrates on three main topics. First, the article maps the previously employed measures for outputs, inputs (prices) and quality of producers of cultural services as well as discusses their applicability. Second, the article examines whether the proxy for output affects in a single output setting the assessment of economic performance and underlying production technology. Besides this, the article proposes an approach that can be used in choosing measures for output in a multi-output setting. The approach is based on Structural Equation Modeling (SEM) method that allows to assess (latent) unobserved variables as well as includes excellent model specification and testing procedures.[6] The two subsequent empirical applications employ a cross-sectional data set of 164 Finnish museums in year 1991.

The article proceeds in four phases. The previously employed measures for inputs (prices), output(s), and quality are first put forward. After this, a parametrisation of a single output translog cost function is briefly presented together with the data set. Single-output cost functions are then estimated by using the developed measures for input prices and the chosen proxies for output. The main emphasis in this is to demonstrate that the choice of the output measure affects the assessment of economic performance. The theoretical background of SEM approach is then briefly outlined, and the applicability of SEM models in choosing the output measures for multi-output producers of cultural services is demonstrated. Possibilities to assess quality of output are then discussed: the quality question is dealt with by estimating alternative SEM's for quality as well as testing the similarity of professional and non-professional museums. Lastly, some concluding remarks are made.

2 Output measures for producers of cultural services

The seminal empirical applications and the more recent treatments of cultural institutions differ in their operationalisations of output. (See Appendix 1) As noted, the seminal empirical applications have generally assumed single output production and measured output either by number of performances or visitors (attendance). Lange et al. (1985) argue for the use of number of performances in the case of symphony orchestras because "on a conceptual level it is difficult to see the relationship between attendance and cost", whereas Gapinski (1979) employs attendance since "each member of the audience receives a cultural experience from being present, and thus it seems natural to regard output as the number of cultural experiences measured by attendance." Jackson (1988), in turn, measures the output of museums by the number of visitors because "it is clear that the central measure by which to judge the scale of the operations is attendance." [7]

Ek (1991a, 1991b, 1994), Paulus (1993,1995), and Mairesse (1997) - all point out the need for multiple measures for output. Ek (1991a, 1991b, 1994) applies both attendance and number of performances together with number of first nights to proxy the output of theatres, while Paulus (1995) defines the output of museums to contain two types of services, passive and active services. The passive services include those activities that are accomplished without almost any staff, e.g. exhibition of collection, whereas the active services include those activities that involve qualified and motivated staff. Basing on this Paulus (1995) applies a multi-output framework and four proxies of output. Mairesse (1997), in turn, employs altogether six output measures for museums.

Besides the differing views on single vs. multiple output production, the treatments differ also in their conceptualisations of the quality aspect: while the recent studies do not include any proxies for quality, the pioneering studies utilise a variety of measures.[8] (See Appendix 1) E.g. Globerman and Book (1974) capture quality of performing arts institutions by attendance per tour performance and find that an increase in attendance per tour performance induces an increase in total costs. Throsby (1977) measure quality by the ratio of grants to box office revenue - such a quality measure, included in a total cost equation, was positive and statistically significant in the case of theatre groups but not statistically significant for other types of performing arts institutions.

As to the museums Jackson (1988) argues that "neither of these quality measures [the ones used by Globerman and Book (1974) or Throsby (1977)] works well in the museum setting.... A valid indication of museum quality is the level of esteem with which it is held by professionals in the field." Basing on this, Jackson (1988) uses the accreditation by the American Association of Museums (AAM) to capture the quality: the estimated cost function includes a dummy variable in which presence of accreditation stands for quality. The estimations by Jackson (1988), however, show that quality is a significant factor only for history museums in which "accredited museums have 61% higher operating costs than similar unaccredited museums". Jackson (1988) attributes this inability of the dummy variable to capture quality among other types of museums partly to "the nature of a dummy variable which does not allow various degrees of museum quality."

3 Measures of labour and capital inputs (input prices)

Performing arts institutions as well as museums have generally been assumed to employ both labour and capital inputs in their production.[9] (See Appendix 2) The operationalisations of labour input (price) have generally been the conventional ones: in a cost function framework the unit price of labour input has been measured as the price of a man year, whereas in production function as well as Data Envelopment Analysis (DEA) settings labour input has been captured by man hours (man years).[10]

The operationalisations of capital input (price) have been less conventional. The sole application of a production function by Gapinski (1979) introduces a "props and papers" approach in which capital input is categorised into "props" that include purchase of rental sets, costumes, lights, sound and other stage equipment and "papers" that contain scores, scripts and royalties. Lange et al. (1985), in turn, pioneered an approach in which the unit price of capital input of symphony orchestras is defined as the ratio of promotional expenditures to donations. A similar measure is employed by Jackson (1988) in the case of museums, even if he notes that "it would be preferable to utilize a cost index based on construction costs and the price of specialized museum equipment and facilities" instead of the measure applied in the study. This is not done due to lack of data and due to "considerable merits" of the employed proxy that "measures the price of a museum must pay for each dollar raised from its suppliers in its capital markets."[11] Besides these two measures, the three applications of DEA capture capital input by operating costs.

4 Application of the measures in a single-output cost function framework

The effects of the choice of measures for output and input prices are first assessed by using neo-classical single-output cost functions and a cross-sectional data set of 164 Finnish art, culture historical, special, nature historical, regional as well as combined art and culture historical museums in year 1991.

Table 1: Descriptive statistics of the data set, year 1991, n = 164 museums, in FIM 1991

Variable	mean	st.deviation	variance
TC	0.17044E+07	0.30934E+07	0.95692E+13
PC	0.11504E+07	0.21116E+07	0.44590E+13
FTE	6.89	12.15	147.72
PTE	0.93	1.73	2.98
RC	0.44072E+06	0.78589E+06	0.61762E+12
CA	0.11325E+06	0.71949E+06	0.51767E+12
AQUI	2218.80	5766.10	0.33248E+08
COLL	50571.00	0.12849E+06	0.16509E+11
OPEN	1301.80	1152.60	0.13285E+07
VISI	16979.00	36933.00	0.13641E+10
NEXB	6.67	7.27	52.87
NPUB	1.61	2.43	5.90

List of variables: TC = total costs, PC = personnel costs, FTE = full-time employees, PTE = part-time employees, RC = real estate costs, CA = costs of new acquisitions, AQUI = new acquisitions, COLL = magnitude of collection, OPEN = yearly open hours, VISI = number of visitors, NEXB = number of exhibitions, NPUB = number of publications

In the estimations four different output measures are utilised, namely yearly open hours, number of visitors, number of exhibitions, and number of publications. The measures for input prices are constructed basing on the assumption that museums use both capital and labour inputs in their production.

The unit price of labour input is defined in a conventional manner as:

$$LP = LC/\ (FTE + PTE/2)$$

in which the total labour costs (LC) are divided by the number of full-time employees (FTE) plus a half of the number of part-time employees (PTE). So, the measure gives the price of one man-year in a museum.[12]

The unit price of the capital input is, in turn, defined as to reflect the price of collection. The reason for this is that the collection is the key capital input of any museum: investments into collection attract public subsidies and visitors, and besides this, investments in buildings (e.g. stores and exhibition space) and equipment (e.g. for conservation or display) are closely connected to the maintenance of existing collection and new acquisitions. The unit price of capital is given by:

$$CP = (CA/AQUI) + (RC/COLL)$$

in which the first term of the right hand side is the costs of new acquisitions divided by the number of new acquisitions and the second term is the real estate costs divided by the total magnitude of collection. The first term of the definition, thus, reflects the price of new capital stock, while the second term indicates the price of maintaining the existing "capital stock". The two termed definition, thus, captures the fact that the price of capital increases when the market value of a new acquisition increases through decreasing the first term of the definition (assuming that funds for new acquisitions remain the same). Besides this, the definition prevents the price of capital being zero when a museum does not make new acquisitions because the price of maintaining the old "capital stock" is included.

These two sets of measures - measures for output as well as measures for labour and capital input prices - are used together with a single-output cost function. The cost function employed here is the flexible translog (TL) cost function introduced by Christensen, Jörgenson and Lau (1973).[13] The parameterisation of the TL cost function, to which are added the conventional disturbance terms (ε), is as follows:

$$\ln c = \alpha_0 + \alpha_y \ln y + \gamma_{yy} (\ln y)^2 + \Sigma_i \alpha_i \ln p_i + \Sigma_i \Sigma_j \gamma_{ij} \ln p_i \ln p_j + \Sigma_i \gamma_{yi} \ln y \ln p_i + \varepsilon_c \qquad (1)$$

and the corresponding cost share of the i^{th} input is:[14]

$$S_i = \alpha_i + \gamma_{yi} \ln y + \sum_j \gamma_{ij} \ln p_j + \varepsilon_i \qquad (2)$$

in which c represents total costs, y is the output, p_i denote prices of inputs. Moreover, α_0 is the intercept, α_l and α_k are the cost shares of labour and capital respectively, γ_{ll}, γ_{kk} and γ_{kl} are the share elasticities, γ_{yl} and γ_{yk} stand for the biases of scale, and γ_{yy} is the derivative of elasticity of cost with respect to output.

Furthermore, in order the TL formulation to represent the dual underlying production technology the following regularity conditions have to be met:

$$\Sigma_i \alpha_i = 1$$
$$\Sigma_i \gamma_{yi} = 0$$
$$\Sigma_i \gamma_{ij} = \Sigma_j \gamma_{ij} = \Sigma_i \Sigma_j \gamma_{ij} = 0$$

In practice, the above definition (1) - (2) yields a system of three equations: a cost function and cost share equations for labour and capital inputs respectively.[15] Due to technical reasons the other cost share equation is, however, eliminated (by using the regularity conditions) from the estimations, and the remaining two equations are estimated simultaneously by using multivariate regression.[16] As demonstrated by Barten (1969), the choice which of the cost share equations is eliminated from the estimations has no effect on the results, hence, the cost share equation for capital input is eliminated.

The analysis is set off by estimating four alternative models utilising four alternative measures for output - yearly open hours, number of visitors, number of exhibitions, and number of publications - and using the full sample of Finnish museums (n=164). The estimated models are not, however, acceptable since all regularity conditions are not met: none of the four estimated cost functions fulfill the regularity condition of non-decreasingness with respect to output. That is to say that for the whole sample an increase in output implies decreasing costs, i.e. α_y was negative in each model!

The regularity conditions can be imposed to (1) - (2) by using two alternative approaches: either by choosing a more restrictive functional form that a priori satisfies the regularity conditions globally or alternatively by finding an output region in which the regularity conditions are fulfilled. Since the former approach necessitates a priori assumptions on the underlying production technology the latter approach is chosen: the sample is truncated to output regions where the translog functional form satisfy the regularity constraints in the largest possible region.[17]

For the number of visitors the feasible region occurs when attendance is greater than 1600, implying that museums with fewer than 30 visitors per week are excluded (n = 122). For the number of exhibitions the feasible region is when aggregate number of exhibitions is greater than 1, thus, only museums that arrange at least one exhibition besides the base exhibition are included (n = 116). The feasible region for the yearly open hours is where the measure is greater than 832: museums that are open less than two days per week are excluded (n = 94). The variable number of publications does not perform sensibly at any region, and thus, it is omitted from the further estimations.

Three cost functions are then estimated by using the truncated samples. Since all three estimated cost functions fulfill the regularity conditions, the estimations proceed to analyse the underlying production technology in each case.

The analysis of the underlying production technology is set off by testing homotheticity and homogeneity of the production technology with respect to output. This is done by using the Likelihood Ratio (LR) test. The LR test is carried out by estimating for each measure of output (yearly open hours, number of visitors and number of exhibitions) three different models - a model that imposes neither homotheticity nor homogeneity, a model that imposes homotheticity ($\gamma_{yi} = 0$), and a model that imposes homogeneity ($\gamma_{yi}= 0$, $\gamma_{yy} = 0$) - and then calculating the LR test statistics. As shown in Table 2, the test statistics for all three models suggest that the null hypothesises of homotheticity and homogeneity cannot be rejected, all test statistics remain below the critical value. This suggests, most importantly, that the relative utilisation of inputs remain constant when output expands.

Table 2: LR test statistics for homotheticity and homogeneity

Measure of output	Homotheticity	Homogeneity
number of visitors	$\chi 2(2) = 4.53$	$\chi 2(3) = 9.01$
number of exhibitions	$\chi 2(2) = 2.25$	$\chi 2(3) = 2.48$
yearly open hours	$\chi 2(2) = 3.06$	$\chi 2(3) = 4.77$
Critical value	$\chi 2(2) = 9.21$	$\chi 2(3) = 11.34$

Homotheticity and homogeneity of the underlying production technology have, moreover, a bearing on the assessment of scale properties of production. Generally, the scale properties are assessed in a cost function framework by using either the concept of *cost flexibility* or *elasticity of size* that both measure the effect of output change on cost. The cost flexibility can be formally written as $\partial \ln c(p,y)/\partial \ln y$ that coincides the following TL formulation:

$$\mu(p,y) = \alpha_y + \gamma_{yy} \ln y + \textstyle\sum_i \gamma_{yi} \ln (p_i).$$

The elasticity of size, in turn, is a reciprocal of cost flexibility, and can be written as:

$$\eta(p,y) = (\alpha_y + \gamma_{yy} \ln y + \textstyle\sum_i \gamma_{yi} \ln (p_i))^{-1}.$$

In case production technology exhibits homotheticity, elasticity of size equals to $(\alpha_y + \gamma_{yy} \ln y)^{-1}$ since homotheticity presumes $\gamma_{yi} = 0$, and alternatively in case technology exhibits homogeneity ($\gamma_{yi} = 0$ and $\gamma_{yy} = 0$) cost flexibility equals to $\mu(p,y) = \alpha_y$.

Table 3 summarises the estimates of the cost flexibilities and elasticities of size for each model and demonstrates that the usage of the number of visitors or exhibitions to proxy the output yields estimates that suggest existence of economic gains from large scale production. Of particular interest is the similarity of the estimates in these two cases. The estimations utilising yearly open hours, in turn, suggest as expected existence of diseconomies of scale. These results can be further illustrated in the respective Average Cost (AC) curves.[18] (See Appendix 3)

Table 3: Cost flexibilities and elasticities of size

Measure of output	Cost flexibility	Elasticity of size
number of visitors	0.49	2.05
number of exhibitions	0.38	2.67
yearly open hours	1.26	0.80

Besides the differences in cost flexibilities, the models utilising alternative output measures also yield different estimates of relative utilisation of inputs as well as price elasticities of inputs: if output is measured by yearly open hours production turns out to be most labour intensive (85% labour and 15% capital), while when employing number of exhibitions technology proves to be least labour intensive (41% labour and 59% capital). This suggest that in order to increase the number of exhibitions a museum will spent four times as much to capital input, acquisitions and maintaining their collection, than when the museum chooses to increase their yearly open hours.

Table 4: Parameter estimates (std. errors in parentheses)

Parameter	number of visitors	number of exhibitions	open hours
α_0	0.27 (1.05)	4.78 (0.44)	-6.49 (3.18)
α_y	0.49 (0.11)	0.38 (0.18)	1.26 (0.42)
α_k	0.43 (0.04)	0.59 (0.05)	0.15 (0.05)
α_l	0.57 (0.04)	0.41 (0.05)	0.85 (0.05)
γ_{kk}	-0.00 (0.00)	-0.00 (0.00)	0.01 (0.00)
γ_{ll}	0.02 (0.00)	0.03 (0.00)	-0.02 (0.00)
γ_{kl}	-0.01 (0.00)	-0.03 (0.00)	0.009 (0.00)

By and large the estimations demonstrate that the proxy for output may have a considerable bearing on the results in a single output setting. Of interest is that while the results by using either number of visitors or exhibitions are of similar order, the results basing on the yearly open hours are radically different. This is not, however, to say whether the three proxies capture the same or a totally different aspect of the output of museums - the estimations are unable to determine whether the three output measures could be used jointly in a multi-output setting. [19]

5 Multiple output framework - Structural Equation Models for output

The basic idea of SEM is to use measurement models to present relations between latent and observed variables.[20] A measurement model can be written as:[21]

$$x = \lambda_x \xi + \delta \tag{3}$$

in which x is a (q x 1) vector of observed random indicators of the latent (unobserved) variable ξ, and δ is a (q x 1) vector of measurement errors for x respectively. The λ_i coefficients represent magnitude of the expected change in the observed variable for one unit change in the latent variable: λ_x is a (q x n) matrix of coefficients relating x to ξ. Besides this, a measurement model contains a (q x q) covariance matrix Θ_δ for the measurement errors of x.[22]

In practice, the application of (1) proceeds in five phases: model specification, identification, estimation, testing fit and respecification.[23] The specification phase includes outlining of a path diagram, formulation of corresponding equations (e.g $x = \lambda_x \xi + \delta$), and decomposition of the theoretical $\Sigma(\theta)$. Identification determines whether unique values can be found for each parameter of the specified model[24], and the actual estimations employ a fitting function:[25]

$$F(S, \Sigma(\theta)), \text{ given by } F = \log |\Sigma(\theta)| + tr(S \Sigma^{-1}(\theta)) - \log |S| - (p + q).$$

The fit of the model (whether the estimated model is consistent with the data) is examined by using over all fit measures, such as χ^2-statistic and goodness-of-fit indices. If the specified model does not fit the data, the model is re-specified basing on modification indices (MI), Likelihood ratio test (LR), Incremental Fit Index (IF), Normed Fit Index (Δ) and Akaike Information Criterion (AIC).[26]

As to the museums, a measurement model can be used to present relations between latent output and its observed measures. The basic assumption of a measurement model is, thus, that output of museums cannot be directly measured, but output is captured by an exogenous unobserved latent variable ξ_i that consists of multiple observed measures.[27]

In the case of Finnish museums applicability of seven observed measures of output is tested, namely yearly open hours (x_1), number of visitors (x_2), number of publications (x_3), total number of exhibitions (x_4), number of permanent exhibitions (x_5), number of exhibitions produced by the museum (x_6), and number of exhibitions produced by other museums but displayed at the museum (x_7).

For the estimations the observed variables (x_i) are summarised in a lower triangular correlation matrix (R) that is employed to examine three main questions.[28] First, does the unobserved latent output of museums (ξ_i) consist of all or only some of the observed variables x_i. Second, whether the output can be modeled by using only one unobserved latent construct (ξ_i) or does the output consist of two latent unobserved constructs. Third, which of the observed variables (x_i) - yearly open hours, number of visitors, number of publications, number of exhibitions, number of permanent exhibitions, number of exhibitions produced by the museum, number of exhibitions produced by other museums but displayed at the museum - best capture the latent output.

Table 5: Correlation matrix R of the observed measures for output

	x_1	x_2	x_3	x_4	x_5	x_6	x_7
x_1	1.000						
x_2	0.392	1.000					
x_3	0.339	0.265	1.000				
x_4	0.191	0.347	0.176	1.000			
x_5	0.408	0.171	0.395	0.193	1.000		
x_6	0.146	0.077	0.391	0.168	0.175	1.000	
x_7	0.436	0.192	0.440	0.352	0.666	0.705	1.000

The two first specifications of the measurement model of output - M_1 and M_2 - both include a single latent variable ξ_1 that is assumed to contain all observed variables x_i: the hypothesis is that all seven observed variables constitute the output. The difference between the two models is in the treatment of the variances of measurement errors ($\delta_1,...,\delta_7$): in M_1 δ_i's are set equal, while in M_2 δ_i's are estimated without constraints. In both models the scale is set by constraining the variance of the latent construct (Φ_{11}) equal to one.[29] The functional form of both models can be written as:[30]

$$
\begin{aligned}
x_1 &= \lambda_{11}\xi_1 + \delta_1 & \qquad x_5 &= \lambda_{51}\xi_1 + \delta_5 \\
x_2 &= \lambda_{21}\xi_1 + \delta_2 & \qquad x_6 &= \lambda_{61}\xi_1 + \delta_6 \\
x_3 &= \lambda_{31}\xi_1 + \delta_3 & \qquad x_7 &= \lambda_{71}\xi_1 + \delta_7 \\
x_4 &= \lambda_{41}\xi_1 + \delta_4 & &
\end{aligned}
\qquad (4)
$$

The overall fit measures in Table 6 - χ^2-test statistics, goodness of fit index (GFI), adjusted goodness of fit index (AGFI) and the coefficient of determination (R^2)[31] - reveal, that both models are misspecified.[32] The standardised residuals of M_1 locate the specification error to three of the observed variables: number of permanent exhibitions, number of exhibitions produced by the museum, and number of exhibitions produced by other museums but displayed at the museum.[33] (The largest standardised residual 6.626 is for x_4 - x_7, and relatively high positive standardised residuals occur also for x_4 - x_6 (4.365), x_7 - x_2 (3.501), and for x_7 - x_6 (-3.594)).[34]

Because three of the observed variables prove to be "redundant", two re-specified models - M_3, M_4 - are estimated. Both models still consist of one latent variable (ξ_1) and the observed variables x_1, x_2, x_3 and x_4, while the observed variables capturing number of permanent exhibitions, number of exhibitions produced by the museum, and number of exhibitions produced by other museums but displayed at the museum are excluded from the model. The scale of the models is set by setting Φ_{11} equal to one, and moreover, in

M_1 the variances of the measurement errors (δ_i) are set equal, while in M_4 measurement errors are estimated without constraints.

Table 6: Overall fit measures for M_1- M_4

Model	χ^2(df)	p-value	GFI	AGFI	R^2_y
M_1	$\chi^2(20) = 235.03$	0.00	0.82	0.74	0.78
M_2	$\chi^2(14) = 126.11$	0.00	0.83	0.65	0.81
M_3	$\chi^2(5) = 13.86$	0.02	0.96	0.92	0.68
M_4	$\chi^2(2) = 9.71$	0.01	0.97	0.86	0.70
M_5	$\chi^2(1) = 2.75$	0.10	0.99	0.92	0.87
M_6	$\chi^2(4) = 9.21$	0.06	0.97	0.93	0.79
M_7	$\chi^2(2) = 3.64$	0.16	0.99	0.95	0.85

The overall fit measures in Table 6 suggest that M_3 and M_4 are again misspecified models, though better ones than the more extensive M_1 and M_2.[35] This implies, that the output of Finnish museums cannot possibly be modelled by a single latent unobserved variable, but a model with at least two latent constructs is required.

The rewritten model M_5 divides the single latent construct into two latent constructs that are assumed to consist of four observed measures of output.[36] The first latent variable (ξ_1) consists of the observed yearly open hours (x_1) and number of visitors (x_2), and thus, describes the output in terms of the "availability of the service". The other latent construct (ξ_2) consists of number of publications (x_3) and total number of exhibitions (x_7), and tries to capture the more "invisible" work of the museums, e.g. research, arranging exhibitions as well as art education.

The model M_5, in which the scale is defined by setting the coefficients λ_{11} and λ_{42} equal to one, can be written as: (See Appendix 4)

$$\begin{aligned} x_1 &= \xi_1 + \delta_1 \qquad & x_3 &= \lambda_{32}\xi_2 + \delta_3 \\ x_2 &= \lambda_{21}\xi_1 + \delta_2 \qquad & x_4 &= \xi_2 + \delta_4 \end{aligned} \tag{5}$$

The overall fit measures in Table 6 indicate a good fit for M_5: χ^2 -statistic is well below the critical value ($\alpha = 0.05$), the Goodness-of-fit Index indicates that the model fits well to the data, and R^2_y is relatively high.

To test further the assumptions on the measurement errors two additional models are estimated: in M_6 the variances of measurement errors δ_i, $i = 1,\dots,4$, are set equal and in M_7 solely δ_1 and δ_2 are set equal. Table 6 demonstrates that also these two models have a good fit: according to the LR test both restrictions on the measurement errors improve the fit of the model $\chi^2(3) = 6.48$ and $\chi^2(1) = 0.89$. The model selected is, however, M_5 with least restrictions on the parameter estimates. This is because the AIC for M_5 is the smallest (AIC-M_5= 4.75, AIC-M_6 = 17.21 and AIC-M_7 = 7.64).[37] According to M_5 the Maximum Likelihood (ML) estimates for λ_x and for Φ are as follows:[38]

Table 7: ML estimates for λ_x and variances and covariances of ξ_1 and ξ_2

Parameter	Estimate	t-value
Φ_{11}	0.71	3.37
Φ_{21}	0.43	5.03
Φ_{22}	0.53	3.71
λ_{11}	1.00	-
λ_{21}	0.55	3.50
λ_{32}	0.83	4.68
λ_{42}	1.00	-

These estimates suggest, first, that the two latent variables are well explained by the four observed measures of output (the positive and statistically significant parameter estimates of variances and covariance of the two latent variables are relatively high). The relatively low covariance of ξ_1 and ξ_2, furthermore, support the assumption of two latent constructs rather than a single unobserved latent variable. Such a finding can be verified by running a test on the correlation between the two latent variables - the hypothesis to be tested is that the correlation between the two latent variables equals one (H^0: $\Phi_{21} = 1$) implying that output consists of a single latent unobserved variable. The hypothesis is rejected by the LR test $\chi^2(1) = 6.96$, confirming that in the case of Finnish museums the output consist of two latent variables containing four observed variables (yearly open hours, number of visitors, number of publications and number of exhibitions).

Table 7 reveals, furthermore, that all the standardised estimates for λ_x are positive and statistically significant.[39] The estimates for λ_x demonstrate that yearly open hours is a more accurate measure of the first latent output than the observed number of visitors. The number of exhibitions, in turn, has a larger loading from the latent variable than the observed number of publications, indicating that the former observed variable captures better the second latent construct.

Since the estimated SEM models M_1 - M_5 do not give any idea of possible proxies for quality of output - but only casts light on the explanatory power of the suggested measures of output - two models are constructed to capture the quality aspect of production. The first model Q_1 includes a single latent quality that is measured by categorical variables that contain education of personnel, and the second model Q_2 captures a single latent quality by using two non-continuous variables indicating the type of the museum (art, culture historical, special, nature historical, regional and combined art and culture historical museums) and organisational structure of the institution (private institutions owned by associations, foundations or firms vs. public museums run by the state, municipalities or towns).[40] Neither the former model in which the latent quality contained education of the personnel ($\chi^2(5) = 440.06$), nor the latter model including the ownership and type of museums ($\chi^2(1) = 24.07$) appear, however, to be statistically significant. Because of this, the full correlation matrix R, employed in M_1 - M_5, is used to capture the quality of production, rather than alternative variables not included in the original R.

The correlation matrix R is, thus, used to test the operationalisation of quality proposed by Jackson (1988) who captured quality by presence or absence of accreditation by the American Association of Museums (AAM). In the Finnish case, the test is based on the categorisation of museums by the Finnish Museum Association (Museoliitto) to professional and non-professional museums: a museum is defined as a professional museum if and only if the museum employs at least one employee with a university degree in art history or equivalent (otherwise the museum is doomed as non-professional). Thus, the test is based on the a priori assumption that quality of production differs between "professional" and "non-professional" museums.

In order to test the applicability of the dichotomy the full sample correlation matrix R is divided into two correlation matrices: the data set (n=164) is apportioned into two sub-samples of professional museums (P, n=115) and non-professional museums (NP, n= 49). The comparison of these two sub-sets is lead off by testing whether the correlation matrices of professional and non-professional museums are equal.[41] In other words the hypothesis to be tested is given by H_{Σ}: $\Sigma^{P} = \Sigma^{NP}$, in which superscripts refer to each sub-group. The hypothesis is rejected basing on a LR-test - $\chi^2(10) = 47.71$ - suggesting that output of professional and non-professional museums is not necessarily of similar calibre, when yearly open hours, number of visitors, number of exhibitions, and number of publications are employed to measure the output. This is not, however, to say whether the difference derives from differences in quality or some other aspects of production.

6 Conclusion

This article has examined measurement of inputs (prices), output(s), as well as quality of production in cultural services. Three main questions have been of focal interest: first, whether the output of museums constitutes of a single or multiple output(s) and how the output can be best measured in either case, second, whether the measure of output affects the assessment of the underlying production technology, and thus, policy recommendations, and third, whether SEM approach can be used to find proxies for output and quality in a multi-output setting. Besides this, the article also pointed out the caveats connected to measurement of inputs.

The caveats connected to measurement of inputs (prices) were shown to concern mainly the capital input (price), while the measurement of labour input (price) has been relatively clear cut: labour input (price) is most often measured - both in performing arts institutions as well as museums - either by man years or unit price of a man year, in which the contribution of volunteers is generally omitted due to lack of data. The ways to measure capital input, in turn, vary to a great extend - the measures of capital input have ranged from "props and papers" approach to a ratio of promotional expenditures to donations. The "props and papers" approach is likely to be problematic since the measure adds up actual amounts of capital - i.e. musical instruments, scrips, scores. etc. - while the latter measure is inappropriate in the case of publicly subsidised European cultural institutions that do not rely on private donations.

Because of these shortcomings, an alternative proxy of capital input (price) was introduced in the case of museums: the unit price of capital was defined basing on the collection, and was operationalised as a sum of the unit price of new capital stock and the unit price of the existing capital stock. The definition, thus, allows the capital input price to increase when the market value of new acquisitions increase, and moreover, prevents the price of capital being zero even if a museum does not make new acquisitions. As to the performing arts, capital input price could be defined accordingly as the ratio of capital costs to seating capacity, in which the seating capacity refers to the maximum audience in the permanent venue of a given theatre/orchestra and the capital costs include costs that are allocated to the running of the estate, costs being caused by investments or aquiring capital (interests), and costs of staging as well as purchases of equipment (stage, lighting, sound equipment, musical instruments, scores and scripts). Such a definition would relate the unit price of capital directly to the capacity of each institution and attendance.

Besides the varying practices to measure capital input (price), also the measures of output have varied to some extend. Of interest is that while the seminal studies have opted for a single output to capture the artistic experience, the more recent studies have generally employed multiple proxies for output. The most common proxies for output have been the number of visitors and performances, and the multi-output settings have included extended combinations of thereof.

According to most previous studies the assumption of a single-output technology seems justifiable in the case of performing arts institutions since their main aim is to provide "artistic experiences" to different audiences. This is reflected e.g. in the fact that the revenues of the institutions' consist mainly of admission revenues - the visitors are willing to pay for the artistic experience that can be measured either by number of visitors or performances. The attendance figure was considered a particularly convenient proxy of output in institutions that perform mainly in their permanent venue places, such as theatres. The number of performances, in turn, was argued to suit to proxy the output of institutions that perform also outside their permanent premises, e.g. orchestras arranging outdoor concerts. The main reason for the usage of number of performances instead of attendance figures would be that the attendance figures - number of artistic experiences - are not necessarily accurate, and thus, the number of performances is used to proxy the "quantity" of artistic experiences.

The early studies on museums have also assumed single output production. The most often employed measure of output has been the number of visitors. This single proxy has been utilised even if the studies have pointed out the multi-output nature of production as well as suggested possible additional measures for output, such as the yearly open hours, number of exhibitions, and number of publications. As to the usage of these measures in a single output setting, estimations of single output cost functions demonstrated that usage of the alternative proxies for output yield different assessments of the underlying production technology, and thus, differing policy recommendations: while the estimations with number of exhibitions or visitors suggest existence of scale economies (elasticities of size of 2.67 in the former case and 2.05 in the latter), and thus, promote relatively large production units, the estimations with yearly open hours advocate relatively small production units and increasing average cost curves (elasticity of size of 0.80).

The constructed SEM's casted more light on the assumption of single-output production of museums. The output of Finnish museums was shown to consist of two latent unobserved variables. The first latent unobserved output consisted of yearly open hours that depict the availability of all services as well as the number of visitors that reflect the number of artistic experiences. The other latent unobserved output included the number of publications and exhibitions: the former captures the research activities of a museum and it is closely connected to art education, whereas the latter is related particularly to accumulation of collection as well as conserving. The estimated SEM's, thus, supported the view by Paulus (1995) and Mairesse (1997) on the multi-output production of museums.

The quality aspect of production has been previously captured by using four different proxies. The quality aspect of performing arts has been captured by attendance per tour performance, ratio of grants to box office revenues as well as a dummy variable picking up the characteristics in which the institutions operate. The quality aspect of museums has, in turn, been measured by using a dummy variable that represents quality in terms of an accreditation of the AAM (or lack of it). A similar variable was tested in the case of Finnish museums by using the classification of the museums, pace Finnish Museum Association, as to professional and non-professional museums: the estimated SEM's suggested that the output of professional and non-professional museums is not identical, and the dichotomy may incorporate some aspect of quality. Since the classification rests on the amount of university educated personnel the results, however, point out the importance of quality differentials of inputs as a determinant of output differentials.

The more recent studies have not employed self-contained variables for the quality aspect. The studies have, instead, implicitly assumed that the utilised output measures capture as such some aspect of quality. Most often such assumption is based on the notion that demand or alternatively production costs of the service reflects its quality. It is of interest to note that while a relatively high demand/costs of a performances/attendance can be quite safely assumed to reflect high quality at least in the sense of what Hansmann (1981) calls "lavishness of production" (exceptionally skilled performers, lavish staging, and well known pieces). The relatively low demand/costs do not, however, necessarily suggest low quality - relatively low demand/costs may only suggest that an institution may "choose to produce works that appeal only to the most refined tastes, avoiding the more popular items in the repertoire", as pointed out by Hansmann (1981). Thus, in the case of cultural services demand/costs are not as such a clear cut determinant of the quality aspect, but necessitates additional information, e.g. peer assessments, in order to result a meaningful proxy for quality - the multi-faceted possibilities to interpret quality in terms of demand/costs puts an emphasis on the interpretation of the results.

Endnotes

1. See Griliches (1992) for a detailed discussion and definition of "the slippery concept of services".
2. These measurement problems have been dealt with in few international conferences, the latest *Conference on Output Measurement in the Service Sectors* was organised in Charleston, South Carolina, US in 1990. See Griliches (ed.) (1992) for the selected papers of the conference. The first conference on the topic was organised in 1958, selected papers of which are collected in a volume labelled *Output, Input and Productivity Measurement.*
3. Throsby (1994) underlines heavily the "serious constraint imposed on research in cultural economics by the lack of comprehensive statistics on the arts industry or its sub sectors." Throsby (1994) goes as far as to argue that "Cultural Economists will need to pay greater attention to the collection of new data in future if they wish their work to be taken seriously by other researchers or to be useful to policy makers, organizations or individuals working in the field."
4. An exception to this list is Gapinski (1979) who utilised a high quality panel data set 1971-1976 of American performing arts institutions - 35 theatres, 27 opera companies, 77 symphony orchestras, and 10 ballet companies.
5. Of the more recent studies Paulus (1995) used a cross-sectional data set on 125 French museums, Mairesse (1997) used a cross-section of 82 Belgian museums year 1995, whereas Ek (1991a, 1991b, 1994) used in his first study a panel of 23 Swedish theatres in 1985-1988, in the second study a panel of 23 theatres form 1976 to 1979 and from 1985 to 1988, the third study used data on 21 theatres 1980-1982 and 1990-1992.
6. See the special issue of Journal of Econometrics vol 22 (1983) for a detailed account of the method.
7. This is the case even if Jackson (1988) points out the multi-output nature of production: Jackson (1988) defines museums' activities to include "1) creating a base community life through its special programs for members, 2) conserving and preserving important artifacts, 3) providing educational opportunities to a variety of age groups, and 4) developing and presenting special exhibitions".
8. See Braeutigam (1986) for discussion and treatment of the quality aspect in main stay econometric applications.
9. Exceptions to this are the early studies by Globerman and Book (1974) and Throsby (1977).
10. Gapinski (1979) categorises labour input in a production function framework furthermore as primary and secondary inputs. The primary inputs are perceived to be sine qua non elements of the production process "without the artist there would be no art" and the secondary inputs are not necessary but "some output could occur in their absence". Such inputs are e.g. ushers, box office help, maintenance personnel, and administrators.
11. Of interest is that Paulus (1993) applies in a cost function context a measure of capital input that is not given in terms of a unit price.

12. The contribution of volunteers is omitted due to lack of data, as well as the fact that Finnish museums do not utilise volunteers to a large extend.
13. The reason for the usage of TL formulation is twofold: first, the TL functional form is by far the most often applied functional form in estimations of cost functions due to its flexibility, and second, the TL formulation has been shown to be "dependable approximation of reality provided that reality is not too complex" in Monte Carlo estimations by Guilkey and Lovell (1980). See Lau (1986) for discussion on the choice of functional forms and Diewert and Wales (1987) on detailed discussion on flexible functional forms in general.
14. As is known from Shephard's lemma $x_i = \partial c(p,y)/\partial p_i$, which implies that $\partial \ln c(p,y)/\partial \ln p_i = p_i x_i/c$. (The cost share of i^{th} -input S_i is the first derivative of ln c(p,y) with respect to p_i).
15. The estimations are carried out by employing SHAZAM 7.0 program.
16. In the estimated systems of equations both the cost share of labour and the total costs are endogenous variables. As unknown parameters are estimated: the intercept α_0, cost share of labour when output does not change α_l, "cost flexibility" α_y, share elasticities γ_{ll} and γ_{kl}, biases of scale γ_{yl} and "second derivative of cost flexibility" γ_{yy}. The remaining parameters - α_k, γ_{kk}, γ_{yk} - are derived by using the regularity conditions.
17. See Röller (1990) for discussion of truncation. Also Jackson (1988) and Lange et al. (1985) have omitted from their samples approximately 10% of the institutions, the criteria and method remain, however, unclear.
18. The AC curves are calculated for each model by fixing the input prices to their mean values and letting the output level to vary.
19. Two alternative homogeneous multi-output cost functions - multi-output hybrid Diewert (HDMCF) and generalised TL multi-product function (GTMCF) - were estimated to examine this. The estimated functions did not, however, yield promising results: neither of the multi-output cost functions fulfilled the regularity conditions nor performed sensibly at any region. See Lau (1986) for details of the two functional forms utilised in the estimations.
20. A measurement model is actually a part of a full structural equation model that consists of a latent variable model and measurement model. See Bollen (1989) or Saris and Stronkhorst (1984) for detailed presentations of full structural equation models.
21. The notation and assumptions are based on the Jöreskog-Keesling-Wiley approach. See Saris and Stronkhorst (1984), Jöreskog and Sörbom (1989) and Bollen (1989) for more detailed descriptions.
22. For a measurement model for which the following assumptions hold - $E(\xi\delta^T) = 0$, $E(\delta) = 0$, $E(\xi) = 0$, $E(x) = 0$, $N_p \sim (0, \Omega, \Sigma)$ - the basic hypothesis is $\Sigma = \Sigma(\theta)$, in which Σ is the population covariance matrix of the observed variables x, and $\Sigma(\theta)$ is covariance matrix of model parameters. In its general form $\Sigma(\theta)$ consist of $\Sigma_{xx}(\theta)$ that is given by: $\Sigma_{xx}(\theta) = \lambda_x \Phi \lambda_x^T + \theta_\delta$.
23. PRELIS 1.1 program is employed to screen and summarise the data set. The actual estimations are carried out by using LISREL 7.0 program.
24. The identification is either to be formally proven for each free parameter of the model or by applying the Null B rule, Recursive Rule or the necessary but not sufficient

t- rule. See Leskinen (1989), Saris and Stronkhorst (1984), as well as Bollen (1989) for detailed presentations of the identification rules.

25. It should be noted, that there is a fundamental difference of the structural equation procedures compared e.g. to multiple regression, in which the regression coefficients or the error variance estimates derive from the minimisation of the residual sum of squares. The structural equation models are in turn estimated from, and tested on summary statistics namely the covariances or correlations, not evaluated relative to the raw data matrix.

26. The Normed Fit index Δ can be written as $\Delta = (T_0 - T_1) / T_0$, in which T_0 is the value of the test statistic for the null model and T_1 is the value of the test statistic for the alternative model. IF is formally given by $T_0 - T_1 / T_0 - (df_1/N - 1)$, in which T_0 is the value of the test statistic for the null model and T_1 is the value of the test statistic for the alternative model. In practice the value of Δ and IF lay between 0 and 1, and in the literature 0.9 has been proposed as a critical value to stop the revisions. In this case it should be noted, that there is no difference between Δ and IF, however in IF it is intended to decrease the dependence of Δ on sample size and simultaneously controlling for degrees of freedom available to evaluate the model of interest. Jöreskog and Sörbom (1989), Bollen (1989), and Bollen and Long (1993) provide throughout discussions of the various over all fit measures applicable in SEM as well as procedures of re-specification of models.

27. It should be noted, that this generally applied notation of SEM is not in line with the notation generally used in applied production theory in which output is generally noted by y_i and inputs by x_i.

28. The reason for application of correlation matrix (R) instead of covariance matrix (S) is that the former is scale free. The use of correlation matrices implies that here the units of measurements of the observed variables are not assumed to have a definite meaning - e.g. the units of measurement in number of visitors is not similar as the units of measurement in collection. See Saris and Stronkhorst (1984) for discussion. However, it should be noted, that in case a sample correlation matrix is used to estimate a covariance structure the normal asymptotic theory is not necessarily valid. Two necessary conditions should be met if one is using the correlation coefficients instead of the covariances , namely the scale invariance of the model and that the condition diag (Σ) = diag (S). The model is scale invariant if for any diagonal matrix D of positive scale factors and any parameter vector θ, there exists another parameter vector θ^*, such that $\Sigma(\theta^*) = D\ \Sigma(\theta)D$. The second condition can be assessed by examining the fitted residuals. See Jöreskog and Sörbom (1989).

29. Because the ξ are latent unobserved variables, their origin and unit of measurement are arbitrary: the latent variables do not have a definite scale. The origin of the measurement is defined by assuming a zero mean for each variable. The unit of the measurement is set by setting a non-zero value for each row of λ_x, and thus, the scale of the latent variable is defined in terms of a latent observed variable. Besides this, the latent ξ could be assumed to have an unit variance, and thus be standardised. See Jöreskog and Sörbom (1989) for scaling in SEM.

30. Direction of causation between a latent variable and indicator is determined by an indicator being either a cause or effect indicator. The former is an observed variable that causes the latent variable and in the latter case the latent variable causes the observed variable. In general, as well as in these estimations, effect indicators are employed. See Bollen (1989) for discussion of causation.
31. The χ^2 test enables to examine whether the model is consistent with the data. The GFI and AGFI, in turn, estimate the extent to which the sample variances and covariances are reproduced by the hypothesised model while R^2_y is a measure of how well the observed variables jointly serve as measurement instruments for the latent variables. See Jöreskog and Sörbom (1989), Bollen (1989), and Bollen and Long (1993) for more detailed discussion.
32. On the basis of the LR test the equality constraints set on the measurement errors should not be posed: $\chi^2(6) = 108.92$. Besides this, it should be noted, that the equality constraints set on the parameter estimates in analysing a correlation matrix may modify the model being analysed.
33. The residuals are examined basing on M_1 even if the model has a poorer fit than M_2. This is because M_2 includes a negative error variance (the Θ_δ is not positive definite) indicating a wrong model specification, and thus, the residuals of the model are not reported. See Wothke (1993) about discussion on non-positive definite matrices in SEM.
34. The reason for the high standardised residuals is either that museums have differing practises in categorising their exhibitions or some degree of collinearity between the variables in the data set. In SEM collinearity can be detected either from the simple bivariate correlation coefficients indicating relatively high coefficients between cetrain variables or by examining the eigenvalues and eigenvectors. For a more detailed discussion see Whotke (1993), according to whome collinearity in SEM can be corrected by omitting variables that are recognised redundant, reducing number of variables and/or gathering more data in a case of a small data set or by matrix smoothing and carrying out estimations by using the ULS method.
35. The LR test indicates that the restrictions on measurement errors are correct: $\chi^2(3) = 4.15$. Notwithstanding this, the model with least restrictions M_4 is used in further comparisons.
36. The exclusion of the three variables can be justified by applying Δ and IF on M_2 and M_4: according to both indices proportion of improvement of fit (0.92) from M_2 to M_4 suggests that the exclusion of the redundant variables is correct.
37. Browne and Cudeck (1989) have advanced the use of fit measures based on the logic of Akaike Information Criterion (AIC) for covariance structures. The Information Criterion is defined as $AIC = T_1 + 2r$, in which r refers to the number of free parameters of the model and T is the value of the test statistic. See Tanaka (1993) for discussion on the use of AIC in SEM.
38. The estimates of the variances of measurement errors δ_i of the observed variables are statistically significant except the error term δ_1, that is relatively small. The measurement error δ_2 - that is a measurement error of the observed x_2 - is relatively high. Also δ_3- that is a measurement error of the observed x_3 - is relatively high.

39. It should be noted, that all the parameter estimates are standardised because the correlation matrix is used: all the variables are expressed in standard deviations and the effects indicate a change in the effect variable that is caused by a change of one standard deviation in the causal variable.
40. In both models polychoric correlation matrices are used because the observed variables are not continuous. See Jöreskog and Sörbom (1989) for more detailed discussion.
41. Only the similarity of correlation matrices is tested, not the applicability of say M_5. The reason for this is that model structures - $H_\lambda : \lambda_x^{(1)} = \lambda_x^{(2)}$, $H_{\lambda\Theta} : \Theta_\delta^{(1)} = \Theta_\delta^{(2)}$ and $H_{\lambda\Phi\Theta} : \Phi^{(1)} = \Phi^{(2)}$ - can not be tested if the analysis is based on correlation matrices. See Jöreskog and Sörbom (1989) for discussion.

APPENDIX 1

Table A: Measures of output(s) and quality in performing arts institutions

Author	Institution type	Measure	Quality of output
Globerman and Book (1974)	symphony orchestra, theatre group	number of performances	attendance/ tour performances
Throsby (1977)	theatre, orchestra, opera, dance	attendance	grants/box office revenue
Gapinski (1979)	theatre, orchestra opera, ballet, modern dance	attendance	dummy variable [a]
Lange et al. (1985)	symphony orchestra	number of performances	N/A
Ek (1991a, 1991b, 1994)	theatre	attendance, number of first nights, number of performances	N/A

[a] A dummy variable is used to capture the characteristics in which the organisation operates: "environmental agents are enumerated including demographics of the local population, the quality and price of live performances, competition from amateur companies, movies, or sporting events, and the draw of suburbia".

Table B: Measures of output(s) and quality in museums

Author	Institution type	Measure	Quality
Jackson (1988)	general, history and science museums	number of visitors[a]	accreditation by AAM
Paulus (1993)	art, culture historical, nature historical, and special museums	number of visitors[b]	N/A
Paulus (1995)	art, culture historical, nature historical, and special museums	number of visitors, number of exhibitions during the last 5 years, number of new research workers, number of children participating the special programmes	N/A
Mairesse (1997)	museums financed by CFB[c]	number of visitors, (visitors/disposal income)/ personnel costs, exhibitions/personnel costs, publications/scientific personnel, activities/personnel,[d] value of collection	N/A

[a] Besides the number of visitors five additional variables were used to capture "museums's priorities". These "priority variables" include cost shares of promotional expenditure, exhibition expenses, conservation and preservation expenses and membership activity expenses.
[b] Besides the number of visitors three additional variables were used to capture diffusion of artistic experiences ("indicateur spécifique de l'activite de diffusion"). These "diffusion variables" include number of exhibitions arranged during the last five years, number of researchers, and number of publications in the museum's library.
[c] Communauté française de Belgique
[d] Activities refer to conferences, work shops, and concerts

APPENDIX 2

Table A: Measures for labour and capital inputs (prices) in performing arts institutions

Author	Method	Labour input (price)	Capital input (price)
Globerman and Book (1974)	cost function	N/A	N/A
Throsby (1977)	cost function	N/A	N/A
Gapinski (1979)[a]	production function	man-hours of artists[b] man-hours of adjuvants[c]	"props"[d] "papers"[e]
Lange et al. (1985)	cost function	wages to musicians/ number of musicians	promotional expendit./ donations
Ek (1991a, 1991b)	DEA	applied one input: total costs	
Ek (1994)	DEA	man years	operating costs

[a] In the study inputs are categorised as primary and secondary inputs.
[b] Man-hours of artists include man-hours of performing and guest artists, directors, conductors, stage managers, instructors, designers, technicians, and other artistic personnel.
[c] Man-hours of adjuvants include administrators and supervisors as well as ancillaries, e.g. stage hands
[d] "Props" include purchase of rental sets, costumes, lights, sound and other stage equipment.
[e] "Papers" include scores, scripts and royalties.

Table B: Measures for labour and capital inputs (prices) in museums

Author	Method	Labour input (price)	Capital input (price)
Jackson (1988)	cost function	total wages/number of full time employees	promotional expendit./ donations
Paulus (1993)	cost function	average wages	total costs excluding personnel costs
Paulus (1995)	DEA	number of employees	operating costs[a]
Mairesse (1997)	DEA	number of employees	operating costs[b]

[a] Operating expenses do not include personnel costs
[b] Operating costs include all costs but personnel costs and e.g electricity

APPENDIX 3

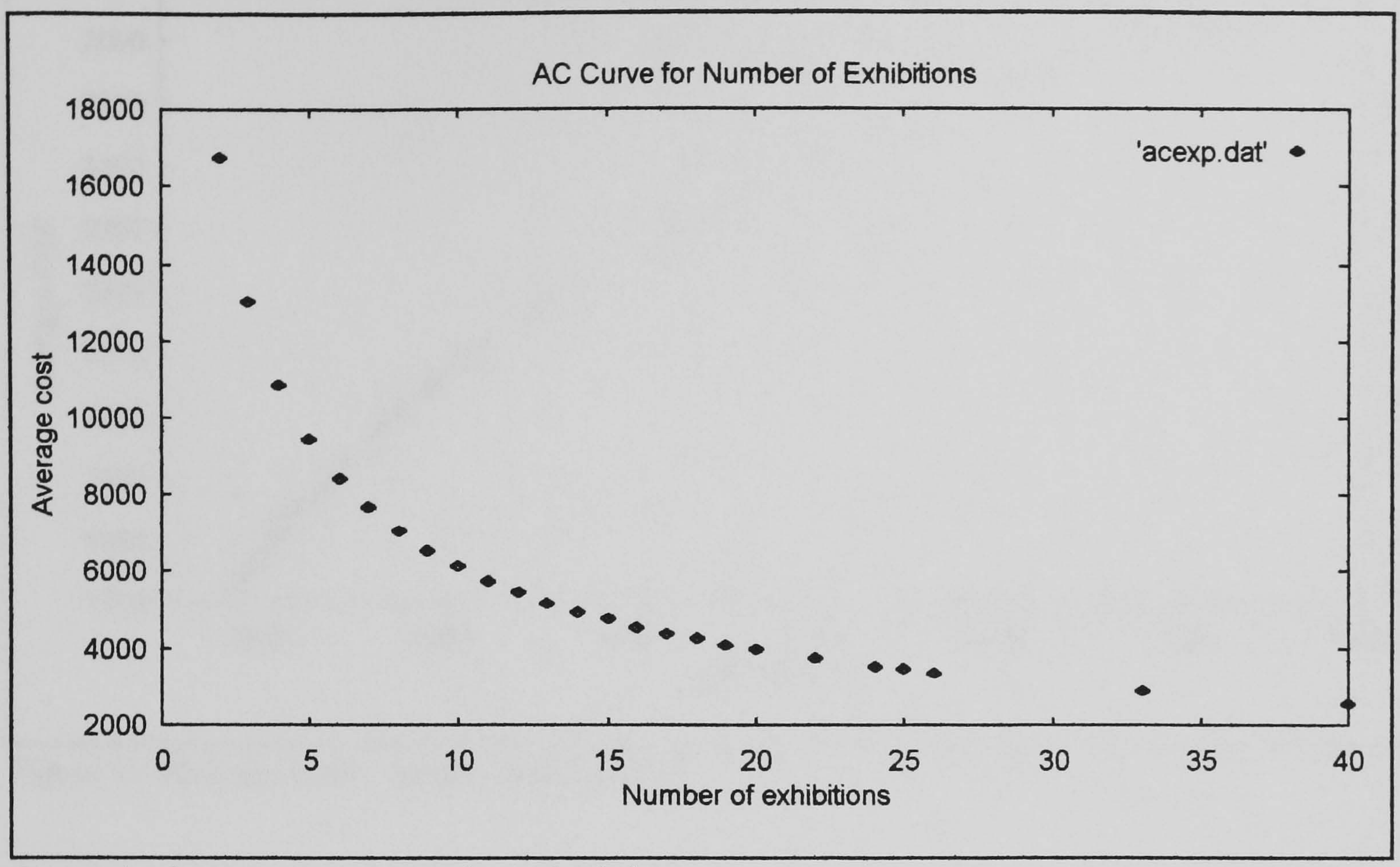

Figure A: Average costs - number of exhibitions

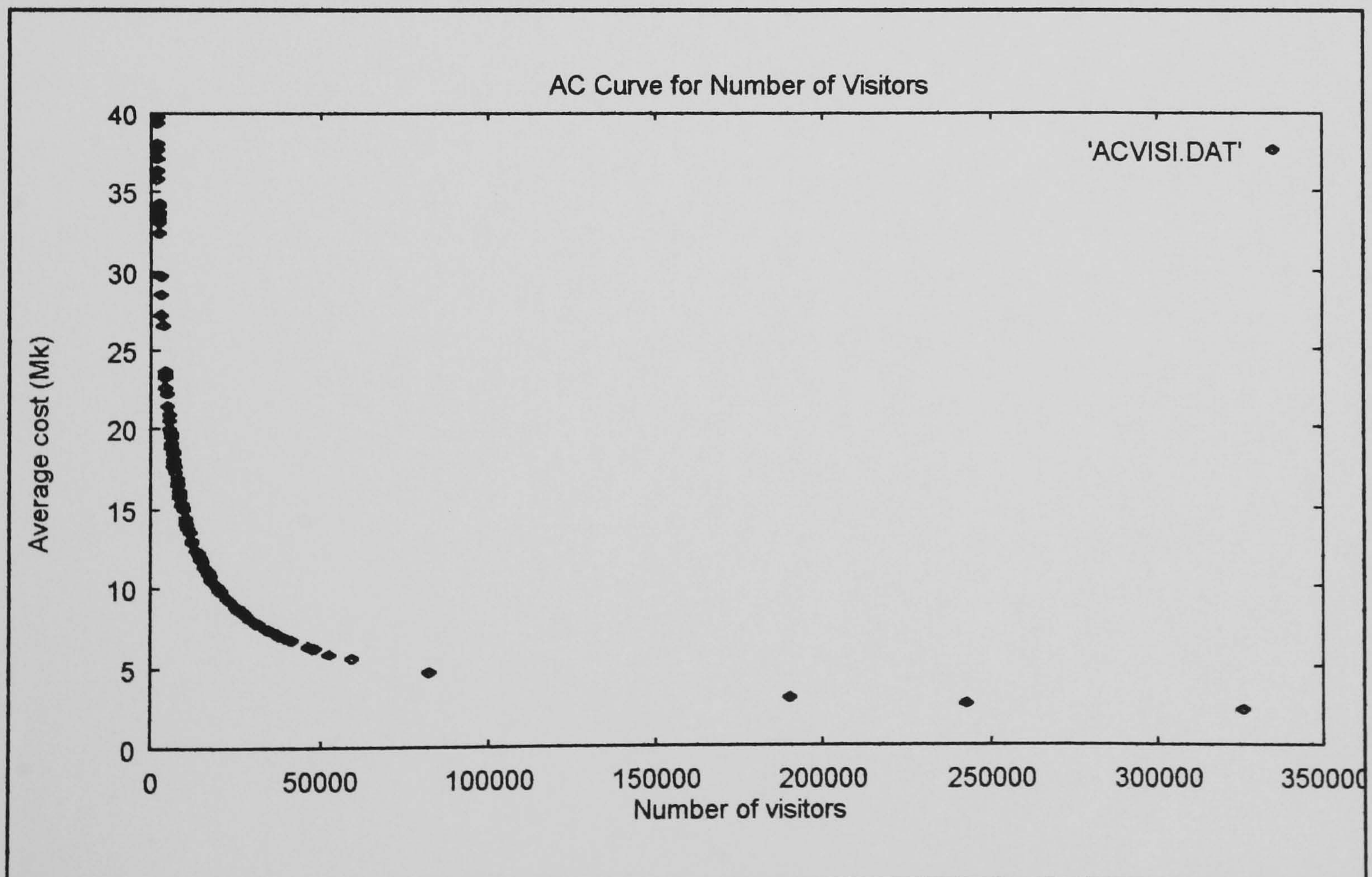

Figure B: Average costs - number of visitors

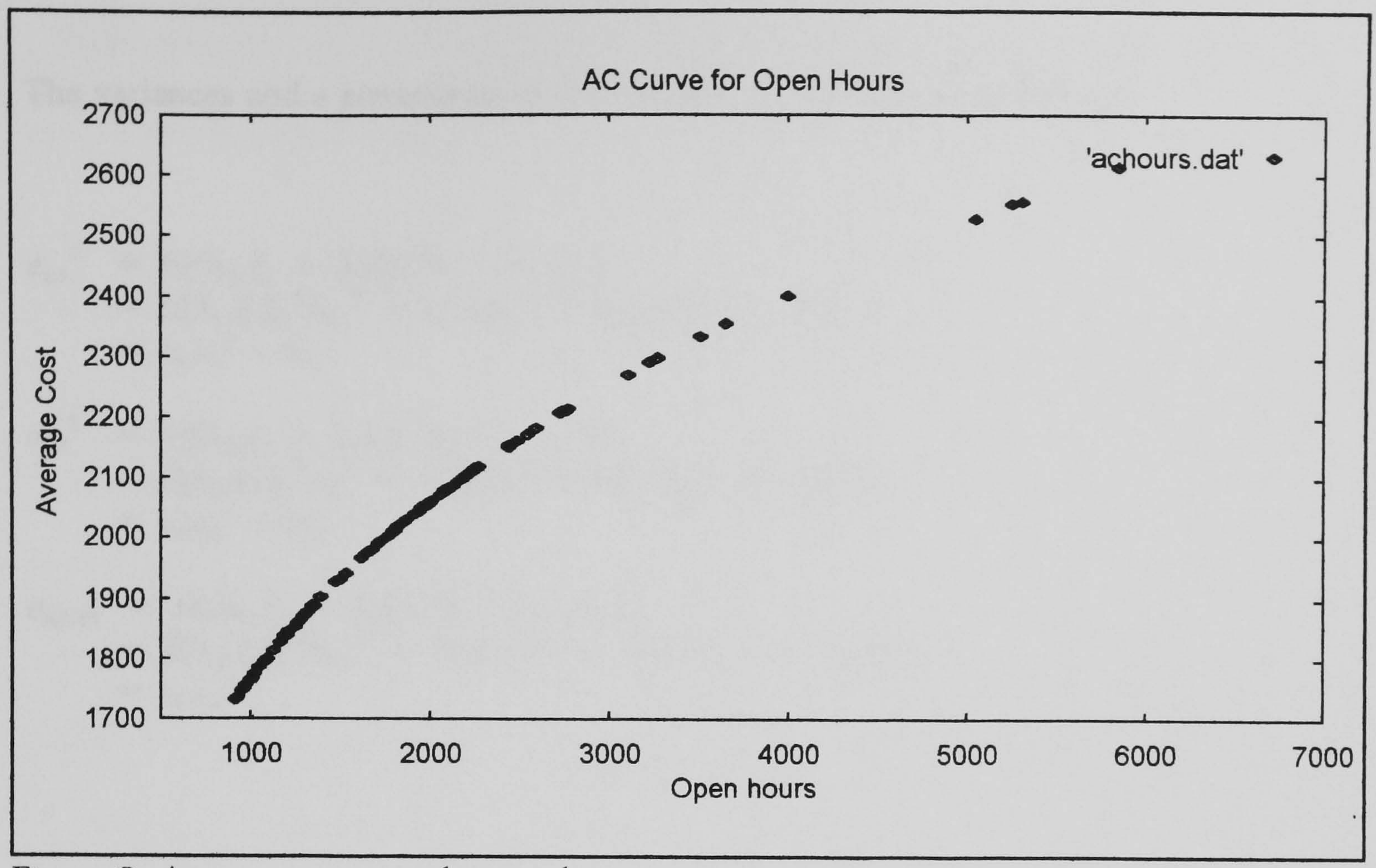

Figure C: Average costs - yearly open hours

APPENDIX 4

The variances and a covariance of the variables in M_5 can be written as:

$$\begin{aligned}
\sigma_{x1}^{2} &= E[(\lambda_{11}\xi_1 + \delta_1)(\xi_1^{T}\lambda_{11}^{T} + \delta_1^{T})] \\
&= E[\lambda_{11}\xi_1\xi_1^{T}\lambda_{11}^{T} + \lambda_{11}\xi_1\delta_1^{T} + \delta_1\xi_1^{T}\lambda_{11}^{T} + \delta_1\delta_1^{T}] \\
&= \lambda_{11}\lambda_{11}^{T} + \Theta_{11}
\end{aligned}$$

$$\begin{aligned}
\sigma_{x2}^{2} &= E[(\lambda_{21}\xi_1 + \delta_2)(\xi_1^{T}\lambda_{21}^{T} + \delta_2^{T})] \\
&= E[\lambda_{21}\xi_1\xi_1^{T}\lambda_{21}^{T} + \lambda_{21}\xi_1\delta_2^{T} + \delta_2\xi_1^{T}\lambda_{21}^{T} + \delta_2\delta_2^{T}] \\
&= \lambda_{21}\lambda_{21}^{T} + \Theta_{22}
\end{aligned}$$

$$\begin{aligned}
\sigma_{x2,x1} &= E[(\lambda_{21}\xi_1 + \delta_2)(\xi_1^{T}\lambda_{11}^{T} + \delta_1^{T})] \\
&= E[\lambda_{21}\xi_1\xi_1^{T}\lambda_{11}^{T} + \lambda_{21}\xi_1\delta_1^{T} + \delta_2\xi_1^{T}\lambda_{11}^{T} + \delta_2\delta_1^{T}] \\
&= \lambda_{21}\lambda_{11}^{T}
\end{aligned}$$

III Total Factor Productivity in Production of Cultural Services

- Productivity Analysis of Orchestras in the Presence of Non-constant Returns to Size and Technological Change

1 Introduction

By using a framework of a two sector unbalanced growth model Baumol (1951,1967) introduced his thesis of cost disease, according to which "the unit cost of a product of a persistently more stagnant activity must rise without limit in comparison with that of a more progressive activity". As a case in point Baumol (1951, 1967) use the production of services vs. the rest of the economy and Baumol and Bowen (1966) test the idea, most notably, in the case of US performing arts institutions.[1]

The argument of "cost disease" (B-B thesis) in performing arts rest on three main assumptions. The starting point of the B-B thesis is that there are two sectors in the economy, sector 1 that produces performing arts and sector 2 that represents the rest of the economy. The production of performing arts is characterised by labour intensity and relatively low or stagnant productivity deriving from lack of technical progress. The production in the other sector is, in turn, characterised by relatively high productivity deriving from innovation and accumulation of capital. The second assumption is that the costs of production are in both sectors determined by labour costs. Besides this, the labour costs in the two sectors are assumed to be equal, and driven by the productivity growth in the rest of the economy. Thus, because of the stagnant productivity in sector 1 the relative costs in that sector increase without limits, while in sector 2 they remain constant over time.[2] Thirdly, B-B thesis assumes that performing arts is characterised by high demand elasticity which implies that mounting costs cannot be covered by increasing admission fees. As a result, the thesis proposes that the US performing arts sector faces an increasing gap between its costs and revenues, a so called earnings gap. (See Appendix 1)

Since Baumol and Bowen (1966), e.g. Throsby and Withers (1979), Leroy (1980), Peacock et al. (1982) as well as Baumol and Baumol (1980, 1984) have further examined the applicability of the B-B thesis in the case of performing arts.[3] These studies have mainly centered on finding evidence of the earning gap by comparing the growth rate of costs in performing arts to the general price level, and generally find that the growth rate of costs (per performance) exceed the general price index. The main trust of these studies has, thus, been on verifying the existence of the earnings gap, while the causes of the gap - labour intensity together with wages determined in the rest of the economy, stagnant productivity growth and high demand elasticity of performing arts - have instigated less empirical interest.[4] (See Appendix 2)

The few empirical applications that have dealt with the causes of the gap include e.g. Felton (1994). Felton (1994) focuses on the assumption of stagnant productivity growth and demonstrate, first, by using an output-per-worker productivity estimate that for the fiscal years 1972-1992 productivity growth in 25 large US orchestras exceed that of manufacturing in half of the examined years! Moreover, Felton (1994) reveal that "while the real compensation per worker in manufacturing only increased by ten percent over the whole period, salaries per player-week rose by almost four times, 38.7 percent....This development clearly violates the assumption that wages are the same in the two sectors."[5] The estimations also include evidence of inelastic demand.[6] According to Felton (1994) "These results demonstrate that orchestras are subject to cost disease when their productivity lags. But they also reveal that productivity increases are possible."

This article concentrates on two main aspects of the B-B thesis. First, the article looks at the earnings gap. By using a panel data set of 19 Finnish symphony orchestras, 1978-1995, the article assesses whether Finnish orchestras are subject to an increasing gap between their costs and revenues. Second, the article focuses on the assumptions of the B-B thesis. An emphasis is on the assumption of stagnant productivity growth, i.e. on whether the assumption holds in the case of Finnish orchestras. The main reason for this is the lack of theoretically sound assessments of total productivity growth in performing arts in general as well as the positive implications of possible productivity improvements to the operation of individual institutions. The main questions of the article, hence, center on how productivity growth evolves in Finnish orchestras and what are the main factors explaining the changes in productivity. It should be noted that productivity growth in orchestras is not compared to that of the rest of the economy, and thus, the dynamics of the B-B thesis is not tested as such.

The article proceeds by first describing the panel data set of 19 Finnish symphony orchestras from 1978 to 1995, with an emphasis on growth rates of costs and revenues, inputs and outputs, as well as the earnings gap. The theoretical background of productivity growth is then put forward: it is demonstrated that the applied definition of total factor productivity (TFP) growth as well as the methods to measure TFP originate from the seminal treatment by Solow (1957). As to the methods, two alternative index number approaches are introduced. First, is introduced the so called Törnqvist Approximated Divisia index, together with the calculated indices of TFP growth, and after this is put forward a generalised version of the Divisia index together with the corresponding TFP measures.[7] The results of the two calculations are then compared and the main factors explaining the changes in productivity discussed. In this, of particular interest is the relative performance of the two alternative index number approaches. Lastly, some concluding remarks are made.

2 Description of the data set and existence of an earnings gap

The data set used in the analysis is a panel of 19 Finnish symphony orchestras from year 1978 to 1995. The data contains information on total costs, labour and capital costs, public subsidies, own revenues, number of visitors, number of concerts, number of full-time and part-time employees, and number of seats. The summary statistics of the data is as follows: (See Appendix 3)

Table 1: Descriptive statistics of the data set, 1978-1995, n = 19 orchestras, in FIM 1994

Variable	mean	st.deviation	minimum	maximum
TC	0.49758E+07	0.61471E+07	0.1654E+05	0.3412E+08
FTE	33.65	28.58	0.00	108.00
PTE	2.65	5.76	0.00	45.00
LC	0.41473E+07	0.49197E+07	0.1380E+05	0.2777E+08
CC	0.81598E+06	0.13682E+07	2582.00	0.8665E+07
PS	0.45279E+07	0.55212E+07	0.1858E+05	0.3147E+08
OR	0.41003E+06	0.63259E+06	1000.00	0.3337E+07
NS	663.00	371.84	196.00	1806.00

List of variables: TC = total costs, FTE = full-time employees, PTE = part-time employees, LC = labour costs, CC = capital costs, PS = public subsidies, OR = own revenues, NS = number of seats

The comparison of total costs and own revenues reveal that during the 1978-1995 period total costs exceed own revenues in all orchestras, and public subsidies are required to cover the deficits:

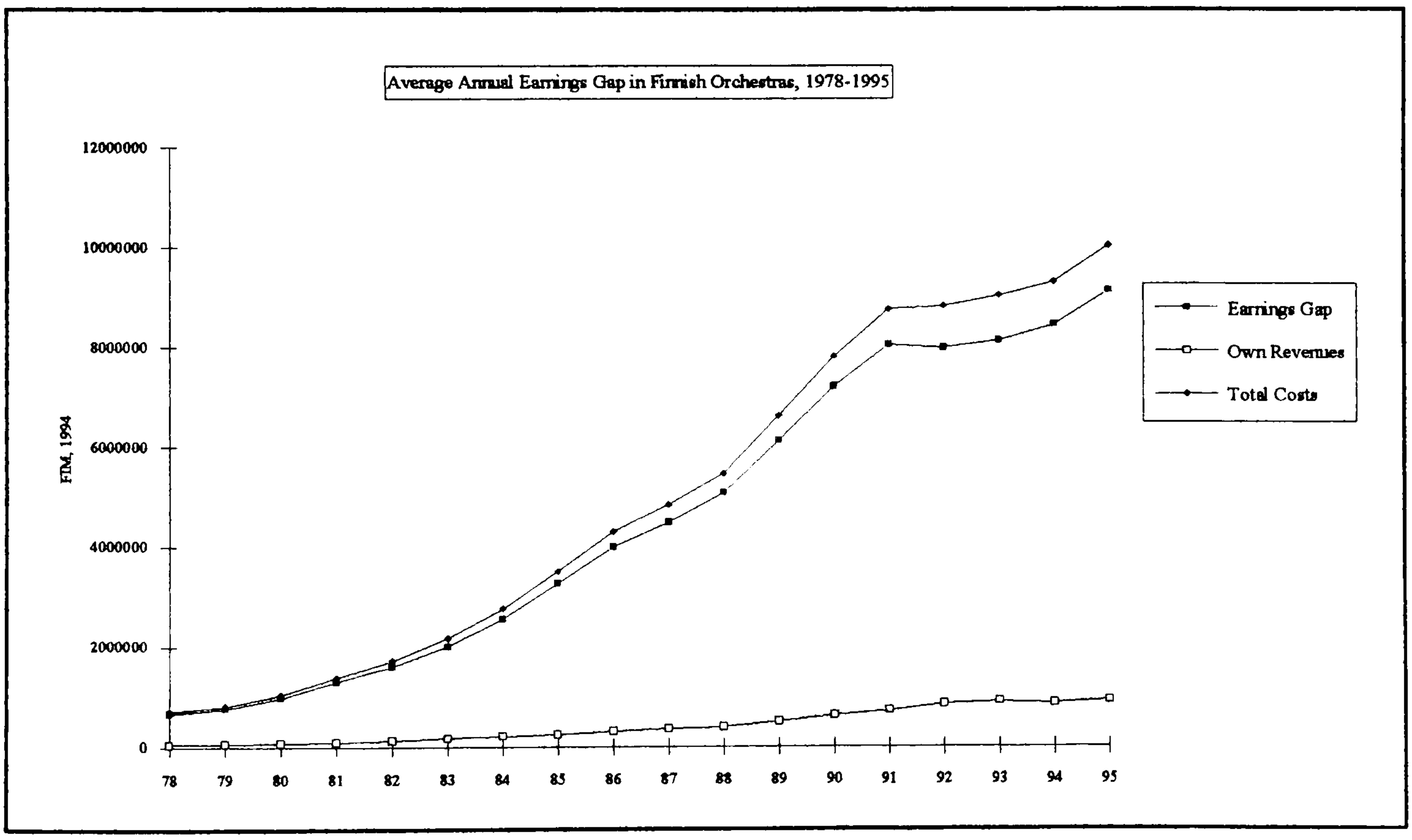

Figure 1: Average annual earnings gap

As shown in Figure 1, the average annual deficit, the average annual earnings gap, has followed the pattern suggested in B-B thesis: the earnings gap has increased steadily in time, except a little slump in 1991 that coincides with the cyclical down turn of Finnish economy. In general, deficits amount more than 90% of total costs, whereas own revenues cover a meager 10%. The percentages of the deficit on total costs have revolved from 94% in 1980 and 1985-1987 to 90% in 1991-1993, suggesting that the relative earnings gap has diminished slightly over time. Both a relative increase in the own revenues, as well as slackened growth of costs have contributed to this. (See Appendix 4) As shown in Figure 2 the decreased growth rate of deficits coincide closely with the decreased growth of costs, whereas the growth rate of own revenues fluctuates more considerably:

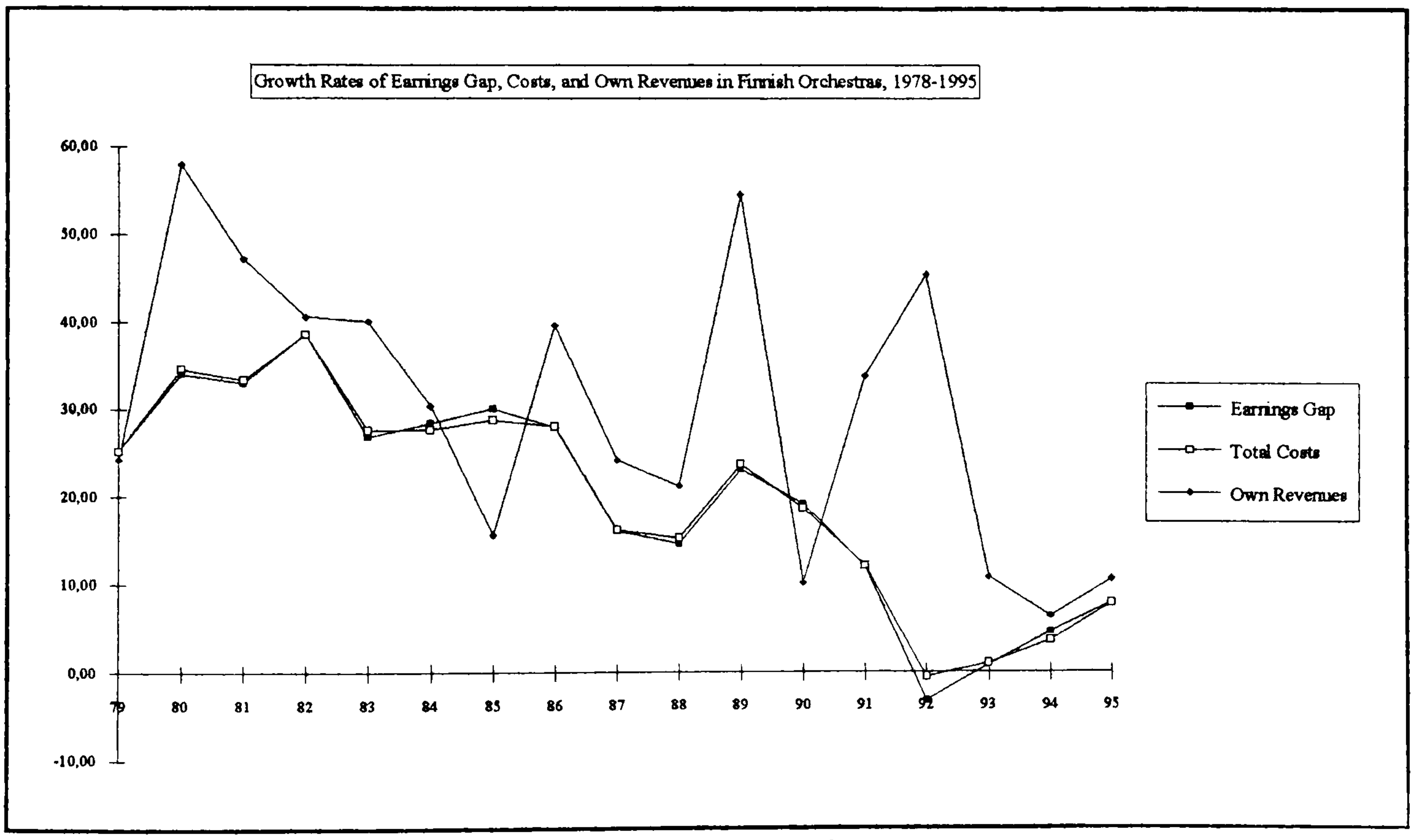

Figure 2: Growth rates of earnings gap, costs and own revenues

Figure 2 demonstrates, moreover, that the growth rate of costs, as the growth rate of the earnings gap, increased till 1983. Since that the growth of costs decreased steadily, except the peaks in 1985 and 1989. A radical drop occurred in 1992: the growth rate of costs reached its minimum as did the growth rate of the earnings gap. In the 1992-1994 time period costs grew relatively slowly - total costs remained almost at the level of previous years - while in 1995 the growth accelerated slightly.

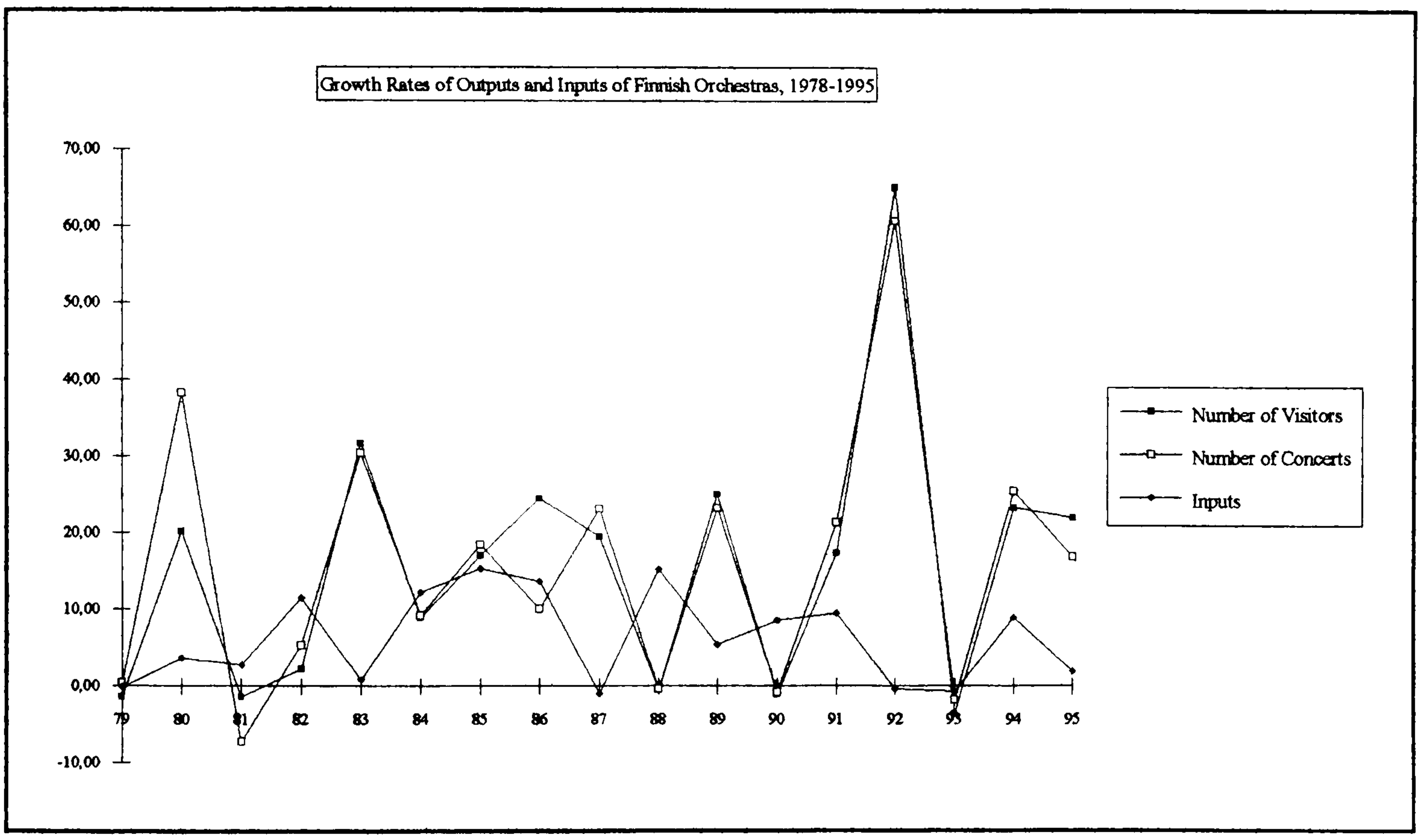

Figure 3: Growth rates of outputs and inputs

The growth rates of aggregate real input and outputs, in turn, diverge from the general declining trend of the growth rate of total costs: both the growth rate of input usage, as well as number of concerts or attendance, fluctuate considerably. The fluctuations in growth rates of number of concerts and visitors are of the same sign, except in 1978-

1979 time period, and of quite similar order. The growth rate of input usage fluctuates less, but exceeds the growth rate of number of concert goers and attendance roughly every other year.[8]

3 The concept of TFP and measurement of productivity growth by using Törnqvist Approximated Divisia Index

The pioneering study by Solow (1957) provides a convenient ground work for the definition of TFP growth as well as operationalisation of the concept.[9] The definition is set off by first decomposing total output of a firm, y_t, into two elements - a neo-classical production function $f(x_i^t)$ and a variable capturing technical change in time $A(t)$:

$$y^t = A(t)f(x_i^t) \tag{1}$$

The neo-classical production function $f(x_i^t)$ is assumed to describe, in each time period, production technology that exhibits constant returns to scale and is characterised by competitive markets. It follows from this, that production is technically efficient, input prices equal their marginal productivity, and moreover, that outputs are sold at marginal costs. The constant returns to scale, furthermore, requires the production function $f(x_i^t)$ to be homogeneous of degree one, suggesting that an equiproportionate increase in inputs yields an equiproportionate increase in output level. Technical change $A(t)$, in turn, is assumed to be Hicks neutral, implying that the ratio of marginal products of inputs remain unchanged for any given input mix, so that technical progress leads to proportional reductions in all inputs.[10] As a result, (1) depicts a situation in which the structure of technology f(x) does not change in time, but the production function may shift in time through the parameter A.

Under these assumptions a total differentiation of (1) with respect to time and division by y_t results a measure of total factor productivity growth that corresponds technical change.[11] Suppressing the t's to simplify notation, and letting dots to denote time derivatives, yields:

$$\dot{y}/y = \dot{A}/A + \Sigma_i(\partial f/\partial x_i)\,(x_i/f(x_i))\,(\dot{x}_i/x_i) = \dot{A}/A + \Sigma_i s_i(\dot{x}_i/x_i) \tag{2}$$

in which s_i is the cost share of i^{th} input that can be rewritten as:

$$s_i = (\partial y/\partial x_i)\,(x_i/y) = p_i x_i/wy = p_i x_i/\Sigma_i p_i x_i \tag{3}$$

Rearranging (2), hence, results a measure of TFP change that corresponds technical change:[12]

$$\dot{A}/A = \dot{y}/y - \Sigma_i s_i(\dot{x}_i/x_i) \tag{4}$$

For empirical applications, for which continuous data required by (4) is seldom available, Solow (1957) proposed a discrete definition of the TFP growth.[13] He suggested that changes in time could be approximated, instead of the time derivatives, by discrete changes. The most often employed discrete approximation of (4) is the Törnqvist Approximated Divisia Index.[14] By using Törnqvist's approximation technical change, ΔTFP or ΔA, can be written as:

$$\Delta TFP = [\ln Y_{i,t} - \ln Y_{i,t-1}] - \tfrac{1}{2} \textstyle\sum_i [s_{i,t} + s_{i,t-1}] [\ln x_{i,t} - \ln x_{i,t-1}] \qquad (5)$$

in which x_{it} represent the inputs, $Y_{i,t}$ the output, and $s_{i,t} = p_{i,t}x_{i,t}/\sum_i p_{i,t}x_{i,t}$ denotes the cost share of the x_i^{th} input in period t.

The assessment of TFP growth in Finnish orchestras is carried out by using (5). Two alternative measures, ΔTFP1 and ΔTFP2, are calculated. In both ΔTFP1 and ΔTFP2, orchestras are assumed to use labour and capital inputs in their production: in the calculations labour input is measured by man years and capital input is measured by number of seats. As suggested in (5), these two inputs are weighted in the calculations by their respective cost shares in each time period.

Two alternative output measures are used: in ΔTFP1 output is measured by number of visitors, while ΔTFP2 is derived by using the number of concerts as a proxy for output. Thus, the former follows the line of Throsby (1977) who employed the number of visitors to measure the output of Australian orchestras, whereas ΔTFP2 is constructed by using the output measure - number of performances - employed by Globerman and

Book (1974) as well as Lange et al. (1985) in estimations of cost functions for Canadian and American symphony orchestras respectively.

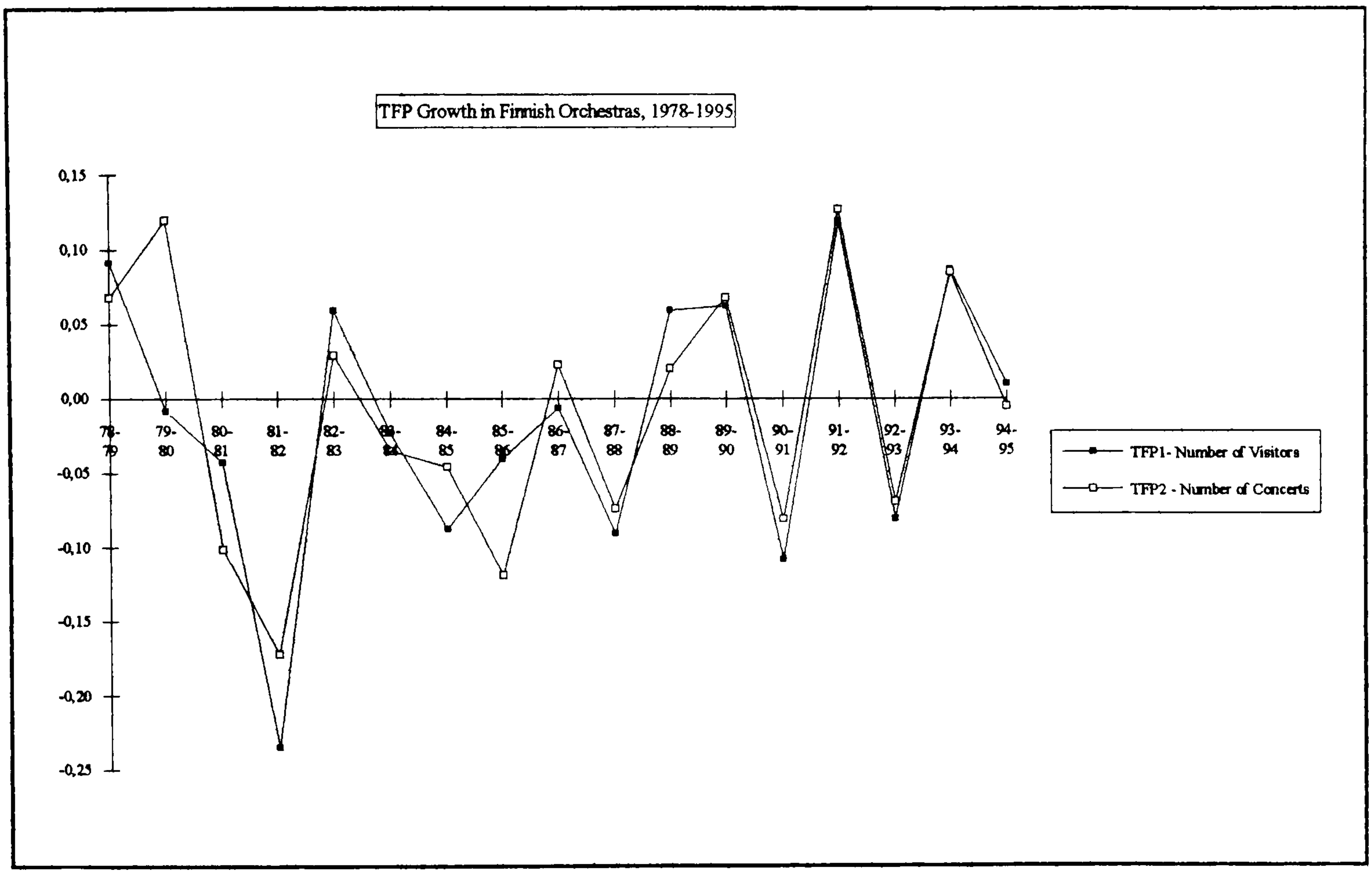

Figure 4: Two alternative Törnqvist Approximated Divisia Indeces

Figure 4 reveals that the two measures propose productivity growth of similar order, suggesting that the changes in productivity of the orchestras can be captured either by ΔTFP1 and ΔTFP2. In more detail, both measures revolve around zero, and result on average yearly TFP growth rates of -0.01. Thus, the traditional TFP growth measures for 19 Finnish orchestras in the 1978-1995 time period seem to support the presumption of the B-B thesis that practically no productivity growth takes place in the performing arts institutions. Alternatively, ΔTFP1 and ΔTFP2 suggest that no technical progress has taken place in Finnish orchestras: in a single-output case, under the assumptions of constant returns to scale and competitive markets productivity growth defined as (5) equals technical change.[15]

4 The concept of TFP and measurement of productivity growth by using Generalised Divisia Index

As already pointed out by Solow (1957), technical change is as such an insufficient explanation of changes in TFP - Solow (1957) noted that the residual difference between rates of growth of real product and weighted rates of growth of labour and capital inputs remains substantial.[16]

The residual has been sought to narrow, first, by including into the measures of inputs factors that change their quality over time.[17] As noted by Kendrick and Vaccara (1980), three main approaches have been employed: components of labour input have been weighted e.g. by effects of increased education, shortened hours of work and changing age-sex composition of the labour force, or alternatively, labour inputs have been adjusted for quality shifts together with a measure for capital input in which input components are weighted by the marginal products. Alternatively, some studies have continued to compute factor inputs unadjusted for quality change and prefer to view the increases in quality as a part of the broader residual. An example of such practise is Kendrick (1973).

Besides the technical change and quality adjustments of inputs, non-constant returns to scale, market imperfections and (in)efficiency of production have been argued to explain TFP growth. As to the inefficiencies of production, two alternative methodologies have been developed: Nishimizu and Page (1982) were first to employ a parametric production function in decomposing TFP growth into technical progress and changes in efficiency, while Tulkens (1990) pioneered the non-parametric frontier approach to TFP measurement.[18] Since the original B-B thesis assumes technically efficient production, neither of these lines of inquiry are followed here, and thus, it is still assumed that production of orchestras is a result of best practice.

Griliches (1963,1964,1967), in turn, was the first to demonstrate empirically that the measure of TFP growth includes not only the effects of technical change, but also the effects of non-constant returns to scale and market imperfections in industries where the assumptions of constant returns to scale and competitive markets do not hold. To solve this problem Denny, Fuss and Waverman (1981) developed a Generalised Divisia Index that allows non-constant returns to scale and non-competitive markets. This framework explains TFP growth in a multi-output setting by technical progress, scale effects, and effects of non-marginal cost pricing of outputs. This work was heavily based on Caves, Christensen and Swanson (1980) as well as Caves and Christensen (1980).

The work by Caves, Christensen and Swanson (1980) is based on Solow's (1957) insight according to which productivity growth can be defined as a difference between the rates of growth of real product and inputs. Along the lines of (4) the proportionate growth rate of TFP ($T\hat{F}P$) can be written as:

$$T\hat{F}P = \hat{Y} - \hat{F} \tag{6}$$

in which $\hat{Y}$ denotes the growth rate of output and $\hat{F}$ the growth rate of input usage that is defined as in (4) by weighing the growth rate of each input with its cost share, i.e. $\sum_i p_i x_i/c\ \hat{x}_i$. For simplicity's sake, (6) assumes a single output framework that allows multiple (i) inputs.[19]

Caves, Christensen and Swanson (1980) derive their generalised index by exploiting the dual theory of production together with (6).[20] They base the index in the shifts of a generalised cost function given by:

$$C = c(p_1,\ldots,p_n,Y,t) \tag{7}$$

in which p denotes input prices, Y stands for output, and t is time.[21] Totally differentiating (7) with respect to time yields:

$$dC/dt = \textstyle\sum_i \partial c/\partial p_i\ \partial p_i/\partial t + \partial c/\partial Y\ \partial Y/\partial t + \partial c/\partial t. \tag{8}$$

The proportionate shift in the cost function can be derived by dividing (8) by C and setting $\partial c/\partial p_i = x_i$ from Shephard's lemma:[22]

$$1/C\ \partial c/\partial t = 1/C\ dC/dt\ + \sum_i p_i x_i/c\ \mathring{p}_i + \partial c/\partial Y\ Y/C\ \hat{Y} \tag{9}$$

By denoting proportionate shift of the cost function $1/C\ \partial c/\partial t \equiv \hat{B}$ and noting that $(\partial c/\partial Y)$ (Y/C) equals the cost flexibility, allows (9) to be rewritten as:

$$\hat{B} = \hat{C} - \sum_i p_i x_i/c\ \mathring{p}_i - \varepsilon\hat{Y} \tag{10}$$

This implies that the shift in the cost function ($\hat{B}$) equals the change in the costs minus the change in aggregate inputs minus the scale effect.

Total differentiation of $C = \sum_i p_i x_i$ with respect to time and rearranging yields:

$$\sum_i p_i x_i\ \ \mathring{p}_i = \hat{C} - \sum_i p_i x_i/c\ \hat{x}_i\ . \tag{11}$$

Substituting (10) to (11) yields:

$$\hat{B} = \sum_i p_i x_i/c\ \hat{x}_i - \varepsilon\hat{Y} \tag{12}$$

that can be rewritten as

$$\hat{B} = \hat{F} - \varepsilon\hat{Y}. \tag{13}$$

The shifts of the cost function ($\hat{B}$) are, hence, proportioned into two elements: the term $\sum_i p_i x_i / c \ \hat{x}_i = \hat{F}$ that denotes the proportional rate of growth of inputs and the term $\varepsilon\hat{Y}$ that represents the scale effect with proportional rate of growth of output. Now, using the definition of total factor productivity (6), $T\hat{F}P = \hat{Y} - \hat{F}$, the shifts in cost function can be linked with the measure of total factor productivity. Substituting (6) into (12) yields:

$$T\hat{F}P = - \hat{B} + (1-\varepsilon)\hat{Y} \tag{14}$$

This implies that if there are constant size elasticities, $\varepsilon = 1$, then $T\hat{F}P = - \hat{B}$ suggesting that changes in TFP reflect only technical change. Whereas, if the size elasticity departs from unity the measure for TFP growth consists in addition to inter-temporal shifts in cost function (technical change) also the scale effect.

An empirical application of the generalised index (14) into real data, however, neccesitates a discrete approximation. Rearranging (14) yields:

$$\hat{B} = (1-\varepsilon)\hat{Y} - T\hat{F}P \tag{15}$$

in which the discrete approximation of $T\hat{F}P$ can be written, as in the Törnqvist approximation (5), as:

$$\Delta TFP = [\ln Y_{i,t} - \ln Y_{i,t-1}] - \tfrac{1}{2} \sum_i [s_{i,t} + s_{i,t-1}] [\ln x_{i,t} - \ln x_{i,t-1}] \qquad (16)$$

where the arithmetic averages of cost shares are used to approximate the instantaneous weights. The scale effects, $(1-\varepsilon)\hat{Y}$, in turn, can be approximated by first defining a discrete approximation for the cost flexibility. As proposed by Caves, Christensen, and Swanson (1980) the cost flexibility $\varepsilon = (\partial c/\partial Y)(Y/C)$, that is generally written as $\varepsilon = (\partial \ln c/\partial \ln Y)$, can be approximated by using the first differences of logarithms to approximate logarithmic derivatives. Again using the arithmetic averages to approximate the instantaneous weights of cost flexibility, and assuming that $\hat{Y}$ can be approximated by $\ln Y_{i,t} - \ln Y_{i,t-1}$, results:

$$\Delta (1-\varepsilon)Y = [1 - \tfrac{1}{2} \sum_i [(\partial \ln c/\partial \ln Y)_{i,t} + (\partial \ln c/\partial \ln Y)_{i,t-1}] [\ln Y_{i,t} - \ln Y_{i,t-1}] \qquad (17)$$

Then by using (16) and (17), a discrete approximation of the technical change ΔB can be written as:

$$\begin{aligned} -\Delta B = & \tfrac{1}{2} \sum_i [(\partial \ln c/\partial \ln Y)_{i,t} + (\partial \ln c/\partial \ln Y)_{i,t-1}] [\ln Y_{i,t} - \ln Y_{i,t-1}] \\ & + \tfrac{1}{2} \sum_i [s_{i,t} + s_{i,t-1}] [\ln x_{i,t} - \ln x_{i,t-1}] \qquad (18) \end{aligned}$$

In (18) all but the cost flexibilities $\partial \ln c/\partial \ln Y$ can be obtained directly from the data - the growth of output $[\ln Y_{i,t} - \ln Y_{i,t-1}]$, the growth of inputs $[\ln x_{i,t} - \ln x_{i,t-1}]$, and the changes in the cost shares $[s_{i,t} + s_{i,t-1}]$ can all be calculated directly from the raw data, whereas the cost flexibilities $(\partial \ln c/\partial \ln Y)$ have to be estimated by using a cost function.

Thus, in order to calculate the first term on the right hand side in the discrete approximation (18) - $\frac{1}{2} \sum_i [(\partial \ln c/\partial \ln Y)_{i,t} + (\partial \ln c/\partial \ln Y)_{i,t-1}] [\ln Y_{i,t} - \ln Y_{i,t-1}]$ - a cost function has to be estimated.

The cost function employed here to derive the cost flexibilities - for each orchestra in each year - is the translog (TL) cost function introduced by Christensen, Jörgenson, and Lau (1973). The parameterisation of the flexible TL cost function, to which are added the conventional disturbance terms (ε_c and ε_i) and a dummy structure, is as follows:

$$\ln c = \alpha_0 + \alpha_y \ln y + \gamma_{yy}(\ln y)^2 + \sum_i \alpha_i \ln p_i + \sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j + \sum_i \gamma_{yi} \ln y \ln p_i + \delta_f + \delta_t + \varepsilon_c \ , i = l, k \tag{19}$$

and the corresponding cost share of the i^{th}-input is:

$$S_i^s = \alpha_i + \gamma_{yi} \ln y + \sum_j \gamma_{ij} \ln p_j + \varepsilon_i \tag{20}$$

in which α_0 is the intercept, α_l and α_k are the cost shares of labour and capital respectively, γ_{ll}, γ_{kk} and γ_{kl} are the share elasticities, γ_{yl} and γ_{yk} stand for the biases of scale, and γ_{yy} is the derivative of elasticity of cost with respect to output. The orchestra specific costs that are not included in the explanatory variables are captured by δ_f, and δ_t is a dummy variable for the time effects.

Furthermore, in order the TL formulation (19) - (20) to be dual to the underlying production technology the following regularity conditions have to be met:

$$\Sigma_i\alpha_i = 1,$$
$$\Sigma_i\gamma_{yi} = 0,$$
$$\Sigma_i\gamma_{ij} = \Sigma_j\gamma_{ij} = \Sigma_i\Sigma_j\gamma_{ij} = 0$$

Because, as noted, the cost flexibility can be written as $\mu(p_i,y) = \partial \ln c/\partial \ln Y$ the TL formulation of a neo-classical cost function (19) yields the following definition of the cost flexibility:

$$\mu(p,y) = \alpha_y + \gamma_{yy}\ln y + \sum_i\gamma_{yi} \ln (p_i) \qquad (21)$$

This definition yields estimates of cost flexibilities for each orchestra in each year, that are needed in calculation of the equation (18).

In practice, empirical application of (18) proceeds in three phases. First, the cost flexibilities needed in calculation of the scale effect are derived by estimating the TL cost function (19) together with the corresponding cost share equations (20). Then, raw data is employed to calculate the observable variables, i.e. the growth of output, growth of inputs, and the changes in the cost shares. Third, the estimated cost flexibilities are used together with the observable variables to calculate (18). The calculation of (18) produces measures for technical change (ΔB) and scale effect Δ $(1-\varepsilon)Y$ that are then substituted to (15). These substitutions, together with a rearrangement, yields the generalised TFP indices. The generalised indices, henceforth denoted as ΔTFP3, explain TFP growth by two components - technical change (ΔB) and the scale effect $\Delta(1-\varepsilon)Y$.

4.1 Estimation of cost flexibilities and notes on the production technology

The calculation of discrete approximations of the Generalised Divisia Index (18) for Finnish orchestras is set off by estimation of the cost flexibilities. The cost flexibilities - needed in calculation of the scale effect - are derived by estimating the TL cost function (19) together with the corresponding cost share equations (20).[23] The estimations are carried out by using a modification of Zellner's (1962) SUR procedure in which the share equation for capital is deleted in order to avert the problem of singularity of the contemporaneous covariance matrix, and the remaining parameters are derived by using the regularity conditions.[24]

In the estimations the output of orchestras is measured, along the lines of Globerman and Book (1974) and Lange et al. (1985), by the number of concerts.[25] Along the lines of Lange et al. (1985) orchestras are, furthermore, assumed to employ capital and labour inputs in their production. Lange et al. (1985) derived the unit price of labour input by dividing total artistic expenses by number of players in the orchestra, and the price of capital input was defined as the ratio of promotional expenditures to contributions from all sources (donations and subsidies). In order to include into the labour input price also the administrative and technical personnel, in addition to the artistic personnel, the unit price of labour input is measured by:

$$LP = LC /(FTE + PTE/4)$$

in which FTE is the man years of full-time workers and PTE the part-time employees who are assumed to work one quarter of a man year in a given orchestra.[26] The capital input price is, in turn, measured as the ratio of capital costs to number of seats in the permanent venue place:

$$CP = CC/NS$$

in which CC denotes capital costs (rents, interests, and maintenance), acquisitions of instruments, as well as loans of notes, and royalties, whereas NS is the number of seats. This definition reflects the fact that the Finnish orchestras do not rely on private donations, but on own revenues and public subsidies that do not involve promotional expenditures.

Table 4 demonstrates that the estimated system (19) - (20), by using the above measures for output and input prices, fulfills the regularity conditions: $\alpha_k + \alpha_l = 1$, $\gamma_{yk} + \gamma_{yl} = 0$, as well as $\gamma_{kl} + \gamma_{kk} + \gamma_{ll} = 0$. Besides this, all parameter estimates, but the intercept α_0, are statistically significant and of the right sign. (See Appendix 5) The magnitudes of individual parameter estimates are of the expected order, except the estimates of the cost shares of labour and capital: the estimates for α_l and α_k suggest, contrary to B-B thesis, that production in Finnish orchestras is not distinctly labour intensive (labour 45% and capital 55%). Thus, the assumption of labour intensity of production, presupposed in B-B thesis, is not an appropriate assumption in the case of Finnish orchestras.

The parameter estimates of the system (19) - (20) are as follows:

Table 2: Parameter Estimates (s.e in parentheses)

Parameter	Estimate	Parameter	Estimate
α_0	21.76 (84.50)	α_k	0.55 (0.01)
α_y	99.51 (44.57)	γ_{kk}	0.04 (0.00)
γ_{yy}	-18.80 (5.86)	γ_{yk}	-0.15 (0.01)
α_l	0.45 (0.01)	γ_{kl}	-0.02 (0.00)
γ_{ll}	-0.02 (0.00)	γ_{yl}	0.15 (0.01)

The estimated cost function, furthermore, reveals that production technology exhibits non-homotheticity - the hypothesis that the underlying production technology is homothetic ($\gamma_{yk}= \gamma_{yl} = 0$) is rejected at the 0.05 level ($\chi^2(2) = 369.30$; critical value $\chi^2(2) = 5.99$). This implies, first, that the relative utilisation of inputs varies depending on the output level: the biases of scale, γ_{yk} and γ_{yl}, indicate that the relative utilisation of labour input increases when the number of concert increases. Besides this, because homotheticity is a prerequisite to homogeneity ($\gamma_{yk} = \gamma_{yl} = \gamma_{yy} = 0$) production technology proves to exhibit also non-homogeneity. This means that output does not expand at the same rate as the utilisation of inputs increase.

The non-homotheticity and non-homogeneity have implications also on the estimates of cost flexibilities - non-homotheticity and non-homogeneity of the underlying production technology with respect to output imply in TL formulation that the cost flexibilities, $\partial \ln c(p,y) / \partial \ln y$, are derived from $\mu(p,y) = \alpha_y + \gamma_{yy} \ln y + \sum_i \gamma_{yi} \ln (p_i)$.[27]

In practice, the cost flexibilities are calculated for each orchestra by employing the derived parameter estimates (Table 2), using the yearly averages of input prices across the orchestras as the input prices of individual orchestras, and letting the output levels to vary. As a result, the calculations yield cost flexibilities of $\mu(p,y) = 24.94$ on average, suggesting that Finnish orchestras exhibit decreasing size elasticities steadily over the whole time period, i.e. that there are economic gains from small scale production in each and every year.[28] (See Appendix 5)

4.2 Calculation of the Generalised Indices and factors explaining TFP growth

The generalised Divisia indices (ΔTFP3) are calculated, according to (18), by using the growth rates of outputs and inputs, estimated cost flexibilities as well as cost shares of inputs. As in (18), the growth rates of output are weighted by cost flexibilities, the reason being that orchestras exhibit - instead of constant scale economies - considerable diseconomies of size.[29] The growth rates of inputs are, in turn, weighted by their respective cost shares.[30]

The use of (18), use of the number of concerts as a proxy for output, and assuming that orchestras utilise labour and capital inputs in their production result the following measures for TFP (ΔTFP3), technical change (ΔB), and the scale effect ($\Delta(1 - \varepsilon)Y$) :

Table 3: Components of TFP growth in Finnish orchestras 1978-1995

Year	ΔTFP3	-ΔB	$\Delta(1 - \varepsilon)Y$
1978-1979	0.07	2.32	-2.25
1970-1980	0.12	2.97	-2.85
1980-1981	-0.10	-1.34	1.23
1981-1982	-0.17	1.47	-1.64
1982-1983	0.03	3.07	-3.05
1983-1984	-0.04	0.08	-0.11
1984-1985	-0.05	2.00	-2.04
1985-1986	-0.12	-0.08	-0.03
1986-1987	0.02	1.38	-1.36
1987-1988	-0.07	-0.72	0.65
1988-1989	0.02	1.91	-1.89
1989-1990	0.07	1.17	-1.11
1990-1991	-0.08	-1.24	1.16
1991-1992	0.13	3.58	-3.45
1992-1993	-0.07	-2.01	1.94
1993-1994	0.08	1.58	-1.50
1994-1995	0.00	-0.55	0.55
Average	-0.01	0.92	-0.93

Since the measure for TFP'growth in Table 3, ΔTFP3, is by definition the same as ΔTFP2, both measures suggest that TFP growth has been stagnant in the Finnish orchestras.[31] As shown in Table 3 - as well as in Figure 4 - productivity growth is at its highest from 1991 to 1992, ΔTFP2 = ΔTFP3 = 0.13, and at its lowest in 1981-1982 time period, ΔTFP2 = ΔTFP3 = -0.17. The peak in the TFP growth rate coincides with a substantial drop in the growth rate of costs, weighty increases in the growth rates of attendance and number of performances, and a considerable drop in the growth rate of input usage. (See Figure 2 and Figure 3) The lowest productivity growth rates, in turn, coincide with a relatively high growth rate of inputs, but a negative growth of outputs. (See Figure 3)

Notwithstanding the correspondance of ΔTFP3 and ΔTFP2, the two measures, however, yield different interpretations of the origins of stagnant productivity growth. The major difference is in that ΔTFP2 considers stagnant productivity to derive from lack of technical progress, while the Generalised Index ΔTFP3 suggests that stagnant productivity growth originates from fluctuations in both technical progress and the scale effect.

Figure 5 reveals that the fluctuations in technical progress and scale effect are considerable within ΔTFP3: the highest rate of technical progress is $\Delta B = 3.58$ and the lowest rate is -2.01, whereas the greatest scale effect is $\Delta(1 - \varepsilon)Y = 1.94$ and the most adverse scale effect is -3.45. Of interest is that the technical change and scale effect consistently fluctuate to opposite directions and cancel out each others: the adverse scale effect of increasing the number of concerts is canceled out by technical change of roughly the same magnitude and vice versa, thus, resulting a stagnant overall productivity growth rate. Figure 5 shows the pattern in which an improvement in one component - either technical change or scale effect - is generally followed by a relapse in the next period.

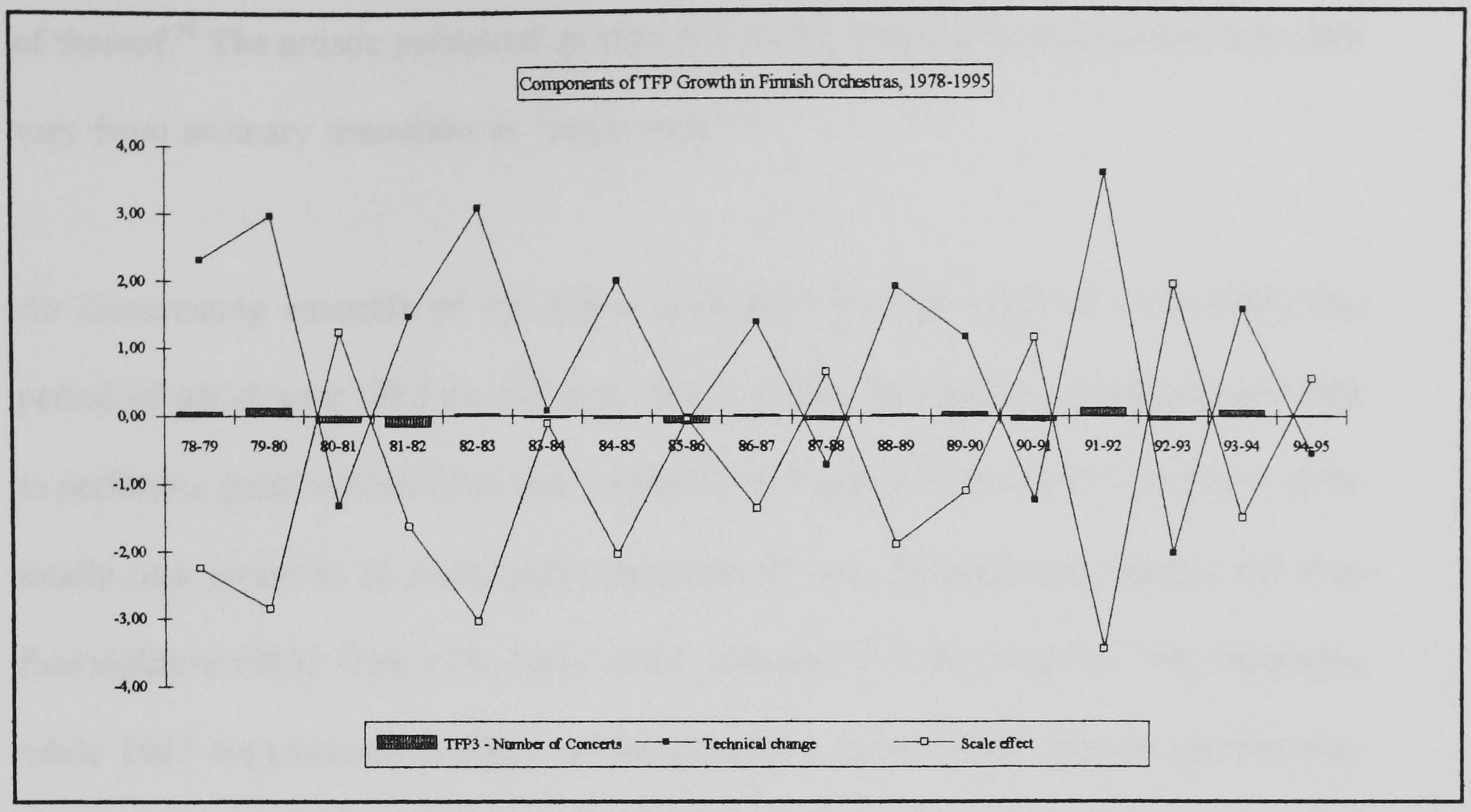

Figure 5: Components of TFP growth

A possible explanation to this rather peculiar cancelling out phenomenon is, first, that orchestras may increase the number of concerts even if the number of musicians is reduced: a part of the increase in number of concerts is attributable to an increase in concerts that are not performed with the whole ensemble, e.g. chamber concerts. An orchestra may also make such choices of repertoire or artistic personnel (musicians and conductors) that induce fluctuations in both technical progress and scale effect: an orchestra may choose relatively easy and well known compositions in the repertoire since "easy pieces" do not require extensive practice and may appeal to the less refined tastes, alternatively, an orchestra may choose less known "difficult" pieces that require extensive practice and may appeal only to the most refined tastes, or any combination of thereof.[32] The artistic personnel, putting the chosen repertoire into practice, may also vary from ordinary musicians to "super stars".[33]

An illuminating example of the above explanations is provided by 1981-1983 time period, of which year 1982 was the anniversary of Finnish music that inspired orchestras to perform a great number of pieces composed by Finnish composers as well as to order totally new pieces to be performed (altogether 43 new Finnish compositions had their first nights in 1982). Year 1981 was, in turn, occupied by rehearsing the 1982 repertoire, while 1983 experienced widening of the repertoire from mostly Finnish compositions with the whole ensemble and reverting to pre 1982 level of inputs (copy right fees and fees to "super stars").

In other words, the 1981-1983 time period suggests in terms of actual growth rates of outputs (number of concerts and attendance) and inputs that year 1981 witnessed a slump in outputs together with a modest increase in inputs, in 1982 growth rate of outputs was positive but relatively low and the growth rate of inputs was relatively high, whereas in 1983 the growth rate of number of concerts and visitors peaked together with a slump in the growth rate of inputs. (See Figure 3) As a result, technical change ΔB increase steadily from -1.34 in 1981 to 3.07 in 1983 whereas the scale effect $\Delta(1 - \varepsilon)Y$ range from 1.23 in 1981 to -3.05 in 1983. Notwithstanding these considerable fluctuations, ΔTFP3 remains close to zero and fluctuate from -0.10 in 1981 to 0.03 in 1983. This suggests that the assumption of stagnant productivity growth deriving from lack of technical progress does not hold in the case of Finnish orchestras, and furthermore, that it is possible to enhance productivity growth via technical change or adjustment of the scale of production. On the basis of the calculations it, however, seems that Finnish orchestras that do not fully exploit the possibilities of productivity improvements, but seem to take action only when they face an adverse scale effect and choose to be more lax when benefitting from the small scale of production.

5 Conclusion

This article has centered on empirical analysis of the B-B thesis. Three main questions have been of interest: first, whether Finnish orchestras are subject to an increasing gap between their costs and revenues, i.e. an earnings gap, and second, whether the assumption of stagnant productivity growth holds in the case of Finnish orchestras and what are the main factors explaining the changes in productivity. Besides this, the article examined whether two alternative measures of TFP growth - Törnqvist Approximated Divisia Index and Generalised Divisia Index - yield different interpretations of the sources of TFP growth and what are their implications to the empirical assessment of cultural instiutions.

The analysis revealed, first, that the examined 19 Finnish orchestras face a considerable earnings gap during the whole time period 1978-1995: costs exceed handsomely own revenues, as proposed by Baumol and Bowen (1966). The calculations suggested that the earnings gap was on average some 93% of total costs. The difference between the costs and own revenues did not, however, increase in time, but decreased slightly - the growth rate of the earnings gap had a slight overall decreasing trend even if it fluctuated quite considerably. At its highest, in the mid 1980's, the growth rate of the earnings gap reached 40% annual rate, whereas at its lowest, in the early 1990's, the growth rate of earnings gap turned negative to some -3% annual rate. Both the increased growth rate of costs and increased growth rate of own revenues contributed to the slight decrease in the growth rate of the earnings gap.

A more detailed analysis of own revenues revealed that there has been a clear increasing trend in admission revenues per concert goer, while the number of visitors and number of performances have not had a slackened growth. This hints that the assumption of high demand elasticity of orchestral performances might not be valid in the case of Finnish orchestras. Thus, as suggested already by Moore (1968), Throsby (1994) and Felton (1992), it is likely that the increasing admission fees can be used to some extend to cover the increasing costs.

The second main finding of the article was that the Finnish orchestras encountered stagnant or even negative productivity growth, as suggested by Baumol and Bowen (1966). The Törnqvist Approximated Divisia Index approach - that considers productivity growth and technical progress synonymous following from the assumptions of constant returns to scale and competitive markets - suggested -0.02 average annual percentage growth of productivity during the 1978-1995 time period. The results were of similar order, notwithstanding the measure of output (the number of concerts or attendance): the annual TFP growth measures were close to zero and revolved around +/- 0.05, with the exceptions of years 1979 and 1982.

The Generalised Divisia Index suggested accordingly stagnant productivity growth, but pointed out that since the assumption of constant scale economies does not hold in the case of Finnish orchestras the lack of technical change is not a sufficient explanation of stagnant productivity.[34] The calculations revealed, most importantly, that stagnant productivity of Finnish orchestras derive from considerable fluctuations, +/- 3.5, in technical change and the scale effect: stagnant productivity is a result of technical change and the scale effect consistently fluctuating to opposite directions and cancelling out each others.

Such a finding has twofold implications: first, the finding implies that usage of Törnqvist Approximated Index would yield undoubtedly biased estimates of technical change in the case of Finnish orchestras - the highest rate of technical progress in Törnqvist Approximated Index is 0.13 in 1991-1992 and the lowest rate is -0.17 in 1981-1982, while according to the Generalised the highest rate of technical progress is 3.58 and the lowest -2.01. As a result of this and omission of the scale effect, the Törnqvist Approximated Divisia Index also underestimates the possibilities to improve TFP growth.

Due to these two major biases, the usage of Generalised Index is preferred to the Törnqvist Approximated Index.

By and large, the findings of the article have shown that the assumptions of the B-B are not in accordance with the findings on Finnish orchestras. The analysis casts doubt on the assumption of high demand elasticity, demonstrates the invalidity of the assumption of highly labour intensive production, and moreover, shows that stagnant productivity does not derive form lack of technical progress, but from fluctuations in technical change and the scale of production. On the basis of this it seems that only a more detailed assessment of the cancelling out effect could provide a solution to the considerable earnings gap, also the Finnish orchestras are facing. This implies a need for more detailed analyses of the effects of the choice of repertoire and usage of artistic personnel with different qualifications as means of productivity improvements.

Endnotes

1. See Towse (ed.) (1997a) for an overview and collection of the early contributions on B-B thesis as well as on developments of the theory of cost disease and its implications to Cultural Economics.
2. This means that wages do not increase more than the productivity growth of labour input allows.
3. See Towse (ed.) (1997a) on implications of the B-B thesis on libraries, health care and education systems. See also Baumol et al. (1985) for discussion.
4. The causes of the earnings gap have inspired a great variety of discussion, instead of empirical testing. See Towse (ed.) (1997a) for discussion on policy implications.
5. Heikkinen and Karhunen (1996) have demonstrated with a cross-sectional data on Finnish wages that there are clear income disparities between artists and other occupational groups (as well as between male and female artists). They show that "Both male and female artists earn about one third less than their counterparts among upper level employees. Compared to lower level employees and manual workers artists are in a better situation."
6. The assumption of high demand elasticity of performing arts has been called into question also by Moore (1968) and Felton (1994). Moore (1968) examined demand for Broadway theatre and found price elasticities ranging from -0.33 to -0.63. Felton (1992) reported price elasticities for US orchestras of around -0.6 and found the price elasticities for major US ballet and opera companies to range from -0.1 to -0.6.
7. It should be noted, that the assessment of productivity growth in Finnish orchestras is carried out, pace Felton (1994), by using index numbers. The approach is, however, more elaborate in two respects: instead of a productivity measure that is based on a ratio of single output to single input (labour) is utilised a concept of total factor productivity that accounts all inputs and outputs, and moreover, instead of a simple output-per-worker measure is employed two alternative TFP indices, namely the Törnqvist Approximated Divisia index and Generalised Divisia Index.
8. It should be noted, that in the graph inputs include both labour and capital input that are weighted by their cost shares.
9. The underlying idea of Solow's (1957) model was originally to distinguish the impact of technical change on output growth from the effects of capital accumulation. In short, he developed an "elementary way of segregating variations in output per head due to technical change from those due to changes in the availability of capital per head."
10. See Grosskopf (1993) for a more detailed discussion on Hicks neutral technical change.
11. It should be noted, that productivity growth defined as (1) equals technical change in a single output case only and only if the assumptions of constant returns to scale and competitive markets hold. See Denny, Fuss, and Waverman (1981) for a proof. See Kendrick (1973) for a non-technical discussion.
12. A similar kind of definition of total factor productivity growth has been put forward also by Kendrick (1973) as well as Jorgenson and Griliches (1967).

13. This approach towards productivity analysis was later established by Jorgenson and Griliches (1967), Richter (1966), Hulten (1973), and Diewert (1976).
14. The theoretical contributions to develop the correspondence of index numbers and theory of production is largely based on Diewert's (1976,1978) work on exact or superlative index numbers showing that there is a unique correspondence between the type of the index used to aggregate over outputs and inputs and the structure of the underlying technology.
15. See Kendrick (1973) for a non-technical discussion.
16. Kendrick and Vaccara (1980) note that this residual was called by Abramovitz, and by many others thereof, as a "measure of our ignorance".
17. See Kendrick and Vaccara (1980) for a detailed discussion on the conceptual and methodological developments.
18. Both approaches have instigated a wealth of empirical applications as well as methodological extensions. See Grosskopf (1993) for a detailed discussion on the methods as well as their subsequent extensions.
19. In multi output cases the output index is usually constructed by weighing different output volumes by their revenue shares. See Grosskopf (1993) for examples.
20. Ohta's (1975) has demonstrated that the duality between cost and production can be exploited to formulate technical progress by using cost functions.
21. The cost function (7) is homogeneous of degree one, non-decreasing, and concave in the input prices p_i and the first partial derivatives of the cost function with respect to the input prices represent the cost minimising input demand (Shepard's Lemma).
22. As is well known, the first partial derivatives of the cost function with respect to the input prices (p_i) are equal to the cost minimising input levels (Shephard's lemma).
23. The estimations are carried out by employing SHAZAM 7.0 program.
24. As shown by Barten (1969) the estimates are invariant to the choice of equation to be deleted.
25. As shown in chapter 3, the calculated Törnqvist Approximated Divisia Indices were similar irrespective of the output measure, number of concerts and attendance.
26. It should be noted, that the way to give statistics on personnel changed in 1985 (the way to assess contributions of part-time employees). As a result of this, the unit price of labour input is likely to be slightly over-estimated between the 1978-1985 time period.
27. As shown, this definition coincides with the elasticity of scale when the underlying production technology is homothetic with respect to output.
28. Size economies - the reciprocal of the cost flexibility - are on average some 0.4 during the time period from 1978 till 1995.
29. The growth rates of outputs are not weighted in ΔTFP1 and ΔTFP2 since constant returns to scales is assumed.
30. Cost shares are acceptable weights for the input growth rates, i.e. are satisfactory estimates of cost elasticities with respect to factor prices, given that Finnish orchestras purchase their factors of production in reasonably competitive markets.
31. This can be simply demonstrated by noting, first, that the traditional Divisia index can be written as $T\hat{F}P = \hat{Y} - \hat{F}$ whereas the generalised index can be written as $\hat{B}$ =

$(1-\varepsilon)\hat{Y}$ - $T\hat{F}P$. Substituting the former to the latter yields: - $\hat{B}$ = $\varepsilon\hat{Y}$ - $\hat{F}$. Rewriting the definition of the generalised Divisia index (14) by using the definition of technical change results: $T\hat{F}P = \hat{Y} - \hat{F}$ which suggests that the value of the measure for total factor productivity is the same in the generalised Divisia index ΔTFP3 and the traditional index ΔTFP2.

32. Similar suggestions have been made e.g. by Throsby (1994) and Peacock (1985) who have noted that productivity growth can take place in performing arts via employment of new venue designs and improved sound and lighting systems, performance of plays with simpler sets or smaller casts, and plays for which copyright fees are not anymore due.

33. See Adler (1985) for discussion of "super stars".

34. As to the underlying production technology it was shown, first, that Finnish orchestras exhibit decreasing scale economies, and second, that production in Finnish orchestras is not distinctly labour intensive, but labour and capital are utilised in production almost in equal proportions. Similar findings has been made by Gapinski (1979) in the case of US orchestras.

APPENDIX 1

The B-B thesis (1966) rests on three main assumptions.[1]

(1) It assumes that there are two sectors in economy, secor 1 producing performing arts and sector 2 representing rest of the economy. The sector 1 is characterised by labour intensity and, furthermore, by constant or stagnant productivity growth of labour input. The labour input and the level of output, at time t, are in sector 1 denoted by $L_{1,t}$ and $Y_{1,t}$:

$Y_{1,t} = \alpha L_{1,t}$, in which α is a constant

The sector 2 is assumed to be more progressive, and productivity growth to be faster than at sector 1. Thus, for sector 2:

$$Y_{2,t} = \beta\, L_{2,t}[1 + r]^t$$

where r represents the productivity growth of labour input, and β is a constant.

(2) The costs of production are determined by labour costs, $p_{1,t}$ and $p_{2,t}$, and thus it is assumed that the capital costs are either constant or zero over time. The labour costs $p_{1,t}$ and $p_{2,t}$ are assumed to vary at the same phase, and be affected by the productivity growth of labour input in sector 2: $p_{1,t} = p_{2,t} = p_t = p[1 + r]^t$. The relative average costs are, hence:

$$c_1 = p_t L_{1,t}/Y_{1,t} = p[1 + r]^t L_{1,t}/\alpha\, L_{1,t} = p[1 + r]^t/\alpha$$
$$c_2 = p_t L_{1,t}/Y_{2,t} = p[1 + r]^t L_{2,t}/\beta\, L_{2,t}[1 + r]^t = p/\beta$$

Thus, the costs in sector 1 augment without limits, while in sector 2 they remain constant in time.

---

[1] The notation of the model is modified from that of Baumol (1951, 1967).

(3) The model assumes that performing arts is characterised by high demand elasticity. The prices of output are assumed to be proportional to the costs, $p_1 = \alpha c_1$ and $p_2 = \beta c_2$,:

$$p_1 y_1/p_2 y_2 = \alpha c_1 y_1/\beta c_2 y_2$$

in which $$c_1 y_1/c_2 y_2 = p[1 + r]^t L_{1,t}/p[1 + r]^t L_{2,t} = L_{1,t}/L_{2,t} = K_0$$

and $$y_1/y_2 = \alpha L_{1,t}/\beta[1 + r]^t L_{2,t} = \alpha K_0/\beta[1 + r]^t$$

where $y_1/y_2 \rightarrow 0$ when $t \rightarrow \infty$, implying that production of sector 1 diminishes inevitably.

The model, hence, proposes that because of (a) lack of possibilities to productivity growth, (b) impossibility of cutting costs without jeopardising artistic quality, and (c) impossibilty of increasing admission revenues due to elastic demand, the performing arts sector faces an increasing gap between its costs and revenues, a so called earnings gap. To maintain sector 1 private donations and public subsidies are required.

APPENDIX 2

data	results
Baumol W. and Bowen W. (1966):	
Years 1771-1776, 1963-1964 Dury Lane Theatre, London, U.K. Royal Shakespeare Theatre, London, U.K	Cost per performance 13.6 fold during the time period, the general price index 6.2 fold.
Years 1843-1964 New York Philharmonic Orchestra, New York, U.S	Annual growth rate of adm. fees 2.5%, the annual growth rate of general price index 1%.
Years 1945 - 23 orchestras, 3 operas, 1 dance group, Broadway theatres, U.S	Growth rate of costs per performance exceed the the general price index.
Years 1945 - Covent Garden, London, U.K. Royal Shakespeare Theatre, London, U.K	Growth rate of costs per performance exceed the general price index.
Throsby C. and Withers G. (1979):	
Years 1964-1978 Various theatres, opera, orchestras, ballet, Australia	Growth rate of costs exceed growth rate of profits and total revenues.
Leroy D. (1980):	
Years 1860-1950, opera, Lille, France Years 1976-1970, opera, Paris, France Years 1871-1965, theatres, Paris Years 1882-1964, Comédie, -Française Years 1860-1965, orchestra, Paris	Growth rate of costs exceed the general price index. Except during periods with high inflation or war: average growth rate of deficits exceed growth rate of price index.
Peacock A., Shoeshmith E. and Millner G. (1983):	
Years 1975-1981, opera, dance, theatre, orchestras, London, U.K.	Growth rate of costs highest in theatres (15.1%), dance (15.25%), opera (13.75%), orchestras (13.5%)
Baumol W. and Baumol H. (1984):	
Years 1974-1983, symphony orchestras, theatres, U.S	Growth rate of costs per performance exceed growth rate of general price index, by 1% in theatres and by 0.9% in orchestras

APPENDIX 3

List of variables: TC = total costs, CC = capital costs, LC = labour costs, PS = public subsidies, VISI = number of visitors, CON = number of concerts, LP = labour input price, CP = capital input price, OR = own revenues, NS = number of seats, FTE = full-time employees, PTE = part-time employees

Table A: Descriptive Statistics, 1978-1995, n = 19 orchestras, in FIM 1994

	TC	CC	LC	PS	VISI	CONC
1978						
Mean	0.71517E+06	0.61704E+06	98128.00	0.62994E+06	28844	63.26
Std.Dev.	0.76151E+06	0.61555E+06	0.16775E+06	0.67324E+06	25048	42.70
1979						
Mean	0.81130E+06	0.71090E+06	0.10040E+06	0.75232E+06	27506	56.84
Std.Dev.	0.87094E+06	0.76099E+06	0.11627E+06	0.78067E+06	25071	35.93
1980						
Mean	0.10414E+07	0.89976E+06	0.14165E+06	0.96671E+06	26492	60.37
Std.Dev.	0.11139E+07	0.94302E+06	0.17434E+06	0.10175E+07	24273	36.21
1981						
Mean	0.13787E+07	0.12164E+07	0.16225E+06	0.12931E+07	26473	57.68
Std.Dev.	0.14656E+07	0.12872E+07	0.18869E+06	0.13469E+07	25700	35.61
1982						
Mean	0.17261E+07	0.15115E+07	0.21460E+06	0.16144E+07	25388	59.00
Std.Dev.	0.17279E+07	0.15358E+07	0.19908E+06	0.16147E+07	22003	34.28
1983						
Mean	0.21731E+07	0.18922E+07	0.28032E+06	0.20554E+07	27599	61.26
Std.Dev.	0.21155E+07	0.18501E+07	0.27635E+06	0.20715E+07	25245	34.20
1984						
Mean	0.27687E+07	0.23861E+07	0.39215E+06	0.25494E+07	27773	62.63
Std.Dev.	0.27175E+07	0.21605E+07	0.60696E+06	0.23620E+07	24141	34.82
1985						
Mean	0.35050E+07	0.29257E+07	0.57936E+06	0.32209E+07	27897	63.79
Std.Dev.	0.33727E+07	0.25131E+07	0.10398E+07	0.30001E+07	23785	30.08
1986						
Mean	0.43040E+07	0.36955E+07	0.60852E+06	0.39399E+07	27515	61.32
Std.Dev.	0.41587E+07	0.36939E+07	0.59574E+06	0.36794E+07	20249	27.47
1987						
Mean	0.48367E+07	0.41825E+07	0.65423E+06	0.44201E+07	28478	63.62
Std.Dev.	0.43095E+07	0.37721E+07	0.65170E+06	0.37476E+07	22270	27.14

1988						
Mean	0.54701E+07	0.46634E+07	0.76464E+06	0.50392E+07	26018	61.42
Std.Dev.	0.48151E+07	0.42233E+07	0.80406E+06	0.43058E+07	19244	27.08
1989						
Mean	0.66152E+07	0.56818E+07	0.93339E+06	0.60392E+07	28014	61.90
Std.Dev.	0.57343E+07	0.49888E+07	0.85716E+06	0.51499E+07	23191	25.48
1990						
Mean	0.78089E+07	0.64546E+07	0.13543E+07	0.71209E+07	29876	70.68
Std.Dev.	0.66759E+07	0.49530E+07	0.19958E+07	0.58159E+07	21220	39.72
1991						
Mean	0.87609E+07	0.74692E+07	0.13006E+07	0.79669E+07	28212	63.63
Std.Dev.	0.75541E+07	0.62992E+07	0.13245E+07	0.67203E+07	22003	25.70
1992						
Mean	0.88244E+07	0.72769E+07	0.15224E+07	0.80145E+07	30571	70.63
Std.Dev.	0.80218E+07	0.60176E+07	0.21293E+07	0.71754E+07	22870	24.03
1993						
Mean	0.90346E+07	0.73451E+07	0.17304E+07	0.81576E+07	28487	67.74
Std.Dev.	0.81413E+07	0.65719E+07	0.19410E+07	0.72286E+07	20199	29.28
1994						
Mean	0.93004E+07	0.74116E+07	0.18888E+07	0.84425E+07	32507	72.53
Std.Dev.	0.85760E+07	0.65162E+07	0.22422E+07	0.78153E+07	26479	26.51
1995						
Mean	0.10042E+08	0.81075E+07	0.19341E+07	0.90745E+07	29890	71.95
Std.Dev.	0.91476E+07	0.70269E+07	0.22423E+07	0.84019E+07	18659	27.90

Descriptive Statistics: year 1978-1995, N = 19 Orchestras, in FIM 1994

	LP	CP	OR	NS	FTE	PTE
1978						
Mean	25554.00	125.35	50615.00	646.68	24.56	5.33
Std.Dev.	6654.30	115.64	80776.00	345.85	26.04	10.61
1979						
Mean	34162.00	151.88	58343.00	646.68	25.22	2.28
Std.Dev.	20770.00	131.51	92119.00	345.85	26.33	4.03
1980						
Mean	60418.00	209.59	67057.00	646.68	28.11	1.78
Std.Dev.	87886.00	195.41	99761.00	345.85	28.47	4.11
1981						
Mean	78183.00	247.67	89105.00	646.68	26.83	3.00
Std.Dev.	0.12036E+06	224.66	0.12580E+06	345.85	26.51	6.50
1982						
Mean	61969.00	334.74	0.12179E+06	646.68	28.34	5.00
Std.Dev.	32682.00	257.41	0.16315E+06	345.85	28.09	9.54

1983						
Mean	73445.00	432.71	0.16835E+06	646.68	29.34	4.42
Std.Dev.	31885.00	355.73	0.23883E+06	345.85	28.16	8.21
1984						
Mean	90273.00	519.19	0.20903E+06	646.68	30.79	4.58
Std.Dev.	46604.00	434.10	0.32461E+06	345.85	28.18	10.24
1985						
Mean	99800.00	687.24	0.23951E+06	646.68	33.45	4.32
Std.Dev.	49803.00	602.91	0.35104E+06	345.85	29.57	7.97
1986						
Mean	0.11249E+06	860.01	0.29915E+06	646.68	35.03	3.95
Std.Dev.	58172.00	566.16	0.44906E+06	345.85	29.44	6.57
1987						
Mean	0.12711E+06	959.12	0.34572E+06	646.86	35.87	2.37
Std.Dev.	64885.00	639.66	0.47417E+06	345.85	29.47	3.67
1988						
Mean	0.12492E+06	1071.50	0.38958E+06	646.68	36.76	2.32
Std.Dev.	45937.00	652.64	0.51085E+06	345.85	29.69	3.03
1989						
Mean	0.16419E+06	1332.00	0.49440E+06	646.68	38.11	1.63
Std.Dev.	86282.00	777.91	0.53532E+06	345.85	29.80	1.61
1990						
Mean	0.19270E+06	1485.00	0.60403E+06	708.37	38.52	1.26
Std.Dev.	0.10898E+06	1103.40	0.78027E+06	436.18	29.92	1.24
1991						
Mean	0.22019E+06	1709.10	0.71383E+06	708.37	38.87	1.11
Std.Dev.	0.14249E+06	1128.90	0.86798E+06	436.18	30.16	1.24
1992						
Mean	0.21678E+06	1652.30	0.83390E+06	708.37	38.03	1.63
Std.Dev.	0.14759E+06	1207.50	0.89203E+06	463.18	28.97	0.94
1993						
Mean	0.20506E+06	2194.60	0.89457E+06	683.05	38.79	1.03
Std.Dev.	0.10627E+06	1431.80	0.94629E+06	448.58	29.81	1.06
1994						
Mean	0.21314E+06	2283.50	0.85057E+06	683.05	38.87	0.87
Std.Dev.	0.13922E+06	1740.90	0.84171E+06	448.58	29.97	0.85
1995						
Mean	0.22570E+06	2357.20	0.91349E+06	682.37	38.59	0.87
Std.Dev.	0.10703E+06	1579.10	0.81717E+06	446.92	30.03	0.78

APPENDIX 4

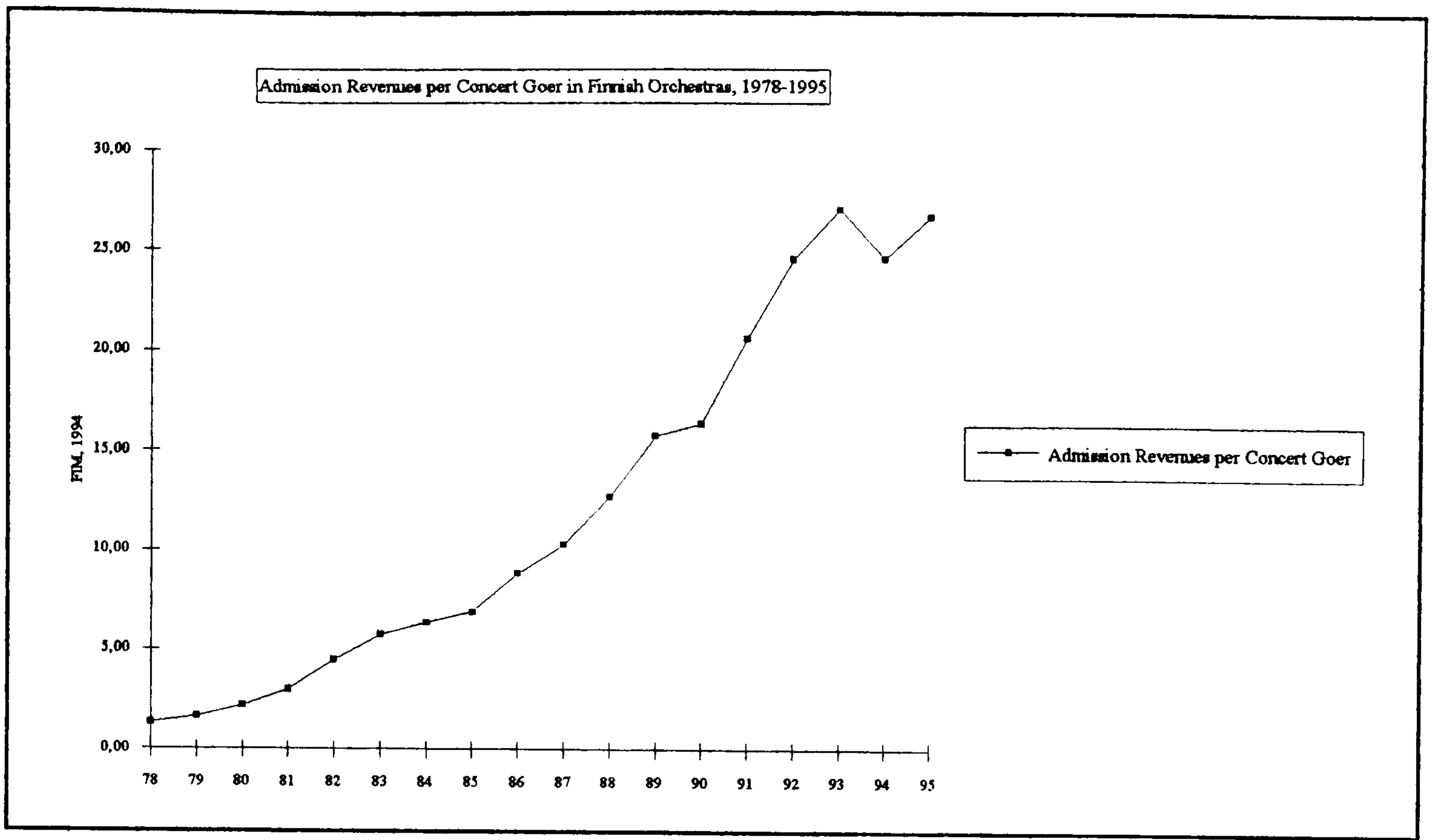

Figure A: Admission fees per concert goer

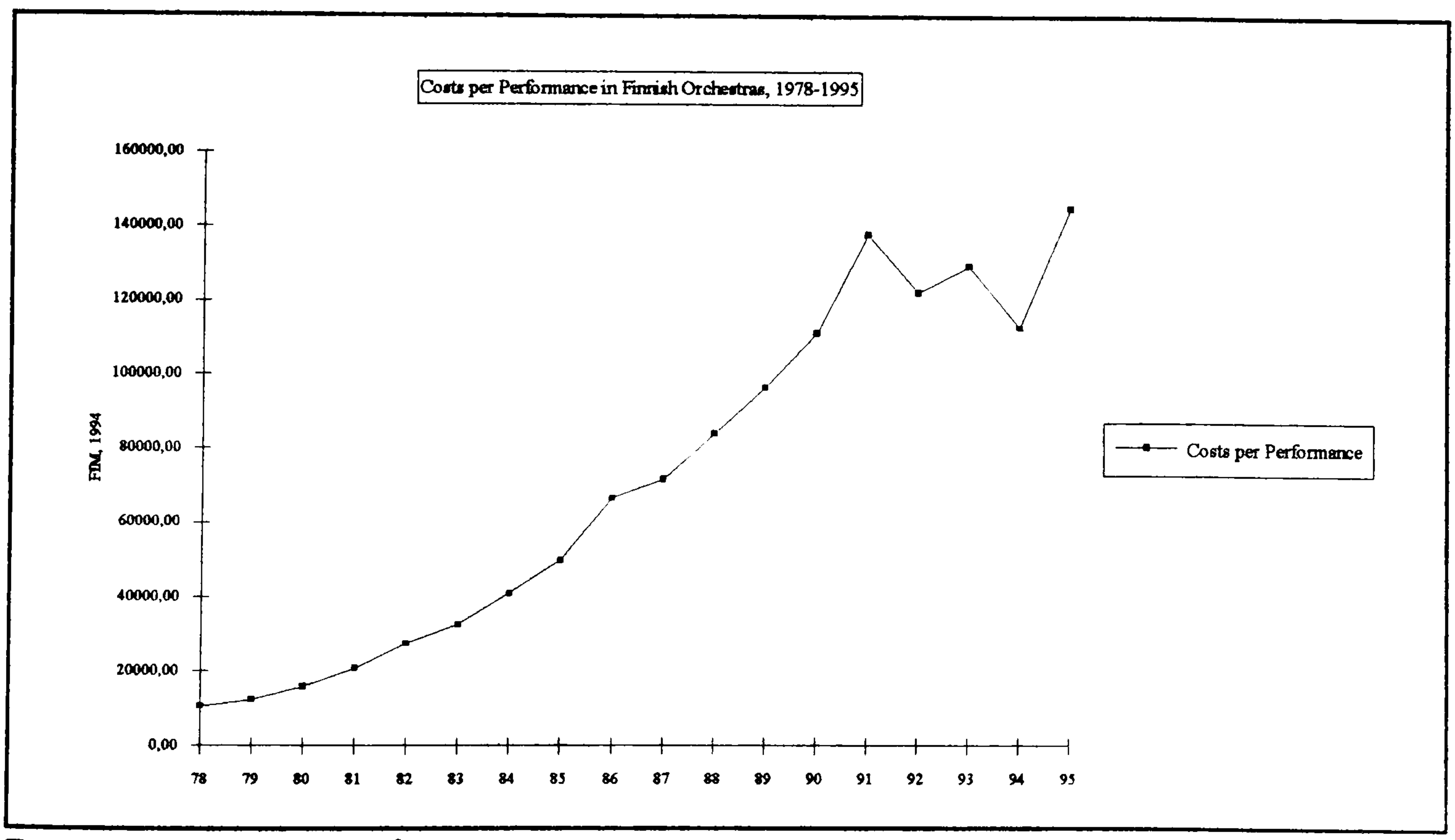

Figure B: Costs per performance

APPENDIX 5

Table A: Estimated cost flexibilities for orchestras

Year	μ(p,y)	Year	μ(p,y)
1978-1979	27.48	1986-1987	24.79
1970-1980	25.86	1987-1988	25.37
1980-1981	26.82	1988-1989	24.64
1981-1982	28.06	1989-1990	22.95
1982-1983	26.63	1990-1991	24.30
1983-1984	26.33	1991-1992	21.85
1984-1985	25.26	1992-1993	23.20
1985-1986	25.61	1993-1994	22.90
		1994-1995	21.99

Table B: Year specific dummies (std.errors in parentheses)

parameter	estimate	parameter	estimate
δ_{1978}	base	δ_{1987}	-113.74 (11.58)
δ_{1979}	-111.60 (11.40)	δ_{1988}	-120.95 (11.59)
δ_{1980}	-111.57 (11.41)	δ_{1989}	-116.03 (11.69)
δ_{1981}	-108.15 (11.41)	δ_{1990}	-112.06 (11.61)
δ_{1982}	-118.57 (11.42)	δ_{1991}	-110.28 (11.64)
δ_{1983}	-118.66 (11.48)	δ_{1992}	-109.24 (11.72)
δ_{1984}	-115.12 (11.46)	δ_{1993}	-115.53 (11.64)
δ_{1985}	-116.80 (11.51)	δ_{1994}	-113.67 (11.67)
δ_{1986}	-116.26 (11.55)	δ_{1995}	-112.02 (11.65)

Table C: Orchestra specific dummies (std. errors in parentheses)

parameter	estimate	parameter	estimate
δ_1	base	δ_{11}	11.39 (11.79)
δ_2	13.91 (11.91)	δ_{12}	-10.17 (12.62)
δ_3	5.43 (11.68)	δ_{13}	-13.22 (12.37)
δ_4	16.33 (11.89)	δ_{14}	59.90 (12.09)
δ_5	4.60 (11.71)	δ_{15}	-11.54 (12.09)
δ_6	-11.43 (11.75)	δ_{16}	-10.25 (12.32)
δ_7	118.58 (11.70)	δ_{17}	2.98 (12.78)
δ_8	-4.13 (12.01)	δ_{18}	-26.28 (13.47)
δ_9	73.19 (11.69)	δ_{19}	64.11 (22.86)
δ_{10}	16.67 (11.72)		

IV Generalised Cost Functions for Producers of Performing Arts
- Allocative Inefficiencies and Scale Economies in Theatres

1 Introduction

In recent years cost functions have been increasingly used to study the structure of production. This has been enabled by the theory of production duality, according to which the structure of production can be examined by using cost functions. Under certain conditions cost functions based on information of input prices and output levels can be used to study the underlying production technology. Hence, cost functions have been widely applied in the analyses of industries where observations of production technology are scarce but observations of economic aspects of production, such as input prices and output, are available.

This lack of information on production technology is particularly true with studies of the production of cultural services, and most of the empirical work done in this field has relied on cost functions: Globerman and Book (1974) estimated cost functions for symphony orchestras and theatre groups, Throsby (1977) for performing arts institutions, Lange et al. (1985) for symphony orchestras and Jackson (1988) for museums. The sole application of a production function has been carried out by Gapinski (1979) who estimated transcendental production functions for performing arts institutions.

The main interest of all previous applications of cost functions for cultural institutions has been in finding evidence on scale economies - Globerman and Book (1974), Throsby (1977), Lange et. al. (1985), and Jackson (1988) all concentrate on this topic. They all discovered different degrees of economic gain from large scale production - the estimates of elasticity of scale ranged from 10 to just over one. These results have important implications both on theoretical modelling and practical management of theatres. In theoretical modelling scale economies indicate monopolistic markets, and in practical management the existence of scale economies suggest possible cost savings from large scale production.

The accuracy of these previous findings is, however, debatable for three main reasons. First, in the treatments by Globerman and Book (1974) and Throsby (1977), the definitions of the cost functions are not based on the theory of production duality, so the estimates of scale elasticities do not necessarily reflect the properties of the underlying production technology. Second, Lange et al. (1985) and Jackson (1988) a priori impose a homothetic underlying production technology with respect to output in their estimations. This assumption is contrary to the widely held view that the production of cultural services exhibits non-homotheticity, i.e. relative shares of input utilisation are likely to vary when output expands. Third, and most importantly, all four studies rely on the assumption that the production of cultural services is technically and allocatively efficient. In short, these studies assume that in the production of cultural services the minimum amount of inputs is used to produce a given output level, and that inputs are combined in optimal proportions in light of prevailing market prices.[1] However, there are grounds to suspect that the production of cultural services is characterised by inefficiencies, and thus, estimations based on the efficiency assumption are likely to result biased estimates.[2]

This article explores the structure of the production of Finnish theatres. It concentrates on three main questions. Along the lines of the previous studies, it first looks at the existence of economic gains from large-scale production. Second, the article examines the underlying production technology to find out whether the relative shares of input utilisation remain constant when the output expands, i.e. is the underlying production technology of theatres homothetic with respect to output. The third question revolves around the efficiency of production. The article tests the allocative efficiency of the production of theatrical performances, and further, it assesses how an omission of allocative inefficiencies affects the results. [3]

This article proceeds in two phases. The analysis begins with a brief presentation of the theoretical basis of cost functions. The main point is that if the hypothesis of allocative efficiency does not hold, then the use of traditional neo-classical cost functions is inappropriate. Thus, a generalised cost function, that retains the desirable properties of the dual neo-classical cost function but allows allocative inefficiencies, is used in the analysis of likely inefficient theatres. The functional form and parameterisation of the generalised cost function rely on the idea that theatres base their production decisions on unobservable shadow prices, rather than market prices of inputs. The formulation is attained, following Atkinson and Halvorsen (1984), by rewriting the translog cost function introduced by Christensen, Jörgensen, and Lau (1973) and by using the notion of shadow input prices.[4] This yields a parameterisation of the generalised cost function in which the existence of allocative inefficiencies, as well as the homotheticity of the underlying production technology, is a testable hypothesis, not an a priori assumption.

The second phase deals with the estimation of the generalised cost function. The estimations employ a panel data set of 37 Finnish theatres from 1985 to 1993 and examine the existence of allocative inefficiencies. This is done by running a test of relative price efficiency, i.e. a test whether the marginal rates of technical substitution equal the corresponding ratios of the market prices of inputs. Then, the assumptions of the homotheticity and homogeneity of the underlying production technology are tested. The estimations are completed by an examination of whether there exist economic gains from large scale production, what kind of average cost curves the estimated model implies, and whether the omission of inefficiencies affect the results.

2 A generalised cost function for theatres

The neo-classical cost function prescribes the minimum cost of producing a given output level.[5] Formally, it is given by,

$$c(p,y) = \min_{x \geq 0}[p \cdot x : x \in V(y)] \tag{1}$$

in which p is a vector of strictly positive input prices, x is a vector of input factors, and V(y) is the input requirement set. As is well known, the first-order conditions for the above cost minimisation problem (1) imply that the marginal rate of technical substitution between the i^{th} and j^{th} inputs equals the ratio of the i^{th} to the j^{th} input price suggesting that there exist no allocative inefficiencies. For the above formulation (1) to incorporate allocative inefficiencies it is assumed that there exists a shadow cost function which depends on the shadow prices of inputs instead of market prices - firms choose inputs in order to minimise the total shadow costs of the chosen level of output. The shadow cost function can be defined as,

$$c^s(q,y) = \min_{x \geq 0}[q \cdot x : x \in V(y)] \tag{2}$$

in which q is a vector of strictly positive shadow input prices defined as $q = v_i p_i$ where v_i is the proportion of which the shadow price of the i^{th} input differs from its (strictly positive) market price p_i. Moreover, x is a vector of input factors and V(y) is the input requirement set.

The shadow cost function (2) can be used, by applying the Shephard's lemma, to derive the actual input demand functions: the vector of derivatives of (2) with respect to the shadow input prices q gives the vector of shadow cost minimising actual input demands, $x(q,y) = \partial c^s(q,y)/\partial q$. These actual input demands $x(q,y)$ can then be used to derive the total actual costs $c^a(q,y)$,

$$c^a(q,y) = \sum_i p_i x_i = \sum_i p_i[\partial c^s(q,y)/\partial q]. \tag{3}$$

In order to rewrite (3) the shadow cost share of the i^{th} input still needs to be defined: the shadow cost share is given by $S_i^s = qx/c^s(q,y)$ which can be written as $x = S_i^s c^s(q,y)/q$. Substituting this to the above formulation (3) yields the actual cost function (4) that retains the desirable properties of the traditional neoclassical cost function - non-negativity, non-decreasingness in q, non-decreasingness in y, positive linear homogeneity in q, concavity and continuity in q, and differentiability - and, thus, is dual to the underlying production technology,

$$c^a(q,y) = c^s(q,y) \sum_i v_i^{-1} S_i^s \tag{4}$$

The estimation of (4) requires a functional form. As noted, the translog (TL) functional form introduced by Christensen, Jörgenson, and Lau (1973) suits for this purpose. Because the basic formulation of the TL cost function does not, however, incorporate the possibility of allocative inefficiencies the neo-classical TL formulation is modified.

Atkinson and Halvorsen (1980; 1984; 1986) suggest that a way to do this is first to define the shadow cost function (2). Thus, the TL shadow cost function - where v_i are the proportions of which the shadow price of the i^{th} input differs form the market price p_i - can be written as,[6]

$$\ln c^s = \alpha_0 + \alpha_y \ln y + \gamma_{yy}(\ln y)^2 + \sum_i \alpha_i \ln (v_i p_i) + \sum_i \sum_j \gamma_{ij} \ln (v_i p_i) \ln (v_j p_j)$$
$$+ \sum_i \gamma_{yi} \ln y \ln (v_i p_i),\ i=1,2 \qquad (5)$$

From this can be derived the shadow cost shares of inputs S_i^s by logarithmic differentiation of (5) with respect to $\ln v_i p_i$:

$$\partial \ln c^s(v_i p_i, y)/\partial \ln v_i p_i = (v_i p_i / c^s(v_i p_i, y))(\partial c^s(v_i p_i, y)/\partial v_i p_i) = v_i p_i x / c^s(v_i p_i, y) = S_i^s.$$

Hence, the shadow cost share of the i^{th}-input can be written in the TL form as,

$$S_i^s = \alpha_i + \gamma_{yi} \ln y + \sum_j \gamma_{ij} \ln (v_j p_j),\ i=1,2 \qquad (6)$$

The shadow cost share (6) and the shadow cost function (5) can then be used to derive the parameterised actual cost function that is based on the shadow prices. Taking logarithms and substituting (6) and (7) to the definition of the actual cost function (4) - $c^a(v_i p_i, y) = c^s(v_i p_i, y) \sum_i v_i^{-1} S_i^s$ - yields,

$$\ln c^a = \alpha_0 + \alpha_y \ln y + \gamma_{yy}(\ln y)^2 + \sum_i \alpha_i \ln(v_i p_i) + \sum_i \sum_j \gamma_{ij} \ln(v_i p_i) \ln(v_j p_j)$$
$$+ \sum_i \gamma_{yi} \ln y \ln(v_i p_i) + \ln[\sum_i v_i^{-1}(\alpha_i + \gamma_{yi} \ln y + \sum_j \gamma_{ij} \ln(v_i p_j))], \quad i=1,2 \quad (7)$$

The actual cost shares, in turn, are defined by $S_i^a = p_i x_i / c^a(v_i p_i, y)$. These actual cost shares can be re-written by using the definition of actual input demands $x_i = S_i^s c^s(v_i p_i, y)/v_i p_i$, derived above, as $S_i^a = p_i(S_i^s c^s(v_i p_i, y)/v_i p_i)/c^a(v_i p_i, y)$. Employing again the shadow cost function (5) and the shadow cost shares (6) yields the parameterisation of the actual costs shares,

$$S_i^a = [\alpha_i + \gamma_{yi} \ln y + \sum_j \gamma_{ij} \ln (v_i p_j)] v_i^{-1} / \sum_i [\alpha_i + \gamma_{yi} \ln y \quad (8)$$
$$+ \sum_j \gamma_{ij} \ln (v_i p_j)] v_i^{-1}, \; i = 1,2$$

Hence, the generalised TL cost function is parameterised as the actual cost function (7) and the two cost share equations (8). For these to be dual to the underlying production technology, the following regularity conditions have to be met,

$$\Sigma_i \alpha_i = 1$$
$$\Sigma_i \gamma_{yi} = 0$$
$$\Sigma_i \gamma_{ij} = \Sigma_j \gamma_{ij} = \Sigma_i \Sigma_j \gamma_{ij} = 0.$$

This yields a system of equations that is flexible enough to test the homotheticity of the underlying production technology, and besides, the parameterisation allows to test whether production is allocatively efficient by analysing the v_i parameter. As is well known, the homotheticity can be tested by examining whether $\gamma_{yi} = 0$ and the homogeneousness by whether $\gamma_{yi} = 0$ and $\gamma_{yy} = 0$. The allocative efficiencies can, in turn, be traced by using the notion of relative price efficiency (RPE).[7] In (7) and (8) the assumption of RPE holds when $v_i \neq 1$ but $v_i = v_j$ implying that the costs are minimised, but not necessarily at the efficient level of production. Whereas if $v_i \neq 1$ but $v_i \neq v_j$, then the assumption of RPE does not hold - the marginal rates of technical substitution differ from the ratios of the market prices of inputs.[8]

The actual cost function (8) can also be used to derive the estimates for the elasticities of substitution between inputs, own price elasticities of inputs, as well as measures for size and scale elasticities. In the TL form, the Allen partial elasticity of substitution is given by;

$$\sigma_{ij} = (\gamma_{ij} + S_i^a S_j^a)/S_i^a S_j^a$$

whereas he own price elasticity can be written as $\eta_i = \sigma_{ii} S_i^a$, in which $\sigma_{ii} = [\gamma_{ij} + S_i^a(S_i^a - 1)]/(S_i^a)^2$. The measure for the elasticity of size can, in turn, be written as;

$$\mu^a(v_i p_i, y) = \alpha_y + \gamma_{yy} \ln y + \sum_i \gamma_{yi} \ln (v_i p_i) + [\sum_i v_i^{-1} \gamma_{yi}]/[\sum_i v_i^{-1} S_i^s]$$

This coincides with the elasticity of scale when the underlying production technology is homothetic with respect to output. Thus, if the production technology is homothetic both the elasticity of size $\in^*(v_i p_i, y)$ and elasticity of scale $\in(v_i p_i, y)$ equal $(\alpha_y + \gamma_{yy} \ln y)^{-1}$ and when the actual cost function is homogeneous $\in^*(v_i p_i, y)$ and $\in(v_i p_i, y)$ equal $(\alpha_y)^{-1}$.

3 Data set and measures for input prices and output

A panel data set of 37 theatres is employed in the estimations. This data of nine cross-sections, from 1985 to 1993, was collected by the Association for Finnish Theatres, and it comprises institutions that have full time personnel and stage performances on a regular basis. (See Appendix 1)

Table 1: Descriptive Statistics of the data set, 1985-1993, n = 37 theatres, in FIM

Variable	mean	variance
TC	0.12977E+08	0.15342E+15
LC	0.88546E+07	0.65554E+14
CC	0.33835E+07	0.16544E+14
LP	0.13949E+06	0.23299E+10
CP	5531.80	29285.00
VISI	59947.00	0.36366E+10
PERFO	226.57	24137.00
FULL	67.41	140.56

List of variables: TC = total costs, LC = labour costs, CC = capital costs, LP = labour input price, CP capital input price, VISI = number of visitors, PERFO = number of performances, FULL = seats taken (%)

The statistics on wages, man-hours, number of full-time and part-time employees, real estate costs, depreciation, number of seats, as well as the number of visitors, are used to construct the measures for input prices and output. As to the measures for input prices, it is assumed that theatres use labour and capital inputs in their production.[9] The unit price of labour input LP (price of one man-year) is defined as,

$$LP = LC / (FTE + PTE)$$

in which the total personnel costs LC are divided by the man-years of full-time employees FTE plus the man-years of part-time employees PTE.[10] The unit price of capital input CP - "price of one seat" - is, in turn, defined as,

$$CP = (RC + OC - D)/NS$$

in which RC denotes real estate costs, OC stands for other costs, D represents depreciation, and NS is the number of seats. The statistics on the real estate costs RC include costs that can be allocated to the running of the estate. The costs being caused by investments or acquiring capital (interest) are included in the other costs OC that also contain the costs of staging and purchases of equipment (stage, lighting, and sound equipment; musical instruments; scores; and scripts). The use of the number of seats NS as the divisor yields a unit price of capital CP that directly relates to the measure for output (number of visitors), as well as the capacity of each theatre.

The output is measured by the number of visitors. The reason for this is that artistic experiences provided to theatre goers, rather than the number of reruns, reflect the output of theatres.[11] Furthermore, the use of the number of visitors seems reasonable in the light that none of the 37 theatres works on full capacity, and that there is always the possibility of making an unrestricted number of reruns of any play if there is demand. (See Appendix 2)

4 Estimation of the generalised cost function

The parameter estimates for the actual TL cost function are derived from the non-linear cost function (7) and the cost share equations (8), to which are added the conventional disturbance terms (ε_c and ε_i), as well as a dummy structure,

$$\ln C^a = \alpha_0 + \alpha_y \ln y + \gamma_{yy}(\ln y)^2 + \sum_i \alpha_i \ln (v_i p_i) + \sum_i \sum_j \gamma_{ij} \ln (v_i p_i) \ln (v_j p_j)$$

$$+ \sum_i \gamma_{yi} \ln y \ln (v_i p_i) + \ln[\sum_i v_i^{-1}(\alpha_i + \gamma_{yi} \ln y + \sum_j \gamma_{ij} \ln (v_i p_j))]$$

$$+ \delta_f + \delta_t + \varepsilon_c \ , i = 1, k \qquad (9)$$

$$S_i^a = [\alpha_i + \gamma_{yi} \ln y + \sum_j \gamma_{ij} \ln (v_i p_j)] v_i^{-1} / \sum_i [\alpha_i + \gamma_{yi} \ln y + \sum_j \gamma_{ij} \ln (v_i p_j)] \, v_i^{-1}$$

$$+ \varepsilon_i, \ i = 1, k$$

In this α_0 is the intercept; α_l is the cost share of labour when the output does not change; α_k is the cost share of capital; α_y represents "the cost flexibility"; γ_{ll}, γ_{kk} and γ_{kl} are the share elasticities; γ_{yl} and γ_{yk} stand for the biases of scale, and γ_{yy} is the derivative of elasticity of cost with respect to output γ_{yy}. The dummy variable δ_f picks the theatre specific costs that are not included in the explanatory variables, while δ_t is a dummy variable for the time effects.

The v_i parameter, as already noted, captures whether the shadow prices of inputs differ from the market prices. To facilitate the estimations, v_i is assumed to be input specific but identical across theatres.[12] Moreover, the generalised cost function (9) is assumed to be homogeneous of degree zero with respect to v_i, i.e. a change in v_i's does not have an effect on the total actual costs.[13] This restrictive assumption is made to enable an estimation of (9) without considering the possible technical inefficiencies that become apparent when v_i has a direct effect on the total costs. It should be noted, that this assumption does not in any way affect the analysis of allocative inefficiencies, but the assumption precludes the testing of technical efficiencies.[14]

The estimation proceeds in two stages. A linear approximation of the system is first estimated, and then the parameter estimates from that are used as the starting values for the non-linear system. The linear system, that is estimated by using a modification of Zellner's (1962) SUR procedure, is a version of (9) with the assumption that v_i equals one. The non-linear TL cost function is then estimated by using the parameter estimates from the linear approximation as the starting values. The procedure applied by Atkinson and Halvorsen (1984) is followed, and thus, the non-linear SUR system (9) is estimated by the iterative maximum likelihood procedure. This estimation incorporates a system of three equations, namely the actual cost function and the cost share equations for labour and capital, of which the share equation for capital is again deleted, and the remaining parameters derived from the regularity conditions.[15]

The use of the non-linear SUR proves to be appropriate: a test for contemporaneous correlation suggests that the null hypothesis of contemporaneous covariances being zero can be rejected at 0.05 level ($\chi^2(2) = 151.65$; critical value $\chi^2(2) = 5.99$). This suggests that there is indeed a need for SUR, because the least squares applied separately to each equation would not be fully efficient.

The parameter estimates in Table 2 are all statistically significant, and of the right sign. They demonstrate that the estimated actual cost function (9) fulfills the regularity conditions: $\alpha_k + \alpha_l = 1$, $\gamma_{yk} + \gamma_{yl} = 0$, as well as $\gamma_{kl} + \gamma_{kk} + \gamma_{ll} = 0$. Furthermore, it appears that the structure of the model, rather than the dummy structure, contributes to the explanatory power of the model. This is supported by the rejection of the hypothesis that all parameter estimates except δ_t and δ_f equal zero at 0.05 level. ($\chi^2(8) = 135860.95$; critical value $\chi^2(8) = 15.5$).

Table 2: Parameter Estimates (t-values in parentheses)

parameter	estimate	parameter	estimate
α_0	1.32 (9.94)	α_k	0.11 (2.86)
α_y	1.57 (24.03)	γ_{kk}	0.05 (11.82)
γ_{yy}	-0.07 (-15.87)	γ_{yk}	0.01 (2.67)
α_l	0.89 (22.23)	γ_{kl}	-0.03 (-6.18)
γ_{ll}	-0.02 (-5.14)	v_k	0.61 (14.85)
γ_{yl}	-0.01 (-2.67)	v_l	1.00[(a]

[a] Normalised to equal 1.0

The estimates of the year and theatre specific dummies, in Table 3 and Table 4, are almost all statistically significant - only one of the year dummies and four of the theatre specific dummies are not significant.

Table 3: Estimates of the year dummies δ_t (t-values in parentheses)

parameter	estimate	parameter	estimate
δ_{1985}	the base	δ_{1990}	0.21 (5.04)
δ_{1986}	0.07 (1.96)	δ_{1991}	0.23 (5.62)
δ_{1987}	0.03 (0.86)	δ_{1992}	0.24 (5.03)
δ_{1988}	0.10 (2.75)	δ_{1993}	0.22 (5.01)
δ_{1989}	0.16 (3.62)		

It appears, that neither the time specific nor theatre specific dummies could be excluded from the model - the hypothesis that the time specific dummies equal zero is rejected at the 0.05 level ($\chi^2(8) = 94.72$; critical value $\chi^2(8) = 15.51$), as is the hypothesis that the theatre dummies equal zero ($\chi^2(35) = 2151.32$; critical value $\chi^2(35) = 55.76$). The fact that all year specific dummies are positive, suggests that costs have risen since the base year 1985.

Table 4: Estimates of the theatre specific dummies δ_f (t-values in parentheses)

parameter	estimate	parameter	estimate	parameter	estimate
δ_1	-1.53 (-11.06)	δ_{13}	-0.29 (-0.77)	δ_{25}	-0.93 (-9.50)
δ_2	-0.03 (-0.29)	δ_{14}	-1.21 (-2.15)	δ_{26}	-0.77 (-1.39)
δ_3	-1.76 (-2.60)	δ_{15}	-1.82 (-6.00)	δ_{27}	-0.26 (-1.21)
δ_4	-1.83 (-4.64)	δ_{16}	-1.63 (-2.86)	δ_{28}	-2.77 (-11.46)
δ_5	-1.35 (-1.90)	δ_{17}	-0.88 (-2.01)	δ_{29}	-3.49 (-18.87)
δ_6	-0.86 (-2.23)	δ_{18}	-1.37 (-3.18)	δ_{30}	-1.97 (-4.67)
δ_7	-1.51 (-4.10)	δ_{19}	-2.31 (-5.09)	δ_{31}	-1.54 (-9.87)
δ_8	-1.42 (-1.94)	δ_{20}	-2.44 (-13.87)	δ_{32}	-0.75 (-6.57)
δ_9	-1.95 (-7.72)	δ_{21}	-1.30 (-1.79)	δ_{33}	-1.54 (-3.05)
δ_{10}	-1.39 (-1.74)	δ_{22}	-2.16 (-4.12)	δ_{34}	-1.98 (-17.51)
δ_{11}	-1.52 (-2.04)	δ_{23}	-2.05 (-3.80)	δ_{35}	-1.69 (-6.15)
δ_{12}	-0.85 (-2.13)	δ_{24}	-1.42 (-3.09)	δ_{36}	-1.57 (-3.92)
				δ_{37}	the base[(a]

[a] The National Theatre

All of the theatre specific effects in Table 4 are of the same sign, the minimum value is -0.03 and the maximum is -3.49. This indicates that in the National theatre (the base theatre) production is, all things equal, the most expensive. Because the theatre dummies capture time invariant firm specific variation the relatively high costs in the National theatre could possibly be interpretated to originate from goodness of management, type of repertoire, quality of productions, or location. [16]

4.1 Parametric test of allocative inefficiency and its magnitude

The parametric test of allocative inefficiency is based on the concept of relative price efficiency (RPE), and the testing involves v_i's that are input specific but identical across firms. This implies, that in order to test the allocative inefficiency v_l has to be normalised. Because v_l is normalised to one ($v_l = 1$), also v_k should equal one, for the RPE to hold and no allocative inefficiencies to exist.[17] This seems, however, not to be the case: the estimate of v_k is 0.61, and the hypothesis that $v_k = 1$ is rejected at the 0.05 level ($\chi^2(1) = 91.37$; critical value $\chi^2(1) = 3.84$). Thus, the assumption that the RPE does not hold, and that there are allocative inefficiencies in production.

Even if the actual cost function (9) is assumed to be homogeneous of degree zero in v_k, in section 3, it can be used to derive estimates of the allocative inefficiencies' effect on total costs. As proposed by Eakin (1993), the extent of the allocative inefficiency can be assessed by using the measure of allocative inefficiency $AI = (C^{obs} - C^{min})/C^{min})$, in which the idea is to compare the fitted actual total costs (v_l = 1, v_k = 0.61) and the fitted total costs when the RPE holds ($v_l = v_k = 1$). This means, that to circumvent the restrictive assumption of the homogeneity of degree zero in v_k two separate models have to be estimated - one efficient and the other inefficient - and the predictions of these two models then compared.[18] The resulting AI, which indicate the effects of allocative inefficiency on total costs, suggests that the actual costs exceed the minimum cost by on average 4.94 per cent. The minimum value for the AI is 0.06 per cent, whereas the maximum is 5.31 per cent, indicating that all theatres in the sample suffer from some degree of allocative inefficiency.

The deviation from the RPE can be further illustrated with the following figure,

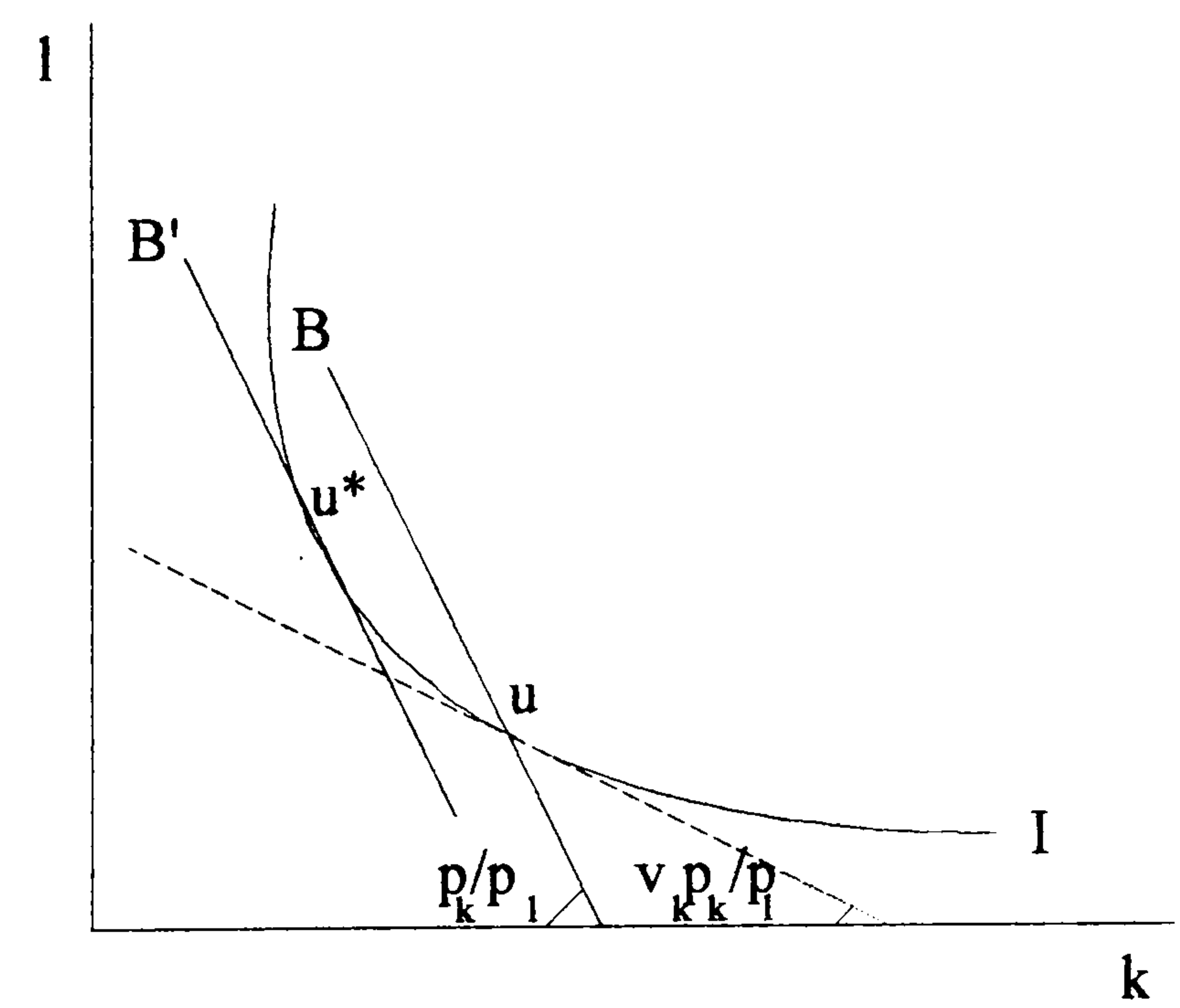

Figure 1: Deviation from the RPE

in which the axes l and k stand for labour and capital inputs, and the isoquant I corresponds with the observed output level y and, thus, the observed input bundle V(y) is on the isoquant. A theatre facing the input price ratio p_k/p_l is located at u. The point u is allocatively inefficient in light of prevailing market prices, but efficient in light of shadow prices of inputs. In other words, with the input price ratio p_k/p_l the efficient point would be u* in which the isocost line's B' slope p_k/p_l tangents the isoquant, while with the shadow input price ratio the efficient point is at u where the isocost line's slope $v_k p_k/p_l$ tangents I. Since v_k/v_l is less than one ($v_k/v_l = 0.61$), the shadow input price ratio is less than the observed input price ratio, and the capital-labour ratio is larger at u, than at the cost efficient point u*.

The effect of allocative inefficiency on input demands can also be estimated by using the same method. Atkinson and Halvorsen (1984) have shown that this can be done by "comparing the fitted quantities with the quantities that would have been demanded if relative price efficiency had been attained." The comparison proceeds in four stages. First, the actual cost share equation $S_i^a = v_i p_i x_i / C^a(v_i p_i, y)$ is solved for x_i, which yields $x_i = S_i^a C^a(v_i p_i, y)/(v_i p_i)$. Second, the fitted values of input demands (input demands when there are allocative inefficiencies) are derived by using the fitted actual cost shares S_i^a and the actual costs C^a when $v_l = 1$, $v_k = 0.61$, and third, the efficient input demands (input demands implied by the efficient TL cost function with no allocative inefficiencies, $v_l = v_k = 1$) are derived.[19] Lastly, the two calculated fitted values are compared.

The comparison of the two fitted values in the case of Finnish theatres suggests that at the mean of the data the estimated effect of allocative inefficiency on input demands is to decrease the demand of capital by 5.93 per cent and to decrease the demand of labour by 5.32 per cent on average. Furthermore, for the former the minimum is 4.59 and the maximum is 14.21 per cent, whereas for the latter the minimum is 1.22 and the maximum is 6.48 per cent.

As to the demands of the inputs in the case when the RPE does not hold ($v_l = 1$, $v_k = 0.61$), the own price elasticities of the inputs reveal that the demand of the capital input is more elastic with respect to its own price than the labour input. The own price elasticities of capital $\eta_{kk} = -0.52$ (s.e 0.08) and of labour $\eta_{ll} = -0.26$ (s.e. 0.04) imply that an increase in the price of capital diminishes its demand more rapidly than a change in the price of labour input. The estimates of Allen partial elasticities of substitution further suggest that capital and labour are Allen substitutes: at the mean values the Allen elasticity σ_{kl} is 0.82 (s.e 0.47), indicating that an increase in the price of labour leads to an increase in the utilisation of capital, and vice versa.

4.2 Homotheticity of production technology and elasticities of size and scale

The underlying production technology proves not to be homothetic with respect to output - the hypothesis that biases of scale equal zero ($\gamma_{yl} = \gamma_{yk} = 0$) is rejected at the 0.05 level

($\chi^2(2)$ = 7.13; critical value $\chi^2(2)$ = 5.99). This result, first, suggests that the relative shares of input utilisation vary when output expands, which is an expected result in the production of cultural services where capital cannot necessarily substitute for labour in equal proportions. The fact that there exist no unitary elasticities of substitution between inputs can be further verified by noting that the hypothesis of unitary elasticities of substitution (γ_{kl} = 0) is rejected at 0.05 level ($\chi^2(1)$ = 38.19; critical value $\chi^2(1)$ = 3.84).

The non-homotheticity of the underlying production technology further implies that the underlying production technology is non-homogeneous with respect to output. The reason for this is, as is well known, that the homotheticity is a prerequisite for homogeneity. This result can be demonstrated by the fact that the hypothesis of homogeneity ($\gamma_{yl} = \gamma_{yk} = \gamma_{yy} = 0$) is rejected at the 0.05 level ($\chi^2(3)$ = 404.56; critical value $\chi^2(3)$ = 7.81), which means that output does not expand at the same rate along the scale line when the utilisation of inputs expands. The fact that the term capturing the non-homogeneity (γ_{yy}= -0.067, in Table 2) is negative suggests that there are increasing cost savings when output expands.

The third implication of the non-homotheticity of the underlying production technology is that the measure of elasticity of size (reciprocal of size elasticity) does not coincide with the measure of elasticity of scale. The estimated cost flexibility, with each input price and output combination, is on average 0.82 implying economies of size of 1.22. Figure 2 shows the elasticities of size with the input prices set to their mean values and suggests that the elasticities of size increase as the number of theatre goers increases (the curve denoted by +). As noted, this increase is mainly attributable to the negative γ_{yy}ln y term. The estimates of the allocatively inefficient model differ form the allocatively efficient model: in the generalised cost function with $v_l = v_k = 1$ the estimated average cost flexibility is 0.75 implying an elasticity of size of 1.34 and increasing economies of size (the curve denoted by ◇ in Figure 2). Thus, omission of the allocative inefficiencies from the estimations results in an underestimation of the cost flexibilities, and an overestimation of the returns to size.

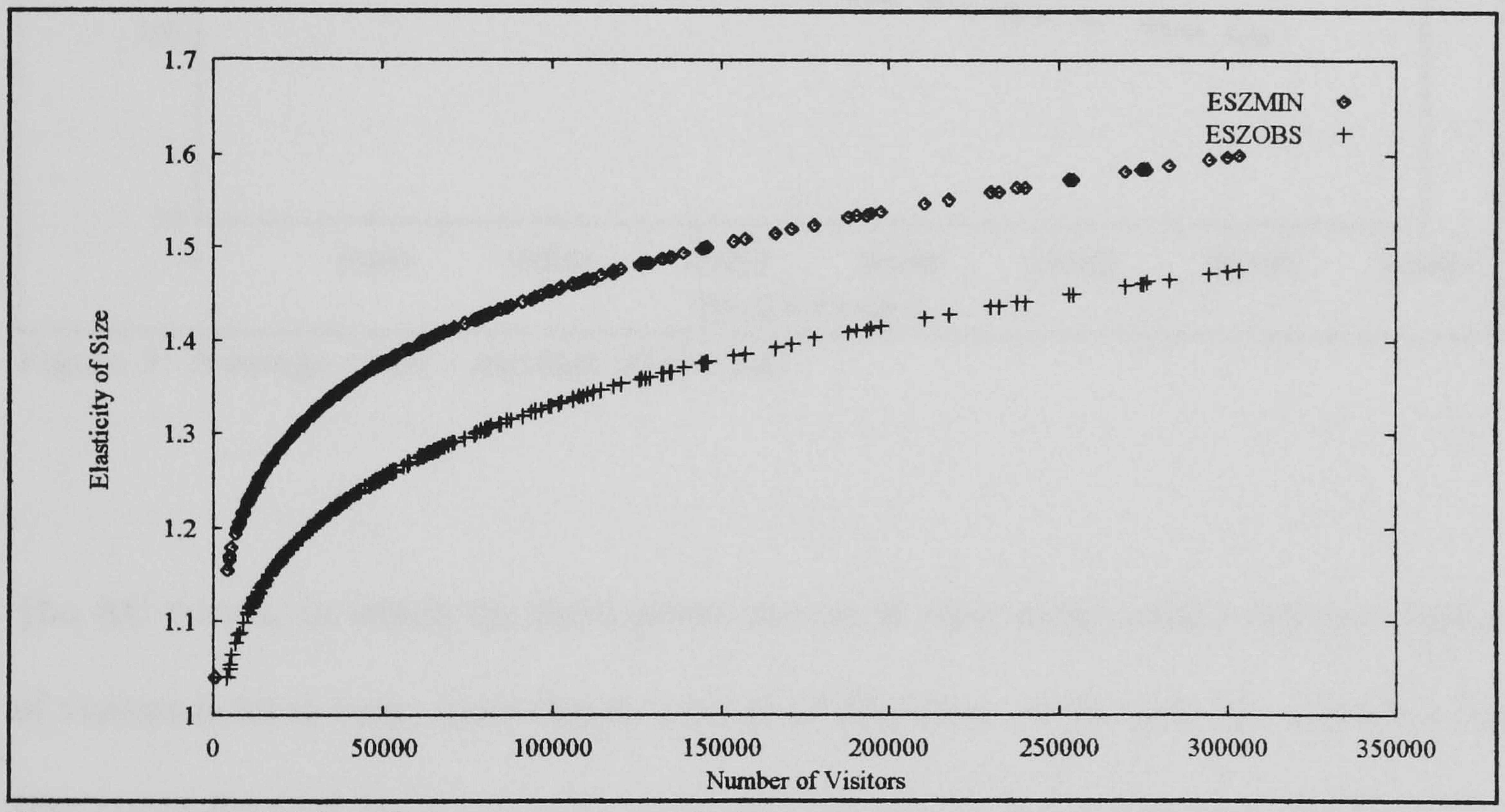

Figure 2: Elasticitiy of size - number of visitors

The difference between the estimates derived from the cost function under the assumption of allocative efficiency and the cost function with the assumption that RPE does not hold can also be seen from the average cost (AC) curves predicted by the two cost functions. (See Figure 3)

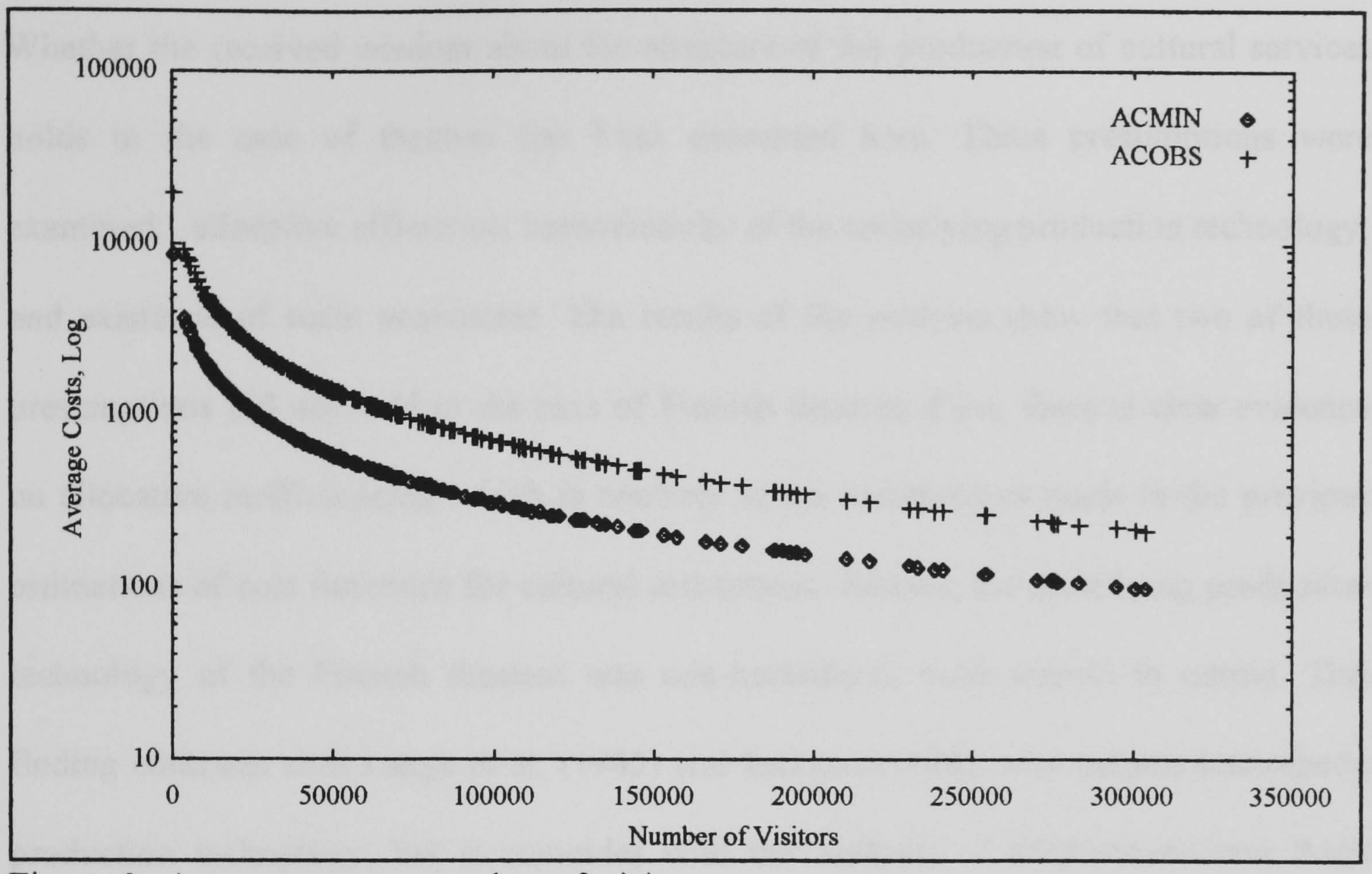

Figure 3: Average costs - number of visitors

The AC curves, in which the input prices are set to their mean values and the number of visitors is let to vary, show that as a result of allocative inefficiency the average costs (the curve denoted by + ; $v_l = 1$, $v_k = 0.61$) are above the minimum cost (the curve denoted by ◇; $v_l = v_k = 1$) in order to produce the same amount. As such, the true predicted average costs (the curve denoted by +) demonstrate that an increase in the audience size results substantial cost savings: the average cost of a visitor at a relatively low level of production is higher than at a relatively high level of attendance.

5 Conclusion

Whether the received wisdom about the structure of the production of cultural services holds in the case of theatres has been examined here. Three presumptions were examined: allocative efficiency, homotheticity of the underlying production technology, and existence of scale economies. The results of the analysis show that two of these presumptions did not hold in the case of Finnish theatres. First, there is clear evidence on allocative inefficiencies, which is contrary to the assumptions made in the previous estimations of cost functions for cultural institutions. Second, the underlying production technology of the Finnish theatres was non-homothetic with respect to output. This finding contrasts with Lange et al. (1985) and Jackson (1988), who assume homothetic production technology, but it coincides with the analyses of Globermann and Book (1974) and Throsby (1977), who both take non-homogeneity into account.[20] Third, production in Finnish theatres is characterised by size economies. This finding is in accordance with previous studies that find evidence of scale economies in performing arts institutions.

The measure of allocative inefficiency finds that on average the actual total costs of theatres exceed the minimum costs by some 4.9 per cent. The capital input appears to be relatively more over-employed than the labour input. Theatres exhibit a 5.9 percent excess demand of capital, and 5.3 percent excess utilisation of labour. By and large these results suggest that theatres do not combine inputs in economically optimal proportions in light of prevailing market prices. There are some plausible explanations for this. The non-optimal usage of inputs may originate from the managers' desire for large audiences, high quality of production, or large budgets. Alternatively, the non-cost minimising behaviour may derive from the strings that are attached to public subsidies, such as quality requirements. This indicates that future empirical analyses should take into account the possibility of allocative inefficiencies. Besides this, 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.

The second main finding indicates biases of scale: when output expands, the relative utilisation of capital input increases. This observation points out that when the number of theatre goers increase, theatres tend to respond by increasing the size of auditorium, rather than by arranging labour intensive reruns. It appears, that the possible cause for the non-homotheticity and the bias for capital input is that in order to increase attendance a theatre has to "grab" a larger amount of initial peak demand, which implies investments on larger auditoriums. Moreover, demand for capital was shown to be more responsive to a change in its price, than the labour input. This relative inelasticity of the demand of labour input reflects the difficulty for performing arts institutions to cut down on personnel, and it verifies Granfield's (1971) [quoted in Gapinski (1979, pp. 2)] argument that, "La Mancha would definitely suffer if Sancho were replaced by additional swords for Quixote." In sum, the assumptions about the homotheticity and homogeneity of the underlying production technology should be tested, rather than posed a priori.

The third main finding indicates the existence of size economies. For the Finnish theatres the estimated size elasticity was on average 1.22. The likely reason for the size economies is, as suggested already by Baumol and Bowen (1966), the relatively high costs of staging and rehearsing a play compared to the relatively low costs of keeping the play in a repertoire. The importance of the relatively high fixed costs of production was vindicated by the fact that the predicted average cost curve was downward sloping, and revealed substantial cost savings from increased attendance. Because the Finnish theatres employed on average only 67 per cent of their capacity they could still gain substantially from larger audiences.

Endnotes

1. Also Paulus (1993) assumes efficient production in estimations of single output cost functions for museums.
2. Atkinson and Halvorsen (1984) have made this point in relation to regulated industries.
3. The focus of this paper is on allocative inefficiencies, not on technical inefficiencies. The main reason for this is that the joint estimation of allocative and technical inefficiencies is problematic in the shadow cost function framework applied in this paper. See Greene (1993) for a detailed discussion. One should, however, note that neglecting technical inefficiency in a cost function does not affect consistence property of the parameter estimates, except the intercept. See Kumbhakar (1991a) for discussion.
4. See Cowing (1981), Nelson and Wohar (1983), Pescatrice and Trapani (1980), and Spann (1974), Hollas and Stansell (1988), Eakin and Kiesner (1988), and Sickles et al. (1986) for alternative applications of shadow cost functions.
5. The definition of the neo-classical cost function is here based on Chambers (1989).
6. Lau and Yotopoulos (1971) have proposed, in an other context, that the shadow prices can be assumed to differ from the market prices of inputs by a fixed proportion v_i. Thus, the shadow prices can be approximated by $q = v_i p_i$.
7. See Atkinson and Halvorsen (1980) for a more detailed discussion of relative price efficiency.
8. One should note that in this parameterisation, the actual cost function (8) equals the neo-classical cost function if the shadow prices of inputs equal market prices, which implies that $v_i = v_j = 1$. In this case, there exist neither technical nor allocative inefficiencies - the value of the marginal product for each input is equal to the market price, and thus, production is efficient.
9. Throsby (1977) used no measure for input prices, Lange et. al. (1985) and Jackson (1989) measured the price of labour input as the wage rate and the price of capital as the ratio of promotional expenditure to contributions from all sources.
10. One should notice that the practice of calculating man-years changed slightly in 1989: till 1989 man-years are calculated on a yearly basis, not separately in each month, whereas since 1989 they are calculated separately in each month and, thus, unpaid leave as well as unfilled vacancies are deducted from the yearly man-hours. As a result of this both the man-years of full-time and part-time employees may be slightly over-estimated till 1989, and hence, the labour input price p_l may be slightly under-estimated. Moreover, the labour input price p_l does not comprehend those employees who take care of the real estates, neither is voluntary work included.
11. Throsby (1977) measured the output by number of visitors, whereas Globerman and Book (1974) and Lange et al. (1985) used number of performances.
12. Atkinson and Halvorsen (1984) made this assumption in order to avoid an identification problem. See Lau and Yotopoulos (1971) and Färe and Grosskopf (1990) for alternative ways to solve the problem.
13. Kumbhakar (1991a) has argued that if the assumption does not hold - (10) is not homogeneous of degree zero in v_i - then the only parameter which consistency is in

jeopardy is the intercept α_0.
14. Actually the technical inefficiencies could be captured by using a deterministic frontier approach pioneered by Aigner and Chu (1968). This is not, however, done because of the fundamental problems of the deterministic frontiers. See Greene (1993) for a detailed discussion.
15. As is well known the estimates are invariant to the choice of equation to be deleted.
16. The previous estimations of cost functions for cultural institutions have tried to capture the quality of production in their estimations: Globerman and Book (1974) captured quality of production by attendance per tour performances, Throsby (1977) by grants per box office revenues, whereas Jackson (1988) used a dummy variable based on the accreditation of American Association of Museums (AMM) to measure the quality (or lack of it).
17. As is well known the estimated relative values of the v_i as well as the rest of the parameters are invariant whichever of the v's is normalised and with whichever value.
18. In both models the fitted values are calculated by setting the input prices to their mean values.
19. The input prices of capital and labour are set to their mean values.
20. Globermann and Book (1974) and Throsby (1977) use in their estimations functional forms that include second and third powers of output.

APPENDIX 1

Table A: Descriptive Statistics of the data set, 1985-1993, n = 37 theatres, in FIM
$\bar{x}$ = mean, σ^2 = variance

	1985-1993	1985	1986	1987
Total costs				
$\bar{x}$	0.12977E+08	0.96685E+07	0.10600E+08	0.11291E+08
σ^2	0.15342E+15	0.84692E+14	0.98629E+14	0.11729E+15
Labour costs				
$\bar{x}$	0.88546E+07	0.65905E+07	0.73572E+07	0.77373E+07
σ^2	0.65554E+14	0.33995E+14	0.41360E+14	0.48673E+14
Capital costs				
$\bar{x}$	0.33835E+07	0.16581E+07	0.18669E+07	0.30303E+07
σ^2	0.16544E+14	0.51231E+13	0.81318E+13	0.13529E+14
Performances				
$\bar{x}$	226.57	261.34	277.54	270.03
σ^2	24137.00	24908.00	24699.00	24455.00
Visitors				
$\bar{x}$	59947.00	66180.00	67464.00	65225.00
σ^2	0.36366E+10	0.47695E+10	0.43452E+10	0.47313E+10
Seats Taken (%)				
$\bar{x}$	67.41	71.35	68.99	67.50
σ^2	140.56	127.94	154.84	127.38
Labour Input Price				
$\bar{x}$	0.13949E+06	0.10739E+06	0.12052E+06	0.12253E+06
σ^2	0.23299E+10	0.33936E+09	0.69155E+09	0.74619E+09
Capital Input Price				
$\bar{x}$	5531.80	2745.0	2775.80	4896.70
σ^2	29285.00	0.33548E+07	0.65194E+07	0.61052E+07

	1988	1989	1990	1991
Total Cost				
$\bar{x}$	0.12660E+08	0.13105E+08	0.14534E+08	0.15046E+08
σ^2	0.14586E+15	0.15650E+15	0.20246E+15	0.20218E+15
Labour Cost				
$\bar{x}$	0.85863E+07	0.89988E+07	0.99204E+07	0.10501E+08
σ^2	0.58799E+14	0.65129E+14	0.85175E+14	0.95629E+14
Capital Cost				
$\bar{x}$	0.36083E+07	0.36011E+07	0.41242E+07	0.38354E+07
σ^2	0.19410E+14	0.18491E+14	0.24180E+14	0.16975E+14
Performances				
$\bar{x}$	285.81	262.35	260.65	262.32
σ^2	31317.00	26380.00	25744.00	22110.00
Visitors				
$\bar{x}$	64756.00	57585.00	56729.00	56730.00
σ^2	0.42733E+10	0.36512E+10	0.33938E+10	0.31498E+10
Seats Taken (%)				
$\bar{x}$	68.64	65.80	66.10	67.69
σ^2	122.51	212.41	159.70	121.44
Labour Input Price				
$\bar{x}$	0.13704E+06	0.15024E+06	0.13358E+06	0.14725E+06
σ^2	0.57820E+09	0.31358E+10	0.39949E+09	0.29018E+09
Capital Input Price				
$\bar{x}$	5888.60	5850.40	6896.00	6504.20
σ^2	0.12760E+08	0.95835E+07	0.13150E+08	0.10622E+08

	1992	1993
Total Cost		
$\bar{x}$	0.14650E+08	0.14876E+08
σ^2	0.18584E+15	0.18078E+15
Labour Cost		
$\bar{x}$	0.10094E+08	0.99653E+07
σ^2	0.84159E+14	0.73170E+14
Capital Cost		
$\bar{x}$	0.37439E+07	0.48047E+07
σ^2	0.16852E+14	0.20435E+14
Performances		
$\bar{x}$	261.11	258.86
σ^2	21788.00	20792.00
Visitors		
$\bar{x}$	54117.00	51757.00
σ^2	0.28257E+10	0.22738E+10
Seats Taken (%)		
$\bar{x}$	66.11	64.82
σ^2	110.01	127.10
Labour Input Price		
$\bar{x}$	0.18275E+06	0.15086E+06
σ^2	0.12530E+11	0.38326E+09
Capital Input Price		
$\bar{x}$	6185.30	7992.50
σ^2	0.95566E+07	0.12141E+08

APPENDIX 2

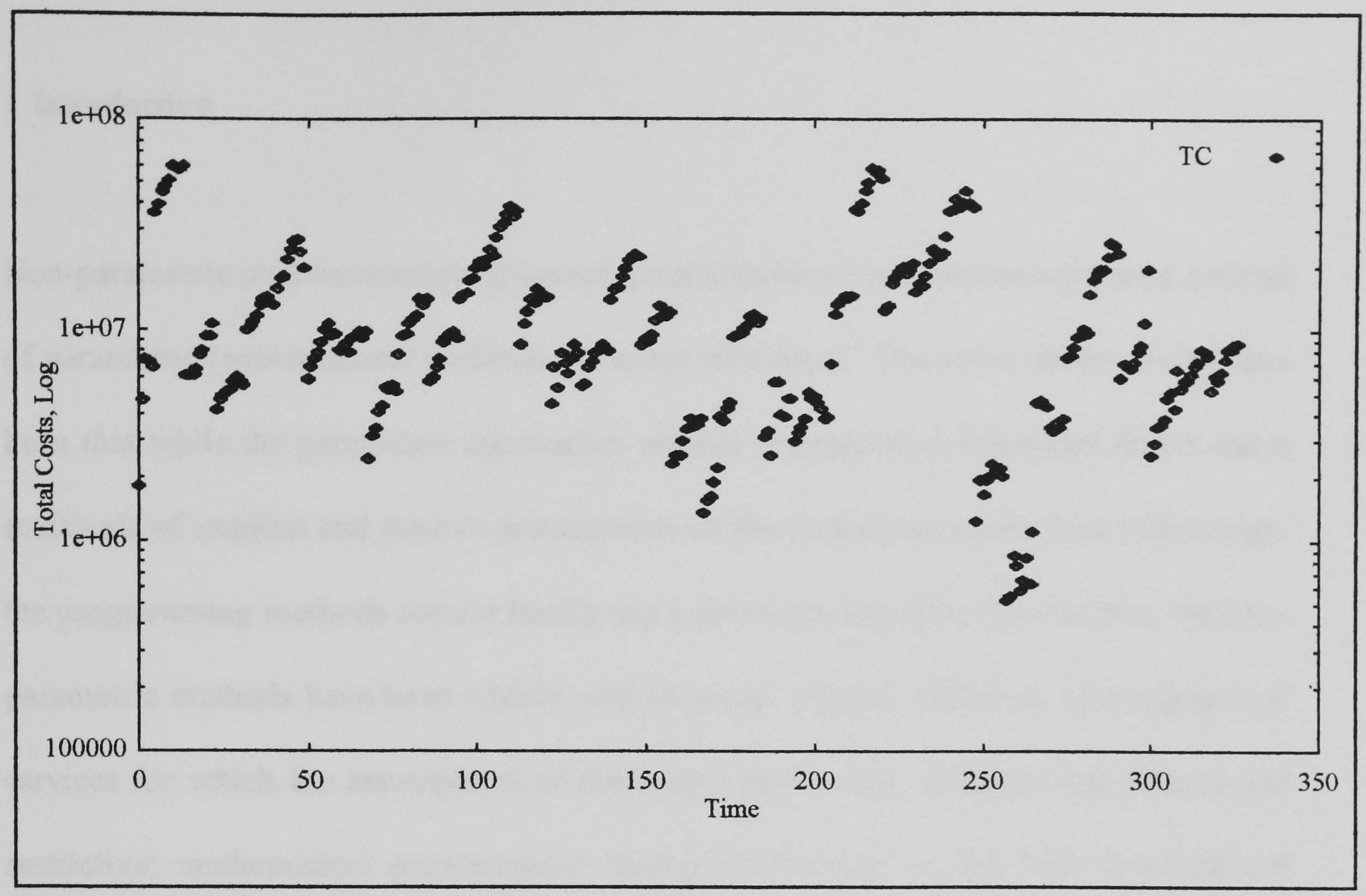

Figure A: Total costs

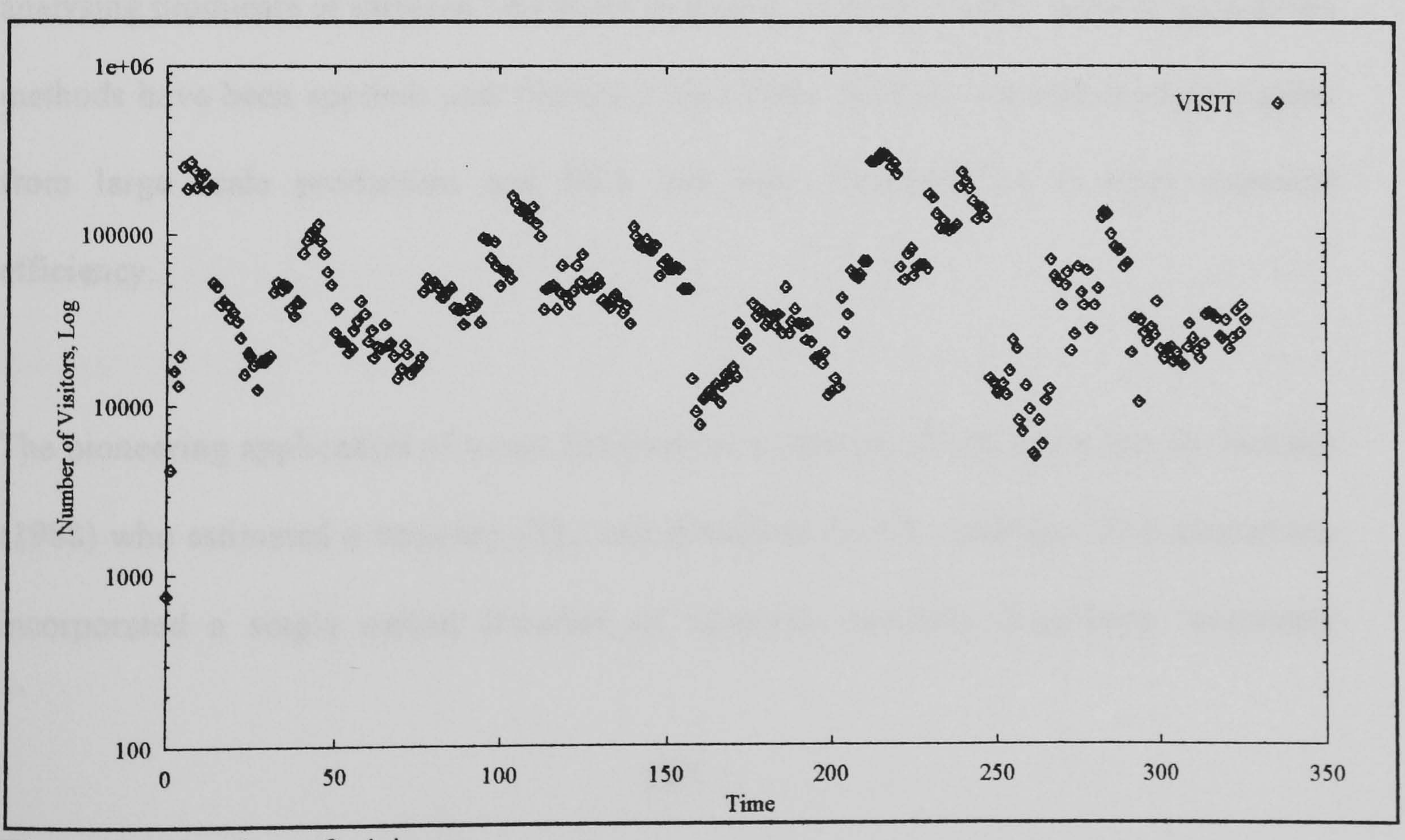

Figure B: Number of visitors

V Efficiency of Museums

- Application of Free Disposal Hull Method to Measure Cost Efficiency

1 Introduction

Non-parametric mathematical programming methods have been increasingly used, instead of parametric (econometric) methods, to assess efficiency.[1] The main reason for this has been that while the parametric approaches require pre-specified functional forms and a multitude of implicit and explicit assumptions on the underlying production technology, the programming methods require hardly any a priori assumptions.[2] Due to this, the non-parametric methods have been widely used to assess relative efficiency of producers of services for which the assumptions of traditional parametric methods have been found restrictive: mathematical programming method referred to as the Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH) have been applied particularly in analysing producers of services.[3] As to the museums, both parametric and non-parametric methods have been applied: cost functions have been applied to assess economic gains from large scale production and DEA has been employed to examine technical efficiency.

The pioneering application of a cost function on a data set of museums was by Jackson (1988) who estimated a trans-log (TL) cost functions for US museums. The estimations incorporated a single output (number of visitors), variables describing "museums' priorities" as to capture "the multifaceted nature of the output of museums", as well as a dummy variable to depict quality of production.[4] The estimations found evidence on size elasticities ranging from 1.4 in art museums to 2.0 in history museums. A similar application was carried out by Paulus (1993), who ran single-output TL cost functions for French and German museums and also found evidence of substantial scale economies.

Even if both treatments suggest results of similar order and existence of scale economies when approximating output by the number of visitors, the applications, however, include few caveats: first, both applications assume efficient production (production is presumed to be both technically and allocatively efficient). Second, the studies employ a single output, namely the number of visitors, to approximate the output of museums. Third, both studies apply a parametric method, i.e. they employ a given functional form for the underlying production technology - a TL cost function that is homothetic with respect to output - even if production technology of a museum producing multiple outputs is likely to be elusive.

The studies by Paulus (1995) and Mairesse (1997) propose solutions for these three caveats. Paulus (1995) uses an output oriented non-parametric DEA pace Charnes, Cooper and Rhodes (1978) to assess technical efficiency of 64 French museums, and argues for the necessity of using multi-output framework. Paulus (1995) employs four measures of output and yields results according to which only 14 % of the French museums are technically efficient. The inefficiency is explained by two main factors. First, increasing opening times are proposed as a source of inefficiency, suggesting that relatively long opening hours generate costs but are not compensated by an increase in outputs. Second, inefficiency is explained by museum type: historical museums were found to be more inefficient than art museums. The number of qualified employees had no impact on efficiency, as did neither the size of the museum nor the ownership.

According to Mairesse (1997) the findings by Paulus (1995) are not, however, accurate due to the employed output measures. In order to avoid the problem of output measurement Mairesse (1997) employs altogether six measures for output - number of visitors, (visitors/disposal income)/personnel costs, number of exhibitions/personnel costs, publications/number of scientific personnel, activities/personnel, and value of collection - and an output oriented DEA in order to assess technical efficiency of 82 Belgian museums. The analysis shows, most importantly, that the choice of measures of output affects the efficiency considerations.

Even if the studies by Paulus (1995) and Mairesse (1997) tackle some of the problems of the previous parametric applications on museums - assumption of technical efficiency and application of an a priori functional form - some problems remain unsolved. First, the output oriented approach of the two studies could be called into question: already the parametric methods on museums employed cost functions instead of production functions due to the fact that data on economic aspects of production, e.g. input prices and total operating costs are available and often more reliable than data on factual amounts of all inputs. Hence, in this light the question of technical efficiency is as its own redundant, whereas the question of cost efficiency that incorporates both technical and allocative efficiency is of more interest. Moreover, the input (cost) oriented approach is particularly useful from the perspective of policy analysis since it provides information of possible savings, were the institutions operate efficiently. In the heavily publicly supported European museums - e.g. French, Belgian and Finnish museums - the degree of cost efficiency is of particular interest: are public funds used for production of cultural services in the most efficient way.

This article assesses cost efficiency of 129 Finnish museums year 1996 by using a non-parametric input (cost) oriented FDH model that incorporates multiple outputs. The article concentrates on three main questions. First, the article examines the relative cost efficiency of different types of museums (art, culture historical, special, nature historical and regional museums as well as combined art/culture historical museums), and moreover, museums owned by private associations, foundations and firms versus museums owned by the state, municipality or town. Thus, the analysis centers on the relation between aggregate cost and the size of the services provided by different types of museums. Second, the article evaluates the effects of sparcity bias and efficiency by default on the assessment of relative efficiency, and, third, the article concentrates on the influence of outliers on efficiency measurement.

The article proceeds by first describing the data set of 129 Finnish museums (art, culture historical, special, nature historical and regional museums as well as combined art/culture historical museums) in year 1996. The theoretical background of FHD is then put forward: an emphasis is on showing that FDH and subsequent variants of DEA (with differing assumptions on scale properties) are nested. This is to demonstrate that the FDH method is a non-parametric mathematical programming method that necessitates least restrictions on the underlying production technology as well as to show that the model employed in the analysis is a generalisation of the traditional DEA model proposed by Charnes, Cooper and Rhodes (1978). The results of the calculations are then presented together with an assessment of the effects of ownership on relative cost efficiency. The effects of sparcity bias, efficiency by default, and outliers on efficiency assessment are then magnified. Lastly, some concluding remarks are made.

2 Descriptive statistics of the data set

The data set used in the analysis is a cross-section of 129 Finnish museums, year 1996. The data contains information on the type of museums (art, culture historical, special, nature historical and regional museums as well as combined art/culture historical museums) as well as on the owner of museums (private institution such as an association, foundation and firm or public authority such as the state, municipality and town). Moreover, the data set includes information on total costs, yearly open hours, man years, number of acquisitions owned by the museum (pieces of art, items, specimen, and documents), number of new acquisitions (pieces of art, items, specimen, and documents), number of exhibitions (produced by the museum or produced by an other institution) and number of publications. The summary statistics of the data is as follows:

Table 1: Descriptive statistics of the data set, 1996, n = 129 museums, in FIM

Variable	mean	st. dev.	variance	min	max
N	65.00	37.38	1397.50	1.00	129.00
OWNER	1.37	0.49	0.24	1.00	2.00
TYPE	3.46	1.78	3.16	1.00	7.00
MANYEAR	11.52	18.92	357.81	1.00	121.00
TC	0.36764E+07	0.57036E+07	0.32531E+14	0.21915E+06	0.39000E+08
OPEN	2413.40	2176.90	0.47388E+07	106.00	16846.00
VISITORS	28788.00	54007.00	0.29168E+10	100.00	0.39934E+06
ITEMS	64374.00	0.45680E+06	0.20867E+12	0.00	0.51645E+07
AQUIITEMS	850.31	3793.10	0.14388E+08	0.00	37967.00
ART	1409.30	5707.30	0.32574E+08	0.00	59484.00
AQUIART	44.434	167.74	28136.00	0.00	1580.00
SPECIMEN	0.12893E+06	0.96118E+06	0.92386E+12	0.00	0.10400E+08
AQUISPECI	2036.20	16065.00	0.25808E+09	0.00	0.17752E+06
DOKUMENTS	52935.00	0.10792E+06	0.11646E+11	0.00	0.73455E+06
AQUIDOKU	2577.90	7797.10	0.60794E+08	0.00	70000.00
EXHIBIT	8.12	7.07	50.05	1.00	54.00
OWNEXHIB	4.93	4.51	20.36	1.00	23.00
OTHEREXHIB	3.14	4.18	17.45	0.00	31.00
PUBLICAT	3.60	15.49	239.82	0.00	171.00

List of the variables: N = number of museums, OWNER = type of owner (0 = private, 2 = public), TYPE = type of museum, MANYEAR = manyear, TC = total costs, OPEN = yearly open hours, VISITORS = number of visitors, ITEMS = number of items, AQUIITEMS = aquisitions of new items, ART = magnitude of collection, AQUIART = aquisitions of art, SPECIMEN = magnitude of specimen collection, AQUISPECI = aquisitions of new specimen, DOKUMENTS = number of documents, AQUIDOKU = aquisitions of dokuments, EXHIBIT = number of exhibitions, OWNEXHIB = number of exhibitions produced by the museum itself, OTHEREXHIB = number of exhibitions produced by other institutions but displayed at the museum, PUBLICAT = number of publications.

The descriptive statistics of the data set in Table 1 reveal that there is great variation between museums. The high variance of total costs indicates that the size of museums vary considerably - total spendings range from a museum with FIM 219 150 total spendings to a museum with total spendings of FIM 39 million. This is suggested also by the relatively high variance of the man years - the man years range from one man year to 121 man years. The "volume" of the museums also vary considerably: the yearly open hours of the exhibitions is at its smallest 106 hours and at its highest 16 846 hours, the number of visitors fluctuate from 100 visitors up to 399 340 visitors, the minimum number of exhibitions is one and the maximum is 54, and the number of publications range from no publications at all up to 171 publications. The variation in size (total costs and man years) and volume between museums is high also among similar type of museums (art, culture historical, special, nature historical and regional museums as well as combined art/culture historical museums), as well as among museums owned by private associations, foundations and firms compared to museums owned by the state, municipality or town. (See Appendix 1)

3 Measurement of cost efficiency by using FDH

DEA method proposed by Charnes, Cooper and Rhodes (1978) and FDH method pioneered by Deprins, Simar and Tulkens (1984) are linear programming based techniques that allow to assess relative performance of producers (henceforth decision making units, DMU, as the jargon goes).[5] The idea of the methods is to determine which of the DMU's of the sample are efficient - i.e. which of the DMU's determine the envelopment surface (best practice frontier) on which DMU's performance is compared with. DMU's that lie on the best practice frontier are considered efficient, while those DMU's that do not lie on the surface are doomed inefficient. In other words, the method does not set an absolute value for efficient production, but defines the most efficient DMU's that form the best practice frontier and then uses this best practice frontier to assess the performance of the other DMU's. The fundamental presumption behind the method is that of Pareto-efficiency: if a given DMU, k, is capable of producing Y(k) units of output with X(k) inputs, then an other DMU should also be capable of the same production schedule were it to operate efficiently.[6]

Theoretically, productive efficiency of a DMU can be assessed by comparing the productivity of the DMU to the best practice productivity at the same time period. In a simple single-output single-input case productivity is generally measured as the ratio of output to input, and in a multi-output multi-input case the ratio is given by:

$$\Sigma^{s}_{r=1}\ u_r\ y_r\ /\ \Sigma^{m}_{i=1}\ v_i\ x_i = (u_1y_1 + u_2y_2 + ...+ u_sy_s)/\ (v_1x_1 + v_2x_2 + ...+ v_sx_s) \quad (1)$$

in which u_r equals the weights of the outputs y_r, v_i represent the weights of the inputs x_i, s is the number of outputs and m represents the number of inputs.

Thus, the question is how to choose weights (u_r and v_i) for the inputs and outputs, since the productivity of a DMU changes in accordance of the weights chosen. For for-profit firms it is customary to use market prices as the weights, but such a practice can not necessarily be applied in the case of publicly subsidised not-for-profit firms that do not sell their outputs or buy their inputs from reasonably competitive markets. The linear programming method developed by Charnes, Cooper and Rhodes (1978) provides a solution to this problem. The method calculates the efficiency score λ of a given DMU k by using the following non-linear model:

$$\text{Max } \lambda = \Sigma^{s}_{r=1} \; u_r \, y_{rk} \, / \, \Sigma^{m}_{i=1} \; v_i \, x_{ik} \tag{2}$$

subject to

$$\Sigma^{s}_{r=1} \; u_r \, y_{rj} \, / \, \Sigma^{m}_{i=1} \; v_i \, x_{ij} \;\leq\; 1, \; j = 1,2,\ldots,k,\ldots n \tag{2.1}$$

$$u_r, \, v_i \;\geq\; 0 \quad \forall \; r \text{ and } i \tag{2.2}$$

in which y_{rj} is the output r produced by the j^{th} DMU, x_{ij} is the input i used by the j^{th} DMU, u_r equals the weights of the outputs y_r, v_i represent the weights of the inputs x_i, s is the number of outputs, m represents the number of inputs, and n is the number of DMU's.

The model (2) calculates the productivity score (1) as the ratio of weighted outputs and weighted inputs. In this the weights of the outputs and inputs are chosen as to maximise the productivity, but subject to the two constraints (2.1) and (2.2) of which the first constraint (2.1) restricts the weights so that when calculating the maximum productivity score of the k^{th} DMU in relation to other DMU's, the productivity score of each DMU is less or equal to one. The latter constraint simply restricts the weights to be non-negative.

As a result, the above procedure yields a score - scaled between 0 and 1 - of maximum productivity of the k^{th} DMU with respect to other DMU's, that actually is the efficiency score λ of k^{th} DMU. The model (2), thus, emphasises that the weights of outputs and inputs are not set a priori, but the method maximises the efficiency score for each DMU by screening through each possible weight, and chooses such weights for outputs and inputs that the productivity of the given DMU is the highest possible with respect to other DMU's. This implies, that a DMU that is best with respective to any possible input-output combination gets an efficiency score of 1. However, if a DMU is found inefficient when using the best possible weights, the DMU is deemed inefficient with any other weights for inputs and outputs.

In order to employ (2) to examine the cost efficiency of museums few alterations are required, namely rewriting the non-linear problem (2) as a linear problem, second, changing (2) form the output oriented (output expansion) approach to input (cost) oriented approach, and third, connected to the second alteration, changing the maximisation problem into a minimisation problem.

As is well known, due to duality of maximisation and minimisation problem a problem can be written in either way without loosing any information. The non-linearity of the model, in turn, can be dealt with by scaling either the weighted sum of outputs or weighted sum of inputs as one. The cost oriented approach can be derived by assuming that total operating costs of a DMU capture the resources (inputs) used to produce the services. This implies that in the rewritten formulation (3) the services provided by museums are taken as given and the total costs they induce are of interest. The assumption seems appropriate bearing in mind that the programmes of museums (e.g. exhibitions, publications and large scale conservation projects) are scheduled years in advance, and hence, can be taken as given at any time point.

Hence, the linear minimisation problem with total cost - multi output orientation can be written as:[7]

$$\min_{\{\lambda_k, z_1, \ldots, z_n\}} \lambda_k \tag{3}$$

subject to

$$\lambda_k C_k - \Sigma^n_{j=1} z_j C_j \geq 0 \tag{3.1}$$

$$\Sigma^n_{j=1} z_j y_{jr} \geq y_{kr} \qquad r = 1,\ldots,s \tag{3.2}$$

$$\lambda_k, z_j \geq 0 \qquad j = 1,\ldots,n \tag{3.3}$$

in which C_k and C_j are the total spendings of the museums k and j, y_{kr} and y_{jr} are the amounts of the r^{th} output of the museums and z_j, $j = 1,\ldots,n$ are weights that indicate which of the efficient DMU's form the envelopment surface (best practice frontier) for each DMU. The value of the objective function λ_k yields, as noted, at the optimum the cost-efficiency degree of a given museum k (value between 0 and 1).

The first constraint (3.1) postulates that DMU k's optimal total costs (adjusted to be efficient) are equal or greater than total costs of the DMU with which its performance is compared with. The second constraint implies that a DMU lying on the envelopment surface and dominating the k^{th} DMU must produce at least the same amount of output than k. The last constraint (3.3) necessitates both the weights (z_j) and the value of the objective function (λ_k) to be non-negative.

As shown e.g. by Eeckaut et al. (1993), further constraints on the weights z_j (3.3) can be used to postulate assumptions on the production technology.[8] The formulation (3) with its assumption of non-negativity of the weights z_j (3.3) represents a case of constant returns to scale (DEA-F). Adding to this (3)-(3.3) an additional restriction:

$$\Sigma^{n}_{j=1}\ z_j \leq 1 \tag{a}$$

describes a mathematical program that implies constant and decreasing returns to scale (DEA-CD): the reference frontier is a convex set that includes the origin and satisfies the assumption of free disposability of inputs. The free disposability of inputs implies in a traditional input oriented approach, and case of two inputs (x_1, x_2), that any increase of input x_1 either reduces output or requires an increase in x_2 in order to maintain the level of output. If neither a reduction of output nor an increase of an other input are free the case is that of weak (free) disposability. If a reduction of output or alternatively an increase of an other input would not induce costs the case would be that of strong disposability (free disposability).[9]

Adding to the non-negativity of the weights z_j restriction (3.3), instead of (a) the following:

$$\Sigma^{n}_{j=1} \; z_j = 1 \qquad \text{(b)}$$

represents, in turn, a case with variable returns-to-scale (DEA-V). A program with the variable returns-to-scale assumption suggests increasing returns of scale for low values of outputs and decreasing returns for high values of output. In such a case the enveloping reference frontier is still convex, it satisfies the free disposability of inputs, but it does not contain the origin.

Adding to (3)-(3.3), instead of c, the following:

$$\Sigma^{n}_{j=1} \; z_j = 1, \; z_j \in \{0,1\}, j = 1,\ldots,n \qquad \text{(c)}$$

suggests that the enveloping reference frontier satisfies the assumption of free disposability, but no other assumption is made on the reference cost-output relation. As proven by Tulkens (1993) a linear model (3)-(3.3) supplemented by (c), henceforth (3.c), corresponds the FDH model proposed by Deprins, Simar, and Tulkens (1984). This implies that the FDH and the variants of DEA are "nested" in one other.[10]

4 FDH measures of relative efficiency

The linear program (3.c) is repeated for each of the 129 museums in the data set. The calculations are, first, carried out for each museum type (art, culture historical, special, nature historical and regional museums as well as combined art/culture historical museums), and hence, the measures for outputs vary to some extend. The output measures for each museum type are following:

Table 2: Output measures by museum type

Museum type	measures for outputs
Art	yearly open hours, number of visitors, acquisition of documents, number of exhibitions, number of publications [a]
Culture historical	yearly open hours, number of visitors, acquisition of items, acquisition of documents, number of exhibitions, number of publications
Special	yearly open hours, number of visitors, number of exhibitions, number of publications
Nature historical	yearly open hours, number of visitors, acquisition of specimen, acquisition of documents, number of exhibitions, number of publications
Regional	yearly open hours, number of visitors, acquisition of documents, number of exhibitions, number of publications
Art&culture hist.	yearly open hours, number of visitors, acquisition of items, acquisition of documents, number of exhibitions, number of publications

a) Acquisitions of new art objects was not included as an output measure because the ways to finance new acquisitions wary across museums

Table 3 and Figures 1 and 2 summarise the results. Table 3 shows the number (per centage) of inefficient museums among each museum type and the level of excess spending of the inefficient museums. Figure 1 portrays the distribution of the efficiency degrees for the inefficient museums and Figure 2 graphs the excess spendings.

Table 3: Efficiency and excess spending among different museum types

Museum type (n)	TC FIM million	efficient n (%)	inefficient n (%)	excess spending FIM million	 % TC
Art museum (27)	124	15 (56 %)	12 (44 %)	28	23 %
Culture histor. (31)	58	26 (84 %)	5 (16 %)	1.2	2 %
Special mus. (34)	76	21 (62 %)	13 (38 %)	20	25 %
Nature historical (8)	26	8 (100 %)	0 -	-	-
Regional mus. (20)	154	19 (95 %)	1 (5 %)	1.3	1 %
Art&culture hist.(9)	22	9 (100 %)	0 -	-	-
Total (129)	462	98 (76 %)	31 (24 %)	50.5	11 %

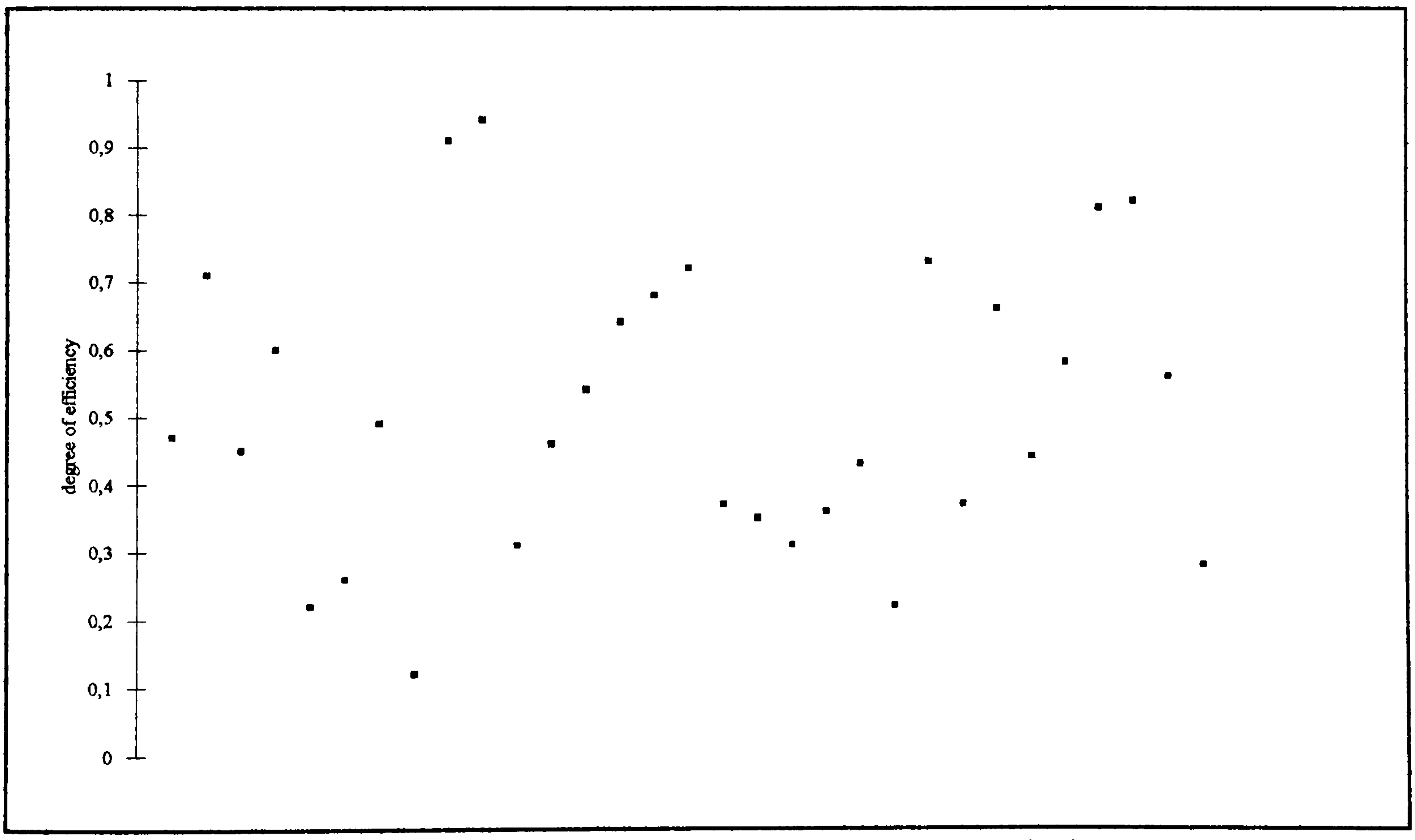

Figure 1: FDH efficiency scores (efficient museums omitted), analysis I

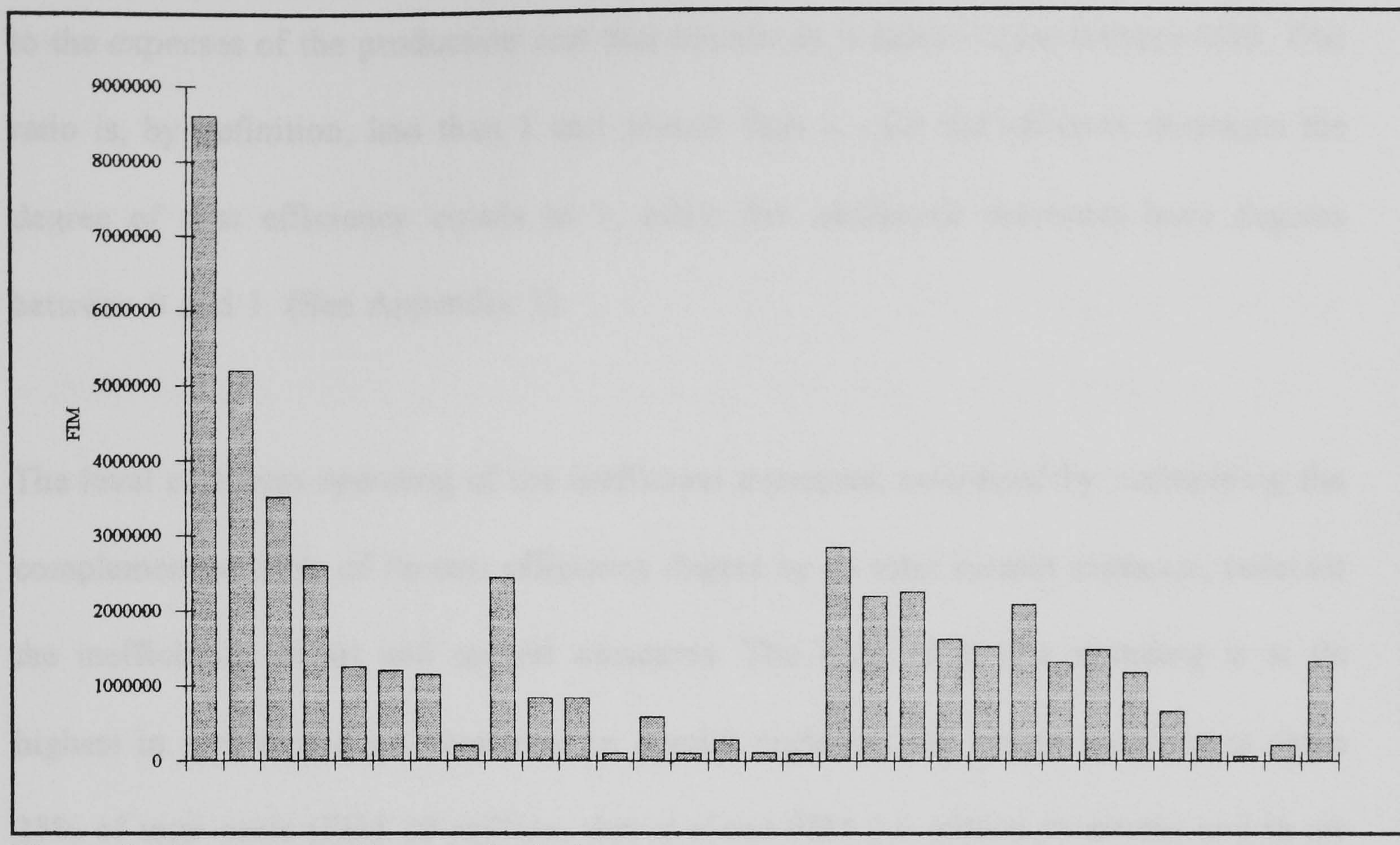

Figure 2: Excess spending, analysis I

Table 3 demonstrates, first, that some 24% of the museums (all museum types) are cost-inefficient. According to 3.c a museum is declared cost-inefficient if it is dominated by one or more production units - total spendings of other DMUs' are less than equal to museums own total spendings and output indicators of other DMUs' are greater than or equal to the museum's output indicators.[11] The proportion of inefficient museums, however, vary considerably between different museum types. The proportion of inefficient museums is considerable among art and special museums, some 40% of museums in both categories are inefficient, while all nature historical and combined art/culture historical museums are declared efficient. (See Appendix 2)

The average degree of cost efficiency - calculated as the ratio of its own expenditures to the expenses of the production unit that dominates it most - is on average 0.88. This ratio is, by definition, less than 1 and greater than 0 - for the efficient museums the degree of cost efficiency equals to 1, while the inefficient museums have degrees between 0 and 1. (See Appendix 2)

The level of excess spending of the inefficient museums, calculated by multiplying the complement to unity of its cost efficiency degree by its total current expenses, reiterate the inefficiency of art and special museums. The level of excess spending is at its highest in special and art museums: in special museums the excess spending is some 25% of total costs (FIM 20 million, that is about FIM 1.6 million/museum) and in art museums the excess spending amount to FIM 28 million (about FIM 2.3 million/museum), that represents some 23% of total costs. The amount of spending that all the museums would have saved, had they been cost-efficient, amount to FIM 50.5 million, i.e. 11 % of the total spendings of the museums. (See Appendix 2)

4.1 Effects of sparsity bias, efficiency by default and outliers on results

As pointed out by Eeckaut, Tulkens and Jamar (1993), three characteristic of the FDH method may affect the efficiency considerations: first, DMU's with relatively few DMU's to compare with may be declared efficient due to so called sparsity bias, second, some DMU's may be defined efficient by default, and third, outliers may affect the results.

The sparsity bias arises from the fact that FDH method declares a DMU efficient in absence of observed better performing DMU with at least as high levels of outputs. E.g. if the number of particularly large museums is small compared to the, say middle range sized museums, the relatively large museums are more likely to be declared efficient than the middle range museums due to lack of DMU's to be compared with. Thus, the method may induce a bias in favour of those production units that lie in the range where observations are scarce.

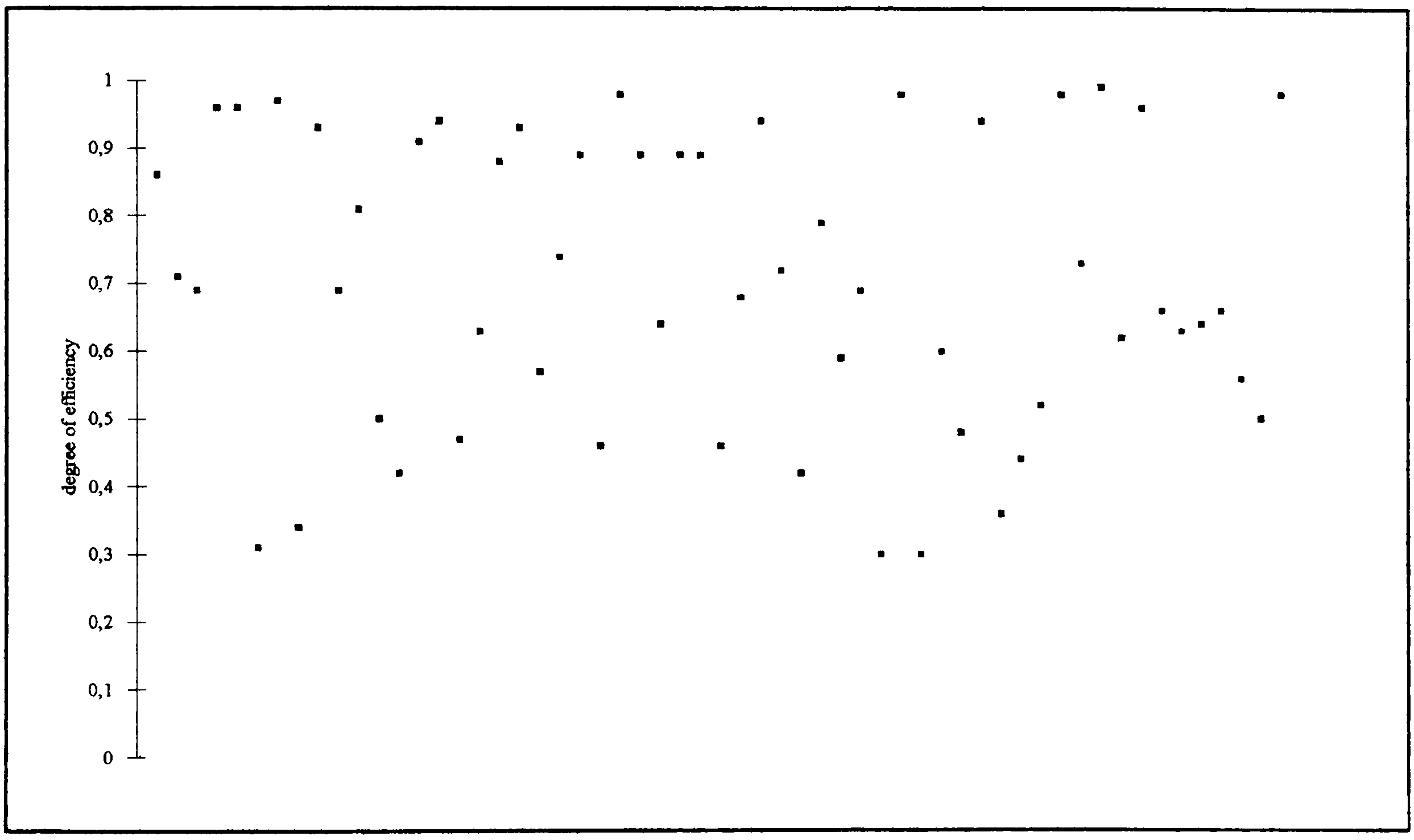

Figure 3: FDH efficiency scores (efficient museums omitted), analysis II

To test whether such sparcity bias takes place in the case of Finnish museums the linear program (3.c) is re-run for each 129 museums without consideration of the museum type.

In the calculations outputs are measured by yearly open hours, number of visitors, number of exhibitions and number of publications. The reason for this is that these four output measures are comparable across all museum types. Table 4 and Figures 3 and 4 summarise the results.[12] (See Appendix 2)

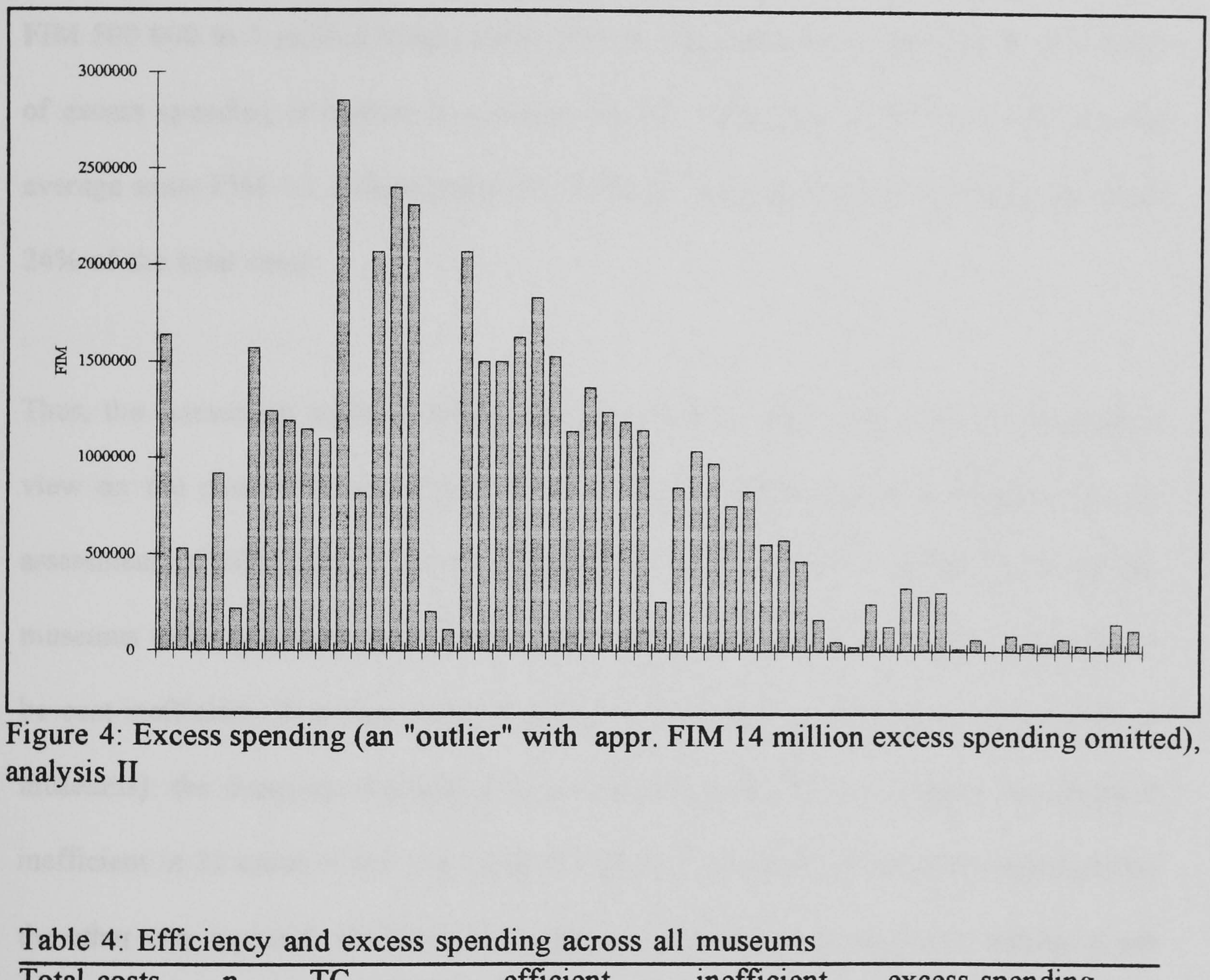

Figure 4: Excess spending (an "outlier" with appr. FIM 14 million excess spending omitted), analysis II

Table 4: Efficiency and excess spending across all museums

Total costs (FIM million)	n	TC FIM million	efficient n (%)	inefficient n (%)	excess spending FIM million	% TC
10+	9	193	6 (67%)	3 (33%)	17	9%
5-10	13	86	10 (77%)	3 (23%)	1.6	2%
1-5	66	161	30 (45%)	36 (55%)	39	24%
0.5 - 1	24	17	13 (54%)	11 (46%)	1.2	8%
- 0.5	17	5	13 (76%)	4 (24%)	0.3	7%
Total	129	462	72 (56%)	57 (44%)	59.5	13%

Table 4 demonstrates that according to re-run (3.c) 44% of the museums are declared inefficient, and that the total of excess spending amount to FIM 59.5 million, i.e. 13% of the total spendings of the museums. The proportion of inefficient museums is greatest in museums in which total costs range from FIM 1 to 5 million, some 55 % of museums in the category are inefficient. The proportion of inefficient museums is high also in the FIM 500 000 to 1 million range, some 46% of the museums are inefficient. The level of excess spending is highest in museums in the range from FIM 1 to 5 million (on average some FIM 1.1 million/museum) in which the excess spending represents some 24% of the total costs.

Thus, the assessment without consideration of museum type yields a more pessimistic view on the cost-efficiency, given the more restricted measures of output, than the assessment of efficiency by museum type: the first analysis declared 24 % of the museums to be cost-inefficient, while the latter analysis found 44% of the museums to be cost-inefficient. The two analyses give contradicting verdicts in 39 cases (30% of museums): the museums declared efficient according to the first analysis are declared inefficient in 32 cases of the latter analysis and in 7 cases the declarations contradicted the other way a round. Of these museums with contradicting efficiency statuses 6 are those within the range of total spendings FIM 5+ million (27% of museums in that range), and the rest are those with total spendings ranging from FIM 0.5 to 5 million (37% of museums in that range). Thus, rather than having lack of comparison in only the relatively high total spending category, there is a sparsity bias also in the lower total spending categories. However, in altogether 90 cases (70% of museums) the two analyses declare a given museum similarly efficient/inefficient indicating that the FDH method seems to be able to identify the most obvious cases of efficiency/inefficiency.

The analysis of cost efficiency is also affected by some of the museums being declared efficient by default - the methodology induces by definition some observations efficient. Museums that are declared efficient by default include those museums that have the lowest expenses among a museum type or all museums, as well as those museums that have the highest value of at least one output. Moreover, in the data set there are museums that are declared efficient because they are not subjugate to comparison: these include museums that are not dominated by any other museum (hence efficient), and that also do not dominate any other museum. In the first analysis - with consideration of museum types - the number of museums that are efficient by default is 22 museums (17% of all museums), while in the latter analysis 17 museums (13% of all museums) are declared efficient by default. In the first analysis 22% of the efficient museums are efficient by default, whereas in the latter analysis the figure is 24%. In both analyses the museums declared efficient by default include museums in all total spending categories as well as all museum types.

Besides the sparsity bias and efficiency by default, outliers in data set may affect the efficiency considerations. For example Wilson (1993) has pointed out that outliers, atypical observations arising from measurement errors, are likely to yield biased assessments of efficiency when a non-parametric mathematical programming method is employed - FDH is particularly prone to measurement errors and production of biased efficiency results since the method envelops the data closely.

Various attempts have been made to develop statistics to detect the possible outliers - e.g. Andrews and Pregibon (1978), Grosskopf and Valdmanis (1987) as well as Eeckaut et al. (1993) have proposed statistics to be used together with non-parametric applications.[13] Of these three methods Eeckaut et al. (1993) approach is the most convenient one. The method identifies two types of outliers - outliers that appear systematically as the (most) dominating production units and outliers that are dominated by several production units - and then assesses the effect of these observations on the results. This method does not, however, account the possibility of measurement errors.

As to the first analysis (efficiency by museum types), the method by Eeckaut et al. (1993) find two observations as obvious outliers, namely Rovaniemen taidemuseo (art museum) and Ilmatorjuntamuseo (special museum). The first outlier, Rovaniemen taidemuseo, is the most dominating production unit in eight cases implying that without the given museum (Rovaniemen taidemuseo) the proportion of inefficient art museums would decrease from 44% (12 museums) to 19% (5 museums). The second outlier, Ilmatorjuntamuseo, by contrast, is dominated by 17 other special museums. This observation does not, however, have implications on the results, but the omission of the outlier would result only one inefficient museum less.

The second analysis (omitting the museum types) includes more cases of outliers: altogether 9 museums are dominated by more than ten DMU's, and moreover, two museums (Rovaniemen taidemuseo and Kajaanin taidemuseo) appear as the most dominating DMU's in 19 cases: Rovaniemen taidemuseo (art museum) is most dominating in eight cases within the total spending category FIM 1 to 5 million and Kajaanin taidemuseo (art museum) is the most dominating DMU within the same total spending range in 11 cases. The omission of these two museums would not, however, alter the results because the museums dominated either by Rovaniemi or Kajaani art museums are dominated also by other DMU's.

4.2 Ownership as an explanation of differences in cost efficiency

The museums of the data set can be further categorised with respect to the owner of the museum: 48 (37%) of the museums are owned by a private association, foundation, or firm, and hence private, whereas 81 (63%) of the museums are owned either by the state, municipality, or town, and hence, public.

The effect of ownership on cost efficiency is demonstrated by rewriting the results of the two previous analyses with respect to ownership: EFF (I) and INEFF(I) denote the proportion of efficient and respectively inefficient DMU's within each museum type, whereas EFFI (II) and INEFF(II) refer to the latter analysis in which the museum type was not taken into account. Table 5 summarises the results:

Table 5: Ownership as an explanation to efficiency differentials

Owner(n)	TC FIM million	EFF (I) n (%)	INEFF (I) n (%)	EFF (II) n (%)	INEFF (II) n (%)
Public (81)	361	68 (84%)	13 (16%)	47 (58%)	34 (42%)
Private (48)	101	30 (63%)	18 (37%)	25 (52%)	23 (48%)
Total (129)	462	98 (76%)	31 (24%)	72 (56%)	57 (44%)

Table 5 demonstrates that in both accounts public museums are more cost-efficient than private institutions. The difference between the private and public institutions is considerable, particularly when cost-efficiency is assessed by museum type (EFF (I), INEFF (I)): while 84% of public museums are efficient, solely 63% of private museums are efficient.

As shown in Table 6 the difference between public and private museums is clear also with respect to the average number of dominations (DO I denotes the first analysis and DO II refers to the latter analysis), as well as the degrees of cost-efficiency (DCE I and DCE II, respectively): the average degree of cost efficiency is higher, and the average number of dominating DMU is lower among the public than among the private ones:

Table 6: Average number of dominations and degrees of cost efficiency

Owner	DO (I)	DCE (I)	DO (II)	DCE (II)
Public	0.25	0.93	1.5	0.89
Private	1.54	0.80	3.7	0.83

A more detailed account of the private and public producers demonstrates possible origins of the finding. First, as to the first analysis by museum type the uneven distribution of private and public museums among different museum types may effect the results: comparison of Table 7 and Table 1 reveals that those museum types that exhibit relatively low proportions of cost-inefficient DMU's include relatively more public producers. An opposite example is provided by the special museums of which solely 38% are cost-inefficient, while 91% of them are privately owned.

Table 7: Proportion of private and public museums within each museum type

Museum type	n	TC (average) FIM million	public n (%)	private n (%)
Art museum	27	4.6	21 (78%)	6 (22%)
Culture historical	31	1.9	24 (77%)	7 (23%)
Special museums	34	2.3	3 (9%)	31 (91%)
Nature historical	8	3.3	7 (88%)	1 (12%)
Regional museums	20	7.7	19 (95%)	1 (5%)
Art & culture hist.	9	2.5	7 (78%)	2 (22%)
Total	129	3.6	81 (63%)	48 (37%)

Furthermore, as to the total spendings of the museums, the average total spendings of public museums are FIM 4.5 million (total costs account to FIM 361 million), whereas the average spendings of private museums are FIM 2.1 million (total costs account to FIM 101 million). Almost all private museums are in the under FIM 5 million range, whereas the public museums are mostly in the range of FIM 5+ million. Since the proportions of inefficient/efficient museums in the range of relatively high total spendings and "middle range" museums do not vary considerably, the almost equal proportions of efficient/inefficient museums (56%/44%) in the latter analysis is an expected result.

5 Conclusion

This article has examined cost-efficiency of museums and focused on three main questions: the relative cost efficiency of different types of museums (art, culture historical, special, nature historical and regional museums as well as combined art/culture historical museums), the effects of sparcity bias, efficiency by default and outliers on efficiency measurement, and lastly, the strength of ownership as an explanation of efficiency differentials between museums.

The analysis demonstrated, first, that the production of Finnish museums is characterised by cost inefficiency. The analysis by museum type suggested that on average some 24% of museums are cost inefficient (76% efficient) whereas the analysis across all museums indicated that 44% of museums are inefficient (56% efficient). Notwithstanding the relatively high proportion of inefficient museums in both accounts, the Finnish museums seem to fare well: as noted, Paulus (1995) found altogether 86% of 125 French museums and Mairesse (1997) 77% of 82 Belgian museums to be technically inefficient. The difference in the results is striking, particularly since cost inefficiency entails both allocative and technical inefficiency (i.e. cost efficient museums choose from technically efficient options the input mix that minimises the cost), and hence, the efficiency scores of Finnish museums include both technical and allocative inefficiency.

Given that the analyses by Paulus (1995) and Mairesse (1997) do not include biases arising from sparsity bias, efficiency by default or outliers, a possible explanation of the striking difference of the results could be, first, that the continental museums indeed are less technically efficient than their Finnish counterparts.[14] Second, the difference may originate from the choice of variables and orientation (output vs. cost-orientation), and third, the difference between DEA and FDH methods may contribute to the differing results. As is well known, DEA is generally more strict in declaring a DMU efficient while FDH is powerful in depicting the most obvious cases of inefficiency.[15]

Besides the relatively low proportion of cost inefficient museums on average, the first analysis by museum type revealed great variation between museum types: nature historical, regional and combined art/culture historical museums were all more or less cost-efficient, 85 % of the culture historical museums were cost-efficient, while the proportion of cost-efficient museums among art and special museums is some 60 %.[16]

The relatively high proportion of inefficient institutions among the special museums is partly explained by the fact that the output proxies do not fully capture the specialty of the museums' output, and thus, the comparison is made between different kind of DMU's unlike in the case of other museum types in which the DMU's conform to each other. The relatively high proportion of cost-inefficient museums (44%) among the art museums is partly explained by an outlier, namely the highly cost efficient Rovaniemen taidemuseo, that appears the most dominating DMU in 7 cases: without the museum the proportion of cost-inefficient art museums would drop from 44% to 19%. In this case the art museums would be in line with the culture historical museums among which 16% are cost inefficient. As to the proportion of inefficient museums across all museums, this would imply also that on average only 19% of museums would be declared cost inefficient.

The analysis without considerations of museum types revealed that also the sparsity bias - lack of DMU's of similar size to compare with - affect the results: altogether 44% of the museums were doomed cost-inefficient. Of interest is, however, that both analyses resulted similar propositions on the level of excess spending of the museums. The first analysis suggested that 11% of total costs could be saved, were all museums cost efficient, whereas in the second analysis the corresponding figure was 13%. The second analysis, furthermore, showed that among the middle sized museums (total costs ranging form FIM 1 to 5 million) the proportion of cost inefficient museums is relatively high, while among museums with either smaller or larger total spendings the proportion of inefficient museums is relatively small. The levels of excess spending vary also considerably in different total spending categories: in the middle sized museums excess spending amount to 24%, whereas in the largest museums savings add up to FIM 17 million (9% of total costs) and in the smallest museums the level of excess spending is some 7%. The analysis by museum type, in turn, indicate that possibilities of cost savings are highest among art and special museums.

The efficiency differentials of museums were investigated also from the view point of ownership. The rewritten results of the two analyses - the first analysis by museum type and the second without the museum type considerations - suggest that there are differences in cost-efficiency of private museums owned by associations, foundations or firms and public museums that are run by the state, municipality or town. In the analysis by museum type 16% of the public and 37% of the private museums were cost inefficient, and in the latter analysis 42% of the public and 48% of the private museums were cost inefficient. By and large this suggests, that the publicly run museums are on average more cost efficient than their private counterparts.[17]

Endnotes

1. See e.g. Seiford and Thrall (1990) - in a special supplement of Journal of Econometrics on parametric and non-parametric approaches to frontier analysis - as well as Ali and Seiford (1993) and Athanassopoulos (1994) for a review and recent developments of the non-parametric frontier analysis.
2. See Lovell (1993) for theoretical discussion of the pros and cons of the parametric (econometric) and non-parametric methods. See Banker et al. (1986), Sengupta and Sfeir (1988), Ferrier and Lovell (1990) as well as Thanassoulis (1993) for comparisons by using empirical data sets. In general, the articles suggest that DEA outperforms the traditional econometric regression analyses.
3. Since the seminal studies in late 1970's, numerous DEA models have appeared in the literature as well as host of studies employing the technique on producers of services. This can be clearly seen form the extensive bibliographies of Data Envelopment Analysis by Emrouznejad and Thanassoulis (1996a,1996b) who list over 1500 journal papers and some 300 working papers.
4. These "priority variables" were measured by the cost shares of promotional expenditure, exhibition expenses, conservation and preservation expenses and membership activity expenses.
5. See Lovell (1993), Ali and Seiford (1993) as well as Boussofiane et al. (1991) for condensed and clear presentations of the mathematical programming approach to efficiency analysis.
6. Alternatively, if a DMU is capable of producing Y(j) units of output with X(j) inputs, then other efficient producers should also be able to do the same.
7. A similar model was used by Eeckaut et al. (1993) in a case of Belgian municipalities.
8. See Eeckaut et al. (1993) as well as Lovell (1993) for discussion on the constraints defining returns to scale.
9. See Färe et al. (1985) for a detailed discussion on both output and input disposability.
10. Because FDH and the variants of DEA are "nested" it is possible to evaluate quantitatively how far each of them lie from the data, and hence, from one other (the degree of closeness is generally expressed as the number of observations that are declared efficient by the corresponding method). This property has been utilised e.g. by Eeckaut et al. (1993) who have analysed the relative performance of the two methods in measurement of cost efficiency.
11. If a DMU is cost inefficient and dominated by more than one other production unit, the dominating one with the lowest expenses is called the most dominating DMU.
12. Even if the mathematical program (3.c) was carried out as a "continuous" analysis (reference set was based on all museums, not museums in one museum type) the results are presented in decreasing order of five museum spending categories.
13. As is well known, various methods have been developed to detect outliers in linear regression models that employ ordinary least squares (OLS) residuals. These methods cannot, however, be employed in relation to non-parametric methods since the methods do not produce OLS residuals.

14. Neither Paulus (1995) nor Mairesse (1997) account for possible sparsity bias, efficiency by default or outliers.
15. This point has been made by Eeckaut et al. (1993) when comparing DEA and FDH in assessment of cost efficiency in Belgian municipalities.
16. It is of interest that also this result is "contrary" to the findings by Paulus (1995): in her study art museums appeared to be technically most efficient, then historical museums, and lastly other types of museums. Mairesse (1997) do not account for differences between museum types.
17. It should be noted, that as to the first analysis by museum type that private museums include 91% of the special museums of which 38% are cost-inefficient, and as to the latter analysis that almost all private museums are in the under FIM 5 million range, whereas the public museums are mostly in the range of FIM 5+ million, thus, evening out the efficiency differentials between private and public museums.

APPENDIX 1

Table A: Descriptive statistics of the data set, 1996, n = 129 museums, in FIM

Art museums (excluding central art museums), n = 15

variable	mean	std.dev.	variance	min.	max.
OWNER	1.33	0.49	0.24	1.00	2.00
TYPE	1.00	0.00	0.00	1.00	1.00
MANYEAR	11.73	23.45	549.78	1.00	95.00
TC	0.47875E+07	0.96785E+07	0.93674E+14	0.42636E+06	0.39000E+08
OPEN	2118.90	1168.00	0.13642E+07	109.00	4969.00
VISITORS	36890.00	77479.00	0.60031E+10	5072.00	0.31343E+06
ITEMS	0.00	0.00	0.00	0.00	0.00
AQUIITEMS	0.00	0.00	0.00	0.00	0.00
ART	3392.70	5599.50	0.31354E+08	488.00	22629.00
AQUIART	128.00	211.34	44665.00	2.00	706.00
SPECIMEN	0.00	0.00	0.00	0.00	0.00
AQUISPECI	0.00	0.00	0.00	0.00	0.00
DOKUMENTS	20254.00	63709.00	0.40588E+10	0.00	0.25000E+06
AQUIDOKU	2849.50	10279.00	0.10566E+09	0.00	40000.00
EXHIBITIONS	8.80	5.71	32.60	1.00	22.00
OWNEXHIB	6.00	4.83	23.29	1.00	20.00
OTHEREXHIB	2.87	2.64	6.98	0.00	10.00
PUBLICAT	3.13	4.44	19.70	0.00	17.000

Art museums (central art museums), n = 12

variable	mean	std.dev.	variance	min.	max.
OWNER	1.08	0.29	0.83333E-01	1.00	2.00
TYPE	6.00	0.00	0.00	6.00	6.00
MANYEAR	11.50	5.11	26.09	4.00	23.00
TC	0.43104E+07	0.28600E+07	0.81793E+13	0.83809E+06	0.12000E+08
OPEN	2774.80	1040.90	0.10834E+07	1664.00	4505.00
VISITORS	32855.00	17792.00	0.31655E+09	6289.00	64342.00
ITEMS	110.08	381.34	0.14542E+06	0.00	1321.00
AQUIITEMS	6.67	23.09	533.33	0.00	80.00
ART	3696.90	1916.90	0.36746E+07	1467.00	8712.00
AQUIART	98.50	132.75	17622.	6.00	497.00
SPECIMEN	0.00	0.00	0.00	0.00	0.00
AQUISPECI	0.00	0.00	0.00	0.00	0.00
DOKUMENTS	13829.00	11361.00	0.12906E+09	3250.00	43660.00
AQUIDOKU	1083.00	1447.70	0.20959E+07	0.00000E+00	5269.0
EXHIBITIONS	16.17	12.55	157.61	8.00	54.00
OWNEXHIB	9.83	5.37	28.88	3.00	23.00
OTHEREXHIB	6.33	8.73	76.24	0.00	31.00
PUBLICAT	4.75	2.99	8.93	1.00	10.0

Culture historical museums, n = 31

variable	mean	std.dev.	variance	min.	max.
OWNER	1.23	0.43	0.18	1.00	2.00
TYPE	2.00	0.00	0.00	2.00	2.00
MANYEAR	7.90	21.13	446.49	1.00	120.00
TC	0.18912E+07	0.44662E+07	0.19947E+14	0.21915E+06	0.25000E+08
OPEN	2104.30	3024.00	0.91447E+07	106.00	16846.00
VISITORS	25092.00	72082.00	0.51959E+10	282.00	0.39934E+06
ITEMS	32100.00	86176.00	0.74263E+10	0.00	0.48547E+06
AQUIITEMS	462.74	719.86	0.51820E+06	0.00	3602.00
ART	249.00	785.71	0.61735E+06	0.00	3969.00
AQUIART	4.97	20.64	425.83	0.00	106.00
SPECIMEN	0.00	0.00	0.00	0.00	0.00
AQUISPECI	0.00	0.00	0.00	0.00	0.00
DOKUMENTS	27883.00	38299.00	0.14668E+10	0.00	0.16000E+06
AQUIDOKU	1296.20	3100.90	0.96156E+07	0.00	14877.00
EXHIBITIONS	6.06	5.35	28.60	0.00	23.00
OWNEXHIB	3.10	3.22	10.36	0.00	14.00
OTHEREXHIB	2.77	3.31	10.98	0.00	11.00
PUBLICAT	0.97	3.13	9.77	0.00	17.00

Special museums, n = 34

variable	mean	std.dev.	variance	min.	max.
OWNER	1.91	0.29	0.82888E-01	1.00	2.00
TYPE	3.00	0.00	0.00	3.00	3.00
MANYEAR	7.82	6.68	44.64	1.00	26.00
TC	0.22627E+07	0.21905E+07	0.47981E+13	0.28774E+06	0.11000E+08
OPEN	1876.90	960.92	0.92336E+06	156.00	5050.00
VISITORS	20353.00	27382.00	0.74976E+09	1900.00	0.15928E+06
ITEMS	0.17802E+06	0.88372E+06	0.78095E+12	800.00	0.51645E+07
AQUIITEMS	2250.70	7213.60	0.52037E+08	0.00	37967.00
ART	89.50	363.90	0.13242E+06	0.00	1600.00
AQUIART	6.56	30.63	938.38	0.00	173.00
SPECIMEN	0.00	0.00	0.00	0.00	0.00
AQUISPECI	352.94	2058.00	0.42353E+07	0.00	12000.00
DOKUMENTS	48915.00	68764.00	0.47285E+10	0.00	0.25000E+06
AQUIDOKU	3501.30	12144.00	0.14748E+09	0.00	70000.00
EXHIBITIONS	6.47	5.47	29.95	0.00	22.00
OWNEXHIB	4.29	4.38	19.18	0.00	22.00
OTHEREXHIB	2.17	3.09	9.54	0.00	15.00
PUBLICAT	1.0588	1.48	2.18	0.00	5.00

Nature historical museums, n = 8

variable	mean	std.dev.	variance	min.	max.
OWNER	1.13	0.35	0.125	1.00	2.00
TYPE	4.00	0.00	0.00	4.00	4.00
MANYEAR	13.88	22.26	495.55	1.00	68.00
TC	0.32524E+07	0.60502E+07	0.36605E+14	0.25500E+06	0.18000E+08
OPEN	1492.60	1086.10	0.11796E+07	140.00	2706.0
VISITORS	19310.00	32387.00	0.10489E+10	100.00	95386.00
ITEMS	3000.00	8485.30	0.72000E+08	0.00	24000.00
AQUIITEMS	250.00	707.11	0.50000E+06	0.00	2000.00
ART	0.00	0.00	0.00	0.00	0.00
AQUIART	0.00	0.00	0.00	0.00	0.00
SPECIMEN	0.20543E+07	0.35178E+07	0.12375E+14	0.00	0.10400E+08
AQUISPECI	31111.00	60569.00	0.36686E+10	0.00	0.17752E+06
DOCUMENTS	3031.20	5977.70	0.35732E+08	0.00	16000.00
AQUIDOCU	128.87	352.15	0.12401E+06	0.00	1000.00
EXHIBITIONS	2.38	1.41	1.98	1.00	5.00
OWNEXHIB	1.50	1.41	2.00	0.00	4.00
OTHEREXHIB	0.63	0.92	0.84	0.00	2.00
PUBLICAT	31.00	57.61	3318.60	0.00	171.00

Regional museums, n = 20

variable	mean	std.dev.	variance	min.	max.
OWNER	1.05	0.22	0.50000E-01	1.00	2.00
TYPE	5.00	0.00	0.00	5.00	5.00
MANYEAR	24.75	27.81	773.25	7.00	121.00
TC	0.76706E+07	0.78620E+07	0.61811E+14	0.20276E+07	0.26000E+08
OPEN	4157.90	2990.90	0.89455E+07	1094.00	12050.00
VISITORS	46172.00	65025.00	0.42283E+10	3171.00	0.30363E+06
ITEMS	55038.00	63401.00	0.40197E+10	0.00	0.25400E+06
AQUIITEMS	711.50	644.60	0.41551E+06	0.00	2355.00
ART	3361.70	13269.00	0.17607E+09	0.00	59484.00
AQUIART	85.25	352.31	0.12413E+06	0.00	1580.00
SPECIMEN	9779.50	26521.00	0.70339E+09	0.00	95200.00
AQUISPECI	71.65	259.21	67190.00	0.00	1161.00
DOKUMENTS	0.17442E+06	0.21025E+06	0.44206E+11	0.00	0.73455E+06
AQUIDOKU	5000.00	6101.80	0.37232E+08	0.00	25000.00
EXHIBITIONS	8.90	6.09	37.04	2.00	25.00
OWNEXHIB	5.30	3.60	12.96	1.00	16.00
OTHEREXHIB	3.60	3.53	12.46	0.00	10.00
PUBLICAT	2.10	2.63	6.94	0.00	11.00

Combined art & culture historical museums, n = 9

variable	mean	std.dev.	variance	min.	max.
OWNER	1.22	0.44	0.19	1.00	2.00
TYPE	7.00	0.00	0.00	7.00	7.00
MANYEAR	6.11	3.69	13.61	2.00	15.00
TC	0.25359E+07	0.26030E+07	0.67758E+13	0.10084E+07	0.93530E+07
OPEN	2455.30	1074.90	0.11554E+07	1200.00	4215.00
VISITORS	24255.00	28610.00	0.81854E+09	5000.00	97400.00
ITEMS	14499.00	10896.00	0.11871E+09	500.00	40000.00
AQUIITEMS	279.11	259.68	67434.00	0.00	646.00
ART	950.56	792.15	0.62750E+06	216.00	2846.00
AQUIART	60.89	107.10	11470.00	8.00	341.00
SPECIMEN	215.89	647.67	0.41947E+06	0.00	1943.00
AQUISPECI	38.11	114.33	13072.00	0.00	343.00
DOCUMENTS	35404.00	49941.00	0.24941E+10	800.00	0.16102E+06
AQUIDOUCU	1839.70	4148.90	0.17213E+08	93.00	12848.00
EXHIBITIONS	13.00	4.39	19.25	6.00	18.00
OWNEXHIB	7.56	4.69	22.03	2.00	15.00
OTHEREXHIB	5.44	4.30	18.53	1.00	12.00
PUBLICAT	0.44	0.53	0.28	0.00	1.00

APPENDIX 2

Table A

	MUSEUM	(Explanations of the variables below)										
	N:O	OWN	TYPE	TC	iEFF	ii EFF	iDOM	iiDOM	iDEG	iiDEG	iDEF	iiDEF
	1	1	1	2 090 987 mk	Y	Y	0	0	1	1	N	N
	2	1	6	6 576 846 mk	N	N	3	1	0,47	0,86	N	N
	3	2	1	4 303 255 mk	N	N	1	1	0,71	0,71	N	N
	4	2	3	628 347 mk	Y	Y	0	0	1	1	N	Y
	5	2	1	1 518 378 mk	N	N	4	6	0,45	0,69	N	N
	6	1	7	1 358 574 mk	Y	N	0	1	1	0,96	N	N
	7	1	2	6 438 158 mk	Y	Y	0	0	1	1	N	N
	8	1	5	5 877 801 mk	Y	N	0	1	1	0,96	N	N
	9	1	5	3 360 536 mk	N	N	1	27	0,6	0,31	N	N
	10	2	2	255 305 mk	Y	Y	0	0	1	1	N	N
	11	2	2	3 169 673 mk	Y	N	0	1	1	0,97	N	N
	12	2	1	3 120 531 mk	N	N	8	36	0,22	0,34	N	N
	13	2	3	1 517 000 mk	Y	Y	0	0	1	1	N	N
	14	1	2	646 617 mk	Y	N	0	2	1	0,93	N	N
	15	1	2	915 835 mk	Y	N	0	1	1	0,69	N	N
	16	1	7	1 393 112 mk	Y	Y	0	0	1	1	N	N
	17	1	5	24 185 982 mk	Y	Y	0	0	1	1	N	N
	18	1	6	11 662 918 mk	N	Y	1	0	0,26	1	N	N
	19	2	3	1 293 598 mk	N	N	3	3	0,49	0,81	N	N
	20	1	2	281 762 mk	Y	Y	0	0	1	1	N	N
	21	1	1	1 868 600 mk	Y	Y	0	0	1	1	N	N
	22	1	5	3 032 923 mk	Y	N	0	3	1	0,5	N	N
	23	1	6	2 240 146 mk	Y	Y	0	0	1	1	N	N
	24	2	3	2 378 395 mk	N	N	17	34	0,12	0,42	N	N
	25	1	7	1 561 082 mk	Y	Y	0	0	1	1	N	N
	26	2	3	693 174 mk	N	N	1	1	0,91	0,91	N	N
	27	2	3	360 430 mk	Y	Y	0	0	1	1	N	Y
	28	1	6	3 265 208 mk	N	N	1	1	0,94	0,94	N	N
	29	1	5	2 241 220 mk	Y	N	0	4	1	0,47	N	N
	30	1	1	1 045 865 mk	Y	Y	0	0	1	1	N	N

	N:O	OWN	TYPE	TC	iEFF	ii EFF	iDOM	iiDOM	iDEG	iiDEG	iDEF	iiDEF
	31	1	7	1 008 416 mk	Y	Y	0	0	1	1	Y	N
	32	1	2	835 504 mk	N	N	6	13	0,31	0,63	N	N
	33	1	6	3 149 671 mk	Y	Y	0	0	1	1	N	N
	34	1	2	682 546 mk	Y	N	0	3	1	0,88	N	N
	35	2	3	1 259 784 mk	Y	Y	0	0	1	1	N	N
	36	1	5	6 692 987 mk	Y	N	0	1	1	0,93	N	N
	37	1	1	426 363 mk	Y	Y	0	0	1	1	Y	Y
	38	1	7	2 262 974 mk	Y	Y	0	0	1	1	Y	N
	39	1	1	678 968 mk	Y	Y	0	0	1	1	N	N
	40	2	3	1 300 000 mk	Y	Y	0	0	1	1	N	N
	41	1	5	6 196 026 mk	Y	Y	0	0	1	1	N	Y
	42	1	4	3 475 224 mk	Y	Y	0	0	1	1	N	N
	43	1	6	2 672 688 mk	Y	N	0	1	1	0,57	N	N
	44	1	5	4 161 540 mk	Y	N	0	1	1	0,74	N	N
	45	1	5	12 410 613 mk	Y	Y	0	0	1	1	Y	Y
	46	1	5	7 813 595 mk	Y	Y	0	0	1	1	N	N
	47	2	3	785 245 mk	Y	Y	0	0	1	1	N	N
	48	1	2	1 193 446 mk	Y	Y	0	0	1	1	N	N
	49	2	2	454 631 mk	Y	Y	0	0	1	1	N	N
	50	2	7	2 125 935 mk	Y	N	0	1	1	0,89	Y	N
	51	1	6	3 443 166 mk	Y	Y	0	0	1	1	N	N
	52	2	3	2 830 410 mk	N	N	1	4	0,46	0,46	N	N
	53	2	2	800 666 mk	Y	N	0	1	1	0,98	N	N
	54	1	6	838 090 mk	Y	Y	0	0	1	1	N	Y
	55	1	2	1 475 270 mk	Y	N	0	1	1	0,89	N	N
	56	1	6	5 660 915 mk	N	Y	1	0	0,54	1	N	Y
	57	2	3	930 604 mk	N	N	4	5	0,64	0,64	N	N
	58	2	2	621 187 mk	Y	N	0	3	1	0,89	N	N
	59	1	2	1 177 172 mk	Y	N	0	1	1	0,89	Y	N
	60	1	2	2 494 941 mk	Y	Y	0	0	1	1	N	N
	61	1	5	3 434 161 mk	Y	Y	0	0	1	1	N	N
	62	1	5	2 290 736 mk	Y	N	0	12	1	0,46	N	N

	N:O	OWN	TYPE	TC	iEFF	ii EFF	iDOM	iiDOM	iDEG	iiDEG	iDEF	iiDEF
	63	1	5	6 085 597 mk	Y	Y	0	0	1	1	N	N
	64	1	6	4 608 645 mk	Y	Y	0	0	1	1	N	N
	65	2	4	385 651 mk	Y	Y	0	0	1	1	N	Y
	66	2	5	2 690 615 mk	Y	Y	0	0	1	1	N	N
	67	1	2	803 783 mk	Y	Y	0	0	1	1	N	N
	68	1	2	1 529 100 mk	Y	Y	0	0	1	1	N	Y
	69	2	1	1 515 139 mk	Y	Y	0	0	1	1	Y	N
	70	1	2	323 968 mk	N	N	1	6	0,68	0,68	N	N
	71	1	6	3 058 970 mk	Y	Y	0	0	1	1	N	Y
	72	1	7	1 307 973 mk	Y	Y	0	0	1	1	N	N
	73	1	2	599 805 mk	Y	N	0	2	1	0,94	N	N
	74	1	1	4 252 000 mk	N	N	1	2	0,72	0,72	N	N
	75	1	5	5 527 598 mk	Y	Y	0	0	1	1	N	N
	76	1	5	2 783 157 mk	Y	Y	0	0	1	1	N	N
	77	2	3	1 249 475 mk	Y	Y	0	0	1	1	N	N
	78	2	3	287 738 mk	Y	Y	0	0	1	1	Y	N
	79	1	3	3 600 153 mk	Y	N	0	1	1	0,42	N	N
	80	1	3	3 878 278 mk	Y	N	0	1	1	0,79	Y	N
	81	2	3	2 103 017 mk	N	N	2	3	0,37	0,59	N	N
	82	2	3	5 327 500 mk	Y	Y	0	0	1	1	Y	Y
	83	2	3	1 807 767 mk	N	N	4	6	0,35	0,69	N	N
	84	2	3	4 103 917 mk	N	N	1	6	0,31	0,3	N	N
	85	2	3	433 941 mk	Y	N	0	1	1	0,98	N	N
	86	2	3	3 449 467 mk	N	N	2	12	0,36	0,3	N	N
	87	2	2	366 940 mk	Y	N	0	7	1	0,6	N	N
	88	2	3	6 117 460 mk	Y	Y	0	0	1	1	Y	Y
	89	1	5	2 196 265 mk	Y	N	0	3	1	0,48	N	N
	90	1	5	26 360 111 mk	Y	N	0	1	1	0,94	N	N
	91	2	3	2 880 558 mk	N	N	2	11	0,43	0,36	N	N
	92	2	3	2 891 638 mk	N	N	6	14	0,22	0,44	N	N
	93	1	5	2 027 600 mk	Y	N	0	8	1	0,52	Y	N
	94	1	5	25 251 199 mk	Y	N	0	1	1	0,98	Y	N

	N:O	OWN	TYPE	TĆ	iEFF	ii EFF	iDOM	iiDOM	iDEG	iiDEG	iDEF	iiDEF
	95	2	6	4 210 273 mk	N	N	1	1	0,73	0,73	N	N
	96	1	2	2 880 312 mk	Y	Y	0	0	1	1	N	Y
	97	1	2	470 703 mk	Y	Y	0	0	1	1	N	N
	98	2	3	1 247 143 mk	Y	Y	0	0	1	1	N	N
	99	1	2	684 532 mk	Y	N	0	1	1	0,99	N	N
	100	1	2	2 006 088 mk	Y	N	0	1	1	0,62	N	N
	101	1	7	2 451 656 mk	Y	Y	0	0	1	1	Y	N
	102	1	2	626 330 mk	Y	N	0	2	1	0,96	N	N
	103	1	1	8 253 614 mk	N	Y	1	0	0,37	1	N	N
	104	1	2	283 629 mk	Y	Y	0	0	1	1	N	N
	105	1	2	333 014 mk	N	N	1	2	0,66	0,66	N	N
	106	1	4	18 083 000 mk	Y	Y	0	0	1	1	Y	Y
	107	1	2	24 720 928 mk	Y	Y	0	0	1	1	Y	Y
	108	1	1	39 367 000 mk	Y	N	0	1	1	0,63	Y	N
	109	1	2	502 450 mk	N	Y	1	0	0,44	1	N	N
	110	1	4	255 000 mk	Y	Y	0	0	1	1	Y	Y
	111	1	4	566 000 mk	Y	Y	0	0	1	1	Y	N
	112	1	4	1 630 000 mk	Y	N	0	8	1	0,64	N	N
	113	1	3	3 204 000 mk	Y	Y	0	0	1	1	Y	N
	114	1	4	1 112 000 mk	Y	Y	0	0	1	1	N	Y
	115	1	4	595 357 mk	Y	Y	0	0	1	1	N	Y
	116	2	7	9 353 046 mk	Y	Y	0	0	1	1	Y	Y
	117	2	3	500 000 mk	N	Y	5	0	0,58	1	N	Y
	118	2	1	528 321 mk	N	Y	1	0	0,81	1	N	N
	119	2	2	219 153 mk	Y	Y	0	0	1	1	N	Y
	120	2	3	335 695 mk	Y	Y	0	0	1	1	N	N
	121	1	2	553 747 mk	N	Y	1	0	0,82	1	N	N
	122	2	3	4 630 900 mk	Y	N	0	1	1	0,66	N	N
	123	2	3	310 000 mk	Y	Y	0	0	1	1	N	N
	124	2	3	10 608 000 mk	Y	Y	0	0	1	1	Y	Y
	125	1	1	1 878 790 mk	N	N	1	3	0,56	0,56	N	N
	126	2	3	599 413 mk	Y	Y	0	0	1	1	N	N

N:O	OWN	TYPE	TC	iEFF	ii EFF	iDOM	iiDOM	iDEG	iiDEG	iDEF	iiDEF
127	2	3	906 881 mk	Y	Y	0	0	1	1	N	N
128	2	3	2 091 000 mk	N	N	11	18	0,28	0,5	N	N
129	1	1	1 332 025 mk	Y	N	0	1	1	0,98	N	N

Explanations:

N:O = Museum

OWN = Owner of the museum (1 = public, 2 = private)

TYPE = Museum type (1 = art, 2 = culture historical, 3= special, 4 = nature historical, 5 = regional, 6 = regional art, 7 = combined art & culture historical museums)

TC = Total costs

iEFF = Cost-efficiency (Y = efficient, N = inefficient), analysis I

iiEFF = Cost-efficiency (Y = efficient, N = inefficient), analysis II

iDOM = Number of dominations, analysis I

iiDOM = Number of dominations, analysis II

iDEG = Degree of cost-efficiency, analysis I

iiDEG = Degree of cost-efficiency, analysis II

iDEF = Efficient by default (Y = yes, N = no), analysis I

iiDEF = Efficient by default (Y = yes, N = no), analysis II

VI Conclusions

This thesis has analysed empirically production of cultural services in four self-contained articles. The four articles have each focused on a different facet of production and applied different methodologies. Together they contribute to the two main themes of the thesis: features of production of cultural services and factors affecting methodological choices.

As to methodological choices, this thesis has pointed out the lack of clarity in previous empirical assessments of production of cultural services. The four articles tackle the problem by first employing four different data sets together with four different methodologies - namely neo-classical and non-linear cost functions, Structural Equation Modeling (SEM), index numbers, and Free Disposal Hull (FDH) approaches - and then assessing the strengths and weaknesses of each methodology. These assessments reveal three main caveats of empirical analysis. The first caveat stems from *measurement problems*, the second danger lurks in *definition of production technology*, while the third problem arises from *availability and quality of data*. This thesis has explored several ways to circumvent or mitigate these three caveats.

Out of the *measurement problems* the most fundamental ones are connected to measurement of inputs and output(s). In terms of *output*, two problems are overriding:

how to measure artistic experiences and how to take into account the quality aspect. This thesis tackles the first problem by measuring the output of theatres as number of visitors and the output of orchestras as number of performances. The multiplicity of museums activities, in turn, demands multiple proxies for output, and hence, empirical analyses of museums require methodologies that allow multi-output framework. In general, this thesis advocates increasing sensitivity towards single vs. multiple output issue in analyses of cultural institutions.

The four articles have also illustrated that developing a uniform measure for the *quality* of output is problematic - the very definition of quality is elusive, operationalisations vary, and implications differ between institutions. The problem does not, however, concern solely the empirical analyses of cultural institutions, but troubles empirical analyses of all service industries in varying degrees. This thesis has suggested a pragmatic approach to the problem, and as a consequence underlines expediency of different dimensions of quality in interpretation of results. For example, the article on orchestras suggests that fluctuations in technical change derive partly from changes in quality, i.e. choice of repertoire and artistic personnel.

In measurement of inputs, definition of *capital input* has been shown to be particularly problematic. Because of this, this thesis proposes - for both performing arts institutions and museums - specific measures of capital input price which reflect the particularity of capital stock. The proposed capital input price of performing arts is defined as a ratio of capital costs to the seating capacity of the permanent venue of the institution, thus, directly relating capacity of each institution and attendance to the unit price of capital. Basing on a similar logic, the capital input price of museums is designed to take into account the importance of collection: the capital input price is defined as a sum of the ratio of cost of new acquisitions to number of new acquisitions and the ratio of real estate costs to magnitude of collection, and thus, the proxy reflects costs of existing capital stock as well as costs of new capital.

Caveats deriving from *definition of production technology* can be largely avoided by minimising the a priori assumptions on technology. In terms of parametric (econometric) methods this implies use of flexible functional forms instead of functional forms that a priori impose restrictions on technology. Alternatively, non-parametric methods (e.g. FDH and DEA) can be used. These methods do not require a functional form, and thus, altogether avoid mis-specification of technology, but prevent testing the properties of production technology. The trade-off between the two methods is, thus, in the testability of properties of technology vs. possibility of mis-specifications.

This thesis has demonstrated that testability is of particular interest in analyses of orchestras and theatres, while complexity of production technology speaks in favour of non-parametric methods in analyses of museums. The empirical results of this thesis have, moreover, pointed out that both parametric and non-parametric methods should incorporate possible inefficiencies, since neither production of orchestras nor museums was a result of best practice. This indicates a need to use methods based on frontiers or methods that incorporate inefficiencies e.g. by utilising shadow prices.

As to the problems connected to data, *availability of data* can be significantly promoted by preferring methods that operate in a price-quantity space. The reason for this is that data on economic aspects of production is more often available than data on technical aspects. In a parametric framework this implies that cost functions are preferred to production functions and in a non-parametric setting cost oriented FDH and DEA are favoured instead of input/output oriented approaches. Problems related to *quality of data* can be mitigated by employing parametric methods. This is because in parametric methods measurement errors are captured by error terms, whereas non-parametric methods, e.g. FDH and DEA, consider measurement errors as inefficiency.

Besides methodological discussion, this thesis has endeavored to establish the central features of production in orchestras, theatres and museums. Three features are of particular interest: *scale properties*, *utilisation of inputs* and *efficiency*.

The *scale properties of production* vary significantly across institution types. Museums are characterised by substantial scale economies: in a single-output setting, output measured either by number of visitors or exhibitions, the average cost flexibility ranges from 0.49 to 0.38. Also theatres exhibit size economies, albeit not as substantial as museums - the average cost flexibility in theatres is 0.75. Orchestras, in turn, are characterised by considerable dis-economies of size with average cost flexibility of 25.0. A likely explanation to this is the restricted demand of "high brow" classical music - with limited potential audience orchestras cannot rely on re-runs, but are forced to re-new their repertoire relatively often. In order to increase their output orchestras must rehearse a new piece that require additional practice and possibly extra musicians, maybe even of "super star" quality.

The three institution types vary also with respect to *input utilisation*. Museums are, in a single-output framework, moderately labour intensive (57% labour), while theatres exhibit significant labour intensity (89 % labour). Interestingly, orchestras prove to be moderately capital intensive (55% capital) challenging the received view, but confirming the findings by Gapinski (1979). Besides these findings, this thesis underlines importance of biases of scale - reflecting changes in cost shares of inputs as responses to changes in output - when assessing the relative utilisation of inputs. In museums the relative use of inputs remain constant as output expands implying that production technology is homothetic. In orchestras and theatres production exhibit non-homotheticity and relative cost shares of labour and capital vary as output expands. In orchestras the relative utilisation of labour increase significantly when output expands, whereas in theatres there was a small increase in relative use of capital.

The results on *efficiency* suggest that production of cultural services is characterised by inefficiencies. This thesis has put an emphasis on cost-efficiency instead of technical efficiency due to importance of cost-efficiency in terms of management and policy making and the fact that technical efficiency is sine qua non for cost-efficiency. The analyses of this thesis suggest that altogether 24 % of museums are cost-inefficient resulting excess spending of 10 % (assessed by museum type). Theatres, in turn, are allocatively inefficient - inputs are not combined in optimal proportions with respect to market prices: capital input is over-utilised some 6 % and labour some 5 %. As a result, the actual costs exceed the minimum costs on average by 5 %. Even if efficiency of orchestras has not been examined, the results on productivity growth suggest that also orchestras are likely to be inefficient. The relatively high fluctuations of technical change and particularly its spectacular falls hint to this direction.

The features of production, established in this thesis, have important *implications on policy making*. Most importantly, the findings emphasise the need to shift discussion from legitimisations and level of public subsidies to *efficient allocation of resources* - whether the resources allocated to production of cultural services are in their most efficient use and what kind of *incentives* could be used to ensure efficiency.

The results on *scale properties of production* in museums and theatres suggest that large scale production should be encouraged. This does not necessarily imply fusion of small institutions, but points out the need of closer co-operation between institutions. A more widespread use of shared services - e.g. administration, marketing and technical services - and increased engagement in joint projects - e.g. circulating exhibitions and performances - would induce cost savings. Hence, policies should foster co-operation both among theatres and museums. Orchestras, in turn, would profit from small scale production due to considerable diseconomies of size. A small chamber orchestra is undoubtedly cheaper to run than a full scale symphony orchestra, but performances of the two are not surely alike. Thus, a straight forward recommendation to advocate small scale production is hazardous.

Policy implications of *input utilisation* are most relevant with respect to investment decisions. Labour intensity of museums and theatres suggests that new investments in capital, e.g. buildings or collection, entail also increasing contributions to labour. Spending on capital has to be matched with spending on labour of roughly the same magnitude because capital cannot easily substitute labour. In the case of orchestras an increase in output requires a significantly larger increase in labour than in capital input, implying a need of even larger "matching effect" than in the case of museums and theatres. The results, thus, strongly point out that investment decisions must include a careful assessment of future operating costs. A case in point is the opening of the new museum of contemporary art, Kiasma, in Helsinki.

The results on *efficiency of production* have pointed out, most importantly, the need to introduce incentives to enhance efficiency. The results on productivity growth in orchestras suggest that with the right incentives orchestras could reap the benefits of productivity growth and possibly increase efficiency. The findings on theatres and museums, in turn, reveal that production is inefficient, but to a lesser extend than often claimed. In terms of policy making this indicates that there are no efficiency based grounds to substantial cuts of public subsidies at industry level. Notwithstanding this, individual institutions could, in some cases, significantly improve their performance. The challenge is again in finding the right incentives.

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DATA SETS (The following sources have been used to compile the data sets):

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Museotilasto 1996, Museovirasto 1997 (year 1996)

Toimintakertomus: Tietoja jäsenorkestereista kalenterivuodelta, Suomen Sinfoniaorkesterit ry (years 1978-1995)

Teatteritilastot, Suomen Teatterijärjestöjen Keskusliitto (years 1985-1993)