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Keywords: Service sector; efficiency; parametric methods; panel data; benchmarking

JEL Classification C14; D24; L80.

Working Paper nº 1419
July, 2014

UNIVERSIDAD
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MADRID

ISSN: **2341-2356**
WEB DE LA COLECCIÓN: http://www.ucm.es/fundamentos-analisis-economico2/documentos-de-trabajo-del-icae

Efficiency of theServices Sector: a Parametric Approach

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Abstract

The question if countries are achieving their maximum production given resource allocation is at the very centre of contemporary debates. The issue becomes even more relevant when directed to service activities, due to their cardinal role in modern societies. However, hardly any studies perform cross-country efficiency comparison of service sectors at aggregated level. The paper aims at measuring and comparing technical efficiency of (total and market) services across 16 developed economies during the past three decades. The empirical estimations are performedby means of frontier parametric techniques applied to both panel data and cross-sectional data. Benchmark figures, useful for cross-country comparison and policy analysis, are provided for efficiency scores and for their evolution across time.

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Introduction

Efficiency may be evaluated from different perspectives, as identified in the pioneer work by Farell (1957). But, essentially, it reflects the ability of any organisational unit to benefit from proper resource allocation. Few times in recent history experimented a greater stress on this concept than the past five years.Owing to the still-present economic crisis in developed economies, the (in)efficiency of markets and countries has become a central issue in contemporary debates. From this, a strong need for measurements of efficiency at sectoral and national level arises. Measuring efficiency at national level allows producing benchmark figures which are a necessary tool for cross country comparison as well as for policy analysis and evaluation.

This need is even more important in the case of service markets. At present, developed economies are service-based economies (Rubalcaba, 2007)[1]. Service activities represent around 70% of employment and GDP in developed countries. During the past three decades, important political and structural changes have transformed services markets functioning. Deregulation, privatisation and liberalisation modified services production and consumption. Frontiers had been opened to international competition (e.g. the GATS framework and all PTA agreements in services activities). Services have grown not at the expense of, but in close interrelation with, industrial activities within a type of *servindustrial* society (Maroto-Sánchez, 2012). Therefore, these activities have increasingly accounted for greater proportions of intermediate inputs (Melvin, 1989; PilatandWölf, 2005) with relevant effects on total productivity (Francois, 1990; HoekmanandMatoo, 2008). The sector has made a substantial contribution to both productivity and employment growth during the past decade in OECD economies

(OECD, 2005). While recognising substantial heterogeneity among the different service sub-sectors, Jorgenson and Timmer (2010) note that since the 1990s market services productivity growth has outweighed productivity growth in goods production in the United States and Japan[2]. It is straightforward that the monitor of services efficiency in production is a matter of great interest in its own right and also due to the influence that these activities have upon the rest of the economy. Increasing the efficiency of tertiary activities may lead to boosting the growth of the whole economy.

The bulk of efficiency research has traditionally focused on firm level analyses. Commercial banks (Gardener et al, 2011; Abdul-Majid et al, 2011), hotels (De Jorge andSuárez, 2013), and retail firms (Sena, 2011; Suárezand De Jorge, 2012) have received a great deal of attention[3]. A high number of studies have also developed cross-country efficiency analysis for particular service sectors. This is the case of the work by Gupta et al. (1997) and Evans et al. (2000) on the efficiency of the health sector, which used a panel of 85 economies and of 191 WHO member countries, respectively. Afonso and St Aubyn (2005) investigated health and education efficiency in OECD countries using measures of expenditure and quantity inputs. Moreover, Clements (2002) performed an empirical study on the efficiency of education in European countries with a particular emphasis on transition economies. In a similar line, Sutherland and Price (2007) analysed educational efficiency and policy and institutional settings in OECD economies. However,few attempts to measure services efficiency at aggregate and cross-country level can be found in literature. This shortcoming may be explained by the lack of available aggregate data (mainly on inputs, e.g. labour and capital) allowing for adequately large cross sections of countries. These data limitations have only recently started to be overcome. One of the first estimations of efficiency by the means of an aggregate frontier production function was performed by Färe et al. (1994). This pioneering work used non-parametric techniques to decompose productivity growth in 17 industrialized countries into technical progress and efficiency change. More recently, Kumar and Russell (2002) analysed economic growth convergence taking as reference a production frontier function at world level estimated by non-parametric techniques. Both Kneller and Stevens (2003) and Kumbhakar and Wang (2005) have used a parametric approach for estimating a stochastic world production frontier. While the former considered the impact of the specification of the functional form (Cobb-Douglas versus Translog), the latter found evidence in favour of taking into account country heterogeneity when measuring technical inefficiency. To the knowledge of the authors, the only work performing a cross-country efficiency comparison of aggregate services sectors is represented by Navarro and Martín (2011). This research applied non-parametric techniques to calculate technical efficiency of total sectors, total services and 16 categories (of which 10 correspond to services activities) in OECD countries in 2006. It is found that the average efficiency level reached in the aggregated service sector by the countries included in the sample is around 57% being Estonia, Luxembourg, United States and Mexico the leading countries in the total services efficiency rankings.

In this context, this papers aims to overcome an important gap in macro-level studies of efficiency embedded in aggregate tertiary activities production by means of a parametric study on the whole services sector. The present work measures the efficiency of 16 national aggregate services sectors markets[4] for a period of 27 years, from 1980 until 2007. Three main research questions are addressed: (i) Which is the average efficiency embodied in services production? (ii) What are the relatively most efficient countries in services production? (iii) How did their efficiency develop over time? In order to give an answer to these questions, the paper aims at comparing efficiency scores across countries and across time. The econometric analysis will allow benchmarking of efficiency in tertiary activities across countries during the observed period.

The study is performed over two services aggregate: total services and the market services. The former is composed by all tertiary activities referred as sectors G to P of the NACE Rev 1.1 classification, in other words, by all tertiary activities, e.g. transport, retail or education[5]. The latter is composed by sectors G to K, namely all service activities but the ones mainly produced by the public sector, such as health or public administration. The choice of the total services aggregate is motivated by the need for a macroeconomic efficiency measure of the most important sector of advanced economies. The choice of the second aggregate reflects the need for a control aggregate given the high heterogeneity encountered in services production and especially in services data collection. In particular, the measurement of the output in non-market services still faces serious problems in national accounts. So far, their output has been approximated by a sum of the inputs involved in the production. The abandonment of the so-called input approach in favour of more direct output volume quantification is still an ongoing debate (DjellalandGallouj, 2008, p. 68). Some initiatives on the measurement of non-market output indicators have been developed (OECD, 1999; Eurostat, 2001; and more recently Atkinson, 2005). However, until these advances are not fully implemented the measures of non-market services outputs and inputs should be interpreted with care (Jorgenson andTimmer, 2010, p. 10).

The 16 economies included in the analysis account for two thirds of world GDP and for almost 70% of all services produced worldwide[6], due to their high specialisation in services. In order to allow for cross-country comparison as well as giving an insight on the evolution of efficiency over time we perform two different analyses: a study for the whole period as well as a breakdown for two specific years: 1996 and 2006. Results show three groups of economies as regards the behavior of relative efficiency scores: high performers (mainly North European economies); average performers (including Anglo-Saxon, Continental Europe and Mediterranean economies) and a set of nations which are comparatively the low performers (Eastern European countries and Japan). Also, according to the dynamics of efficiency scores in the last decade of analysis a winner and a looser group of countries are identified.

The paper is structured as follows. Section 2 discusses definitional and methodological issues as regards efficiency measurement and presents the models and estimation methods in detail. It analyses how a Cobb-Douglas and Translog production functions estimated by panel data and corrected ordinary least squares had been the chosen modelling strategy. Section 3 describes the data on which the analysis is implemented. Particular attention is given to the transformation needed in order to deal with differences in prices across countries and with differences in prices across periods. Then, the results attained are exposed and discussed in Section 4 while Section 5 concludes with some final remarks.

Methodology

Some definitional Issues

The efficiency of a group of agents (firms, organisations or countries) may be evaluated from different perspectives. In his seminal work, Farrell (1957) identifies three different types of efficiency measures[7]. *Technical efficiency* denotes the extent to which the units of analysis are able to produce the highest quantity of output with a given set of inputs, or, alternatively, of producing a given output with a minimum quantity of inputs.

Allocative efficiency takes into account the relative prices of inputs and thus refers to the capability of producing the maximum output given inputs costs, or, alternatively, of minimizing input costs given a quantity of output. *Economic (or overall) efficiency* comprises both concepts: it denotes the maximization of output given the least costly combination of inputs.

In the economic literature, empirical estimations of efficiency are commonly based on frontier techniques. This approach estimates a frontier production function, which represents the maximum attainable output for a firm/organisation/country given the available technology. Deviations of observed output from this optimal benchmark measure technical in(efficiency). Therefore, the higher the distance to the frontier, the more inefficient a firm/organisation/country is (Farell, 1957). Frontier techniques can be broadly classified into parametric or non-parametric[8]. The latter estimates a frontier production function directly from the sample observations on the basis of linear programming methods without establishing any specific technology transformation form *ex ante*. Data envelop analysis (DEA) (Charnes et al., 1978; 1981) has become a widely used technique within this approach. On the other hand, parametric techniques compute the frontier by means of econometric analysis and establish a functional form of the technology and of the inefficiency error term *a priori*. They may be categorised into deterministic (Richmond, 1974; Greene, 1980) or stochastic models (Aigner et al., 1977; Meeusenand van den Broeck, 1977; Batteseand Cora, 1977). While the deterministic approach assumes that all deviations from the frontier are under control of the agent, stochastic models also capture the impacts of exogenous shocks (e.g. institutional, social or demographic factors or simply “luck”). In both parametric approaches, (in)efficiency is therefore associated with the disturbances estimated in the regression model. All along the paper we refer to efficiency as well as to inefficiency indistinctively. Both concepts can be considered as two sides of the same coin when inefficiency is intended as the measure at which a subject fails to reach the highest attainable efficiency.

This paper implements a deterministic approach in order to measure the *technical efficiency* of a group of countries as regards services provision. The choice of the approach is driven by the properties of the deterministic strategy. It makes only minimal assumption on the distribution of the inefficiency term and is suitable for a comparative analysis, such as the one pursued in this research (Green, 2007). Within this framework, the paper estimates the frontier production function for the 16 countries included in the sample using panel and cross-sectional data. In both cases, the focus is set on analysing the disturbances obtained from the regressions as they contain the information about inefficiency.

In our macro-analysis, we consider the gross output at country level for the total services sector (TS) and for market services (MS), as output and the labour and capital compensation as inputs. All variables are adjusted for inflation and purchasing power parity[9].

Models Specification and Estimation Methods

Panel Data

As a first step of the analysis, we estimate the frontier production function on the basis of a panel data set available for 16 countries for the period 1980-2007. As in Evans et al. (2000), in this phase we assume that efficiency is time invariant and that it is related to some characteristics of the observed country (that did not change during the period under study). These strong assumptions will be released later. Nonetheless they are motivated by the need to identify the relative effect of the "core" characteristics of each single economy for comparison purposes. This modelling strategy implies the choice of fixed effects estimators. This approach also has the additional advantage of not having to assume the independence of inefficiencies with respect to input levels. Moreover, it does not need any distributional assumptions on the inefficiency term included in the model. Finally, this approach yields consistent estimations of the residuals (Greene, 2007, page 87). In this framework, the production function to be estimated is represented as:

$$y_{ct} = f(x_{ct}, \beta) TE_c \qquad \text{(I)}$$

where c indexes countries (c = 1,….,N), and t indexes time (t = 1,….,T). y is the gross output expressed as a function of the matrix of inputs (X) and the technical efficiency term (TE)[10]. The vector of parameters of the production function β has marginal relevance in our analysis. In logarithmic terms, equation (I) may be written as:

$$\ln y_{ct} = \ln f(x_{ct}, \beta) + \ln TE_c = \alpha + \beta \ln x_{ct} + v_{ct} - u_c \qquad \text{(II)}$$

The error term is composed by two elements: v_{ct} and u_c.$v_{ct}$is theindependent and identically distributed random error with mean zero, and u_c accounts for time invariant country-specific technical *inefficiency* (u_c). This is a non-negative random variable, which is obtained by:

$$u_c = -\ln TE_c \approx 1 - TE_c \,.$$

We assume the u_c to be independent of the v_{ct}. Equation (II) may therefore be rewritten as:

$$\ln y_{ct} = \alpha_c + \beta \ln x_{ct} + v_{ct} \qquad \text{(III)}$$

where the constant term $\alpha_c = (\alpha - u_c)$ is country-specific and the country with the maximum α_c is assumed to be fully efficient. Estimation proceeds by means of least squares and we define the estimated relative inefficiencies as in Schmidt and Sickles (1984):

$$\hat{u}_c = \hat{\alpha} - \hat{\alpha}_c = max_c(\hat{\alpha}_c) - \hat{\alpha}_c$$

Technical efficiency is estimated via $TE_c = \exp(-u_c)$, where the lower the value, the more inefficient the corresponding country is.

Departing from this model, we fit two specifications of the production function: the full Translog model and a nested version such as the Cobb-Douglas log-linear formulation. Nowadays, both models dominate the applications literature in econometric efficiency estimation (Greene, 2007). Assuming that the national gross output (y) is obtained by labour (l) and capital (k) expenditures, we estimate the following models for both total services (TS) and market services (MS):

$$\ln y_{ct} = \alpha c + \beta_1 \ln l_{ct} + \beta_2 \ln k_{ct} + \beta_3 (\ln l_{ct} \ln k_{ct}) + \beta_4 (\ln l_{ct})^2 + \beta_5 (\ln k_{ct})^2 + v_{ct} \qquad \text{(IV)}$$

and,

$$\ln y_{ct} = \alpha c + \beta_1 \ln l_{ct} + \beta_2 \ln k_{ct} + v_{ct} \qquad \text{(V)}$$

Notwithstanding the similarities with the stochastic frontier specification, this is essentially a deterministic approach in the context of fixed effects models. Namely, we estimate individual intercepts for each country, deem the maximum as fully efficient and the rest of the countries are compared to it instead to an absolute benchmark. It follows that we are not measuring absolute inefficiency but inefficiency of one country relative to the others in the sample.

COLS (Corrected Ordinary Least Squares)

In a second step of the analysis, we release the efficiency time invariance assumption. It is reasonable to expect that the factors influencing services markets functioning, and therefore efficiency in their production, can change over time. For this reason we assume that efficiency can evolve and measure it in two moments, 1996 and 2006, in order to get some insights on the change in relative positions across countries over time. To this end, we define a production function and perform estimations using corrected ordinary least squares (COLS) estimators for cross-sectional data.

The time span chosen allow us to make consideration on recent market reforms that took place in the observed countries before the current economic downturn. This is especially the case of European Union (EU) New Member States (NMS)[11], where important political, institutional and market reforms were implemented during that period.

In this context, the production function to be estimated is represented as:

$$y_c = f(\mathrm{x}_c, \beta) TE_c$$

where$c$ indexes countries (c = 1,….,N), or, when expressed in logs:

$$\ln y_c = \ln f(x_c, \beta) + \ln TE_c = \alpha + \beta \ln x_c - u_c$$

Following Richmond (1974), the COLS methodology to measure efficiency works as follows: after estimating the production function with ordinary least squares (OLS) estimators, the intercept is shifted up by the maximum residual value in order to obtain the estimated production frontier. This method gives a consistent estimator of the frontier value (Greene, 1980). The corrected constant term is:

$$\hat{\alpha}_{COLS} = \hat{\alpha} + max_c(\hat{u}_c)$$

and the resulting inefficiency measures are provided by the corrected residuals:

$$\hat{u}_{c,COLS} = max_c(\hat{u}_c) - \hat{u}_c$$

In the COLS context, we fit a Cobb-Douglas production function for the years 1996 and 2006. In fact, we estimate the following model for both TS and MS:

$$\ln y_{c,96} = \alpha + \beta_1 \ln l_{c,96} + \beta_2 \ln k_{c,96} + u_{c,96} \qquad \text{(VI)}$$

$$\ln y_{c,06} = \alpha + \beta_1 \ln l_{c,06} + \beta_2 \ln k_{c,06} + u_{c,06} \qquad \text{(VII)}$$

Under this approach, the frontier is a parallel shift up of the OLS production function and all countries, except one, remain below it. As in the panel data model previously presented, this deterministic approach captures relative rather than absolute inefficiency and it is especially suitable for comparison purposes.

Data

This paper aims at comparing efficiency across countries and across time. Consequently, current data on inputs and output have to be corrected, first, for differences in prices across countries and, second, for differences in prices across periods. In this section we explain the reasons for these choices and the strategy implemented. The arguments expose hold for total services as well as for market services aggregates indistinctively.

Ideally, efficiency analysis comparisons should make use of physical measures of inputs and output, such as, for example, number of hours worked or volumes of services produced. However, “in services, the use of physical units is often not at all possible. In practice, one is more likely to have only access to figures on the total values rather than quantities of output and inputs.” (InklaarandTimmer, 2008, page 6).Since, in the case of the service sector, aggregate physical units of outputs make little sense due to the intangibility of several tertiary activities and to the high heterogeneity of products produced, we implement our analysis making use of values figures rather than quantities.

Current values figures on gross output, labour compensation and capital compensation are extracted from the EU KLEMS growth and productivity database (www.euklems.net) presented in O’Mahony and Timmer (2009)[12]. Nonetheless, current values data in national currency fall short when an inter-countries and inter-temporal comparison is carried on. Efficiency measurement based on these figures could be biased by both, differences in national prices and the effect of different inflation rates over time.

Therefore, for what relates the cross country comparison, value measures need to be corrected for differences in relative prices between countries[13]. This correction is here made by the means of real exchange rates built on the purchasing power parity indexes (PPPs) provided by Inklaar and Timmer (2008). PPPs use the world technology and productivity leader, the Unites States (US), as the base-country, and are provided exclusively for the year 1997. When two countries share a common currency, the real exchange rates correspond to the relative price ratio. When the two countries make use of different currencies, the real exchange rates correspond to the relative price ratio times the nominal exchange rate. With this transformation we obtain deflated values, in US 1997 dollars. Accordingly, the services output produced in country *c* in 1997 is given by

$$y^{97}_{c,PPP} = y^{97}_{c,curr} PPP^{97}_{c,Y}$$

Where $y^{97}_{c,curr}$ represents the current output value for the year 1997 and $PPP^{97}_{c,Y}$ is the real exchange rate based on relative prices of the services aggregate output. Conversely, the deflated value of labour and capital are constructed as

$$l^{97}_{c,PPP} = l^{97}_{c,curr} PPP^{97}_{c,L}$$

$$k^{97}_{c,PPP} = k^{97}_{c,curr} PPP^{97}_{c,K}$$

Where $l^{97}_{c,curr}$ and $k^{97}_{c,curr}$ are the current values of labour and capital compensation, $PPP^{97}_{c,L}$ and $PPP^{97}_{c,K}$ are the real exchange rates constructed on the relative prices of the service aggregate labour compensation and capital compensation respectively.

In order avoid inflation driven distortions, we need to take into consideration the different evolutions of prices across countries over the observed period. Deflated figures are therefore corrected by an index relating the evolution of country prices with respect to the evolution of the base-country, the US. With this further transformation we obtain double deflated values, in US 1997 dollars, to which we refer as constant values. Services output in constant terms in each year is therefore defined as

$$y_{c,PPP}^{year} = y_{c,curr}^{year} PPP_{c,Y}^{97} \frac{\Delta Y\_P_c^{97,year}}{\Delta Y\_P_{US}^{97,year}}$$

where $\Delta Y\_P_c^{97,year}$ and $\Delta Y\_P_{US}^{97,year}$ represent the growth rate of output prices between each year and 1997, for the considered country c and the US, respectively. The output price indexes are provided by the above mentioned EU KLEMS database.

Unfortunately, no indexes are available for price evolution of labour and capital compensation. Proxies for these indexes are constructed for each country by the ratio of the growth rates of current values ($\Delta l_{c,curr}^{97,year}$ and $\Delta k_{c,curr}^{97,year}$) and the growth rates of volume figures ($\Delta l\_Q_c^{97,year}$ and $\Delta k\_Q_c^{97,year}$). All growth rates are calculated with respect to the base year 1997. Therefore the value of labour and capital compensation in constant term for the aggregate services sector in each considered year is defined as:

$$l_{c,PPP}^{year} = l_{c,curr}^{year} PPP_{c,L}^{97} \frac{\dfrac{\Delta l_{c,curr}^{97,year}}{\Delta l\_Q_c^{97,year}}}{\dfrac{\Delta l_{US,curr}^{97,year}}{\Delta l\_Q_{US}^{97,year}}}$$

and

$$k_{c,PPP}^{year} = k_{c,curr}^{year} PPP_{c,K}^{97} \frac{\dfrac{\Delta k_{c,curr}^{97,year}}{\Delta k\_Q_{c}^{97,year}}}{\dfrac{\Delta k_{US,curr}^{97,year}}{\Delta k\_Q_{US}^{97,year}}}$$

It is worth noticing some features about the data after the implemented transformation in order to obtain constant values. As shown in the Annex (Figure A1) the production of both, market services (MS) and total services (TS), has experienced an upward trend during 1980-2007. Annual growth has been relatively fast in the United States and Australia; and more moderate in Italy and Sweden. Moreover, it is worth noticing the high relevance of MS activities within TS during the period under analysis: MS accounts for three quarters of TS output (Table 3 of the Annex). We could expect that MS capital and labour compensation account for similar percentages of the TS aggregate. Contrariwise, the role played by labour and capital inputs results significantly different. The weight of MS capital compensation accounts for 87% of TS capital compensation, while labour compensation in MS does not go beyond 68% of TS labour compensation. This first exploratory analysis indicates that MS activities are more capital intensive, and that the presence of public services within the TS aggregates r accounts for labour intensive activities.

Results

Panel Data Analysis

Output and input data in constant values are used to estimate the frontier production functions presented in Section 2.3 by means of the software LIMDEP. Table 1 summarises the estimation results of equations IV and V (cross country time invariant efficiency analysis) for the case of TS and MS aggregates. At first glance, it appears clear how the Cobb-Douglas specification fits better the dataset than the Translogmodel, in which most of the parameters are not statistically significant, for both service aggregates. Under the Cobb-Douglas production technology, the TS and MS output elasticities with respect to labour are consistently larger than that with respect to capital, confirming the labour oriented characteristic of the tertiary activities. However, output elasticity with respect to labour in TS is 8% larger than the corresponding value in MS; while elasticity with respect to capital is 33% smaller. These differences could be imputed to the higher labour intensity of the public services included within TS.

Table 1. Coefficients estimates for the frontier of total services and market services production function, 16 countries, 1980-2007

	Total services (TS)		**Market services (MS)**	
	Cobb-Douglas (V)	Translog (IV)	Cobb-Douglas (V)	Translog (IV)
ln*l*	0.98399***	1.12651***	0.91083***	0.89497***
	(0.01729)	(0.18440)	(0.01849)	(0.17887)
ln*c*	0.07301***	-0.18557	0.10828***	-0.0734
	(0.01716)	(0.15865)	(0.01837)	(0.15778)
$(\ln l)^2$		-0.00647		-0.01666
		(0.02120)		(0.02088)
$(\ln c)^2$		0.01107		-0.01067
		(0.01604)		(0.01563)
(ln*l** ln*c)*		0.00079		0.03582
		(0.03495)		(0.03402)
R^2	0.99879	0.99883	0.99843	0.99849
Mean of $\hat{u}_c$	0.447163	0.462213	0.516739	0.51937
StdDev $\hat{u}_c$	0.230358	0.244583	0.278596	0.283006
N	357	357	357	357

Notes: ***, **, * means significance at 1%, 5%, 10% level. Standard deviations in brackets.

As discussed in Section 2, the residuals ($\hat{u}_c$) account for time invariant technical inefficiency and, thus, are our main focus of our attention. The mean of $\hat{u}_c$ can be interpreted as the measure of the average technical inefficiency in the entire sample, e.g.

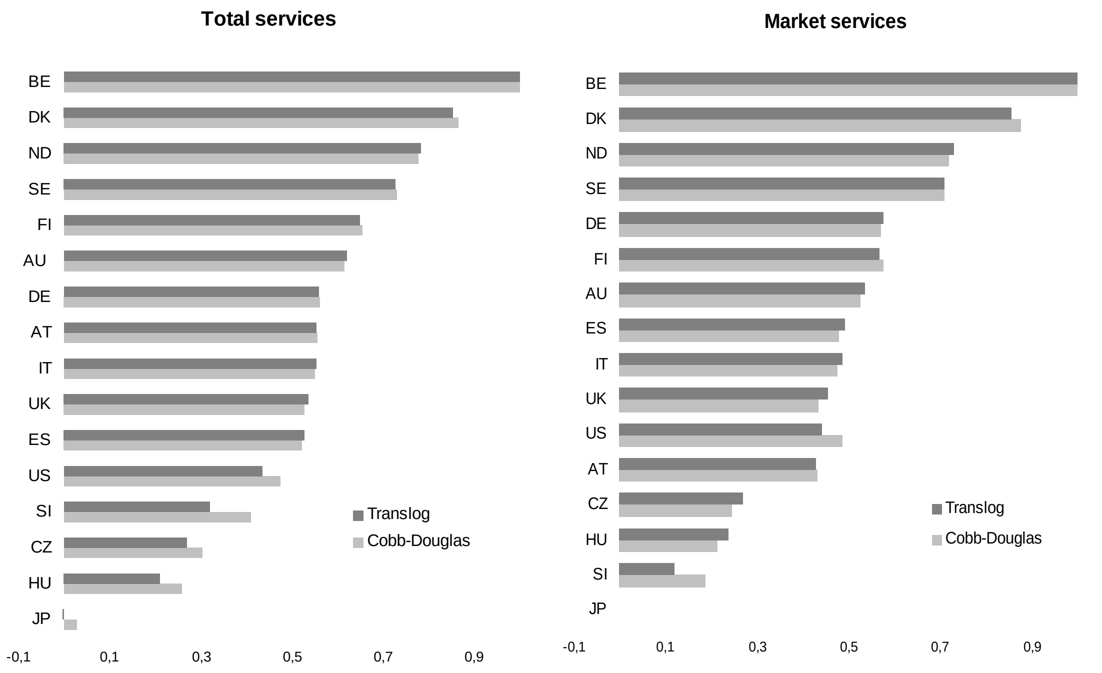
the mean deviation from the frontier. According to Table 1, under the Cobb-Douglas production technology, the technical inefficiency embedded in MS production is larger (51.6%) than that of the aggregated services sector (44.7%)[14]. It is worth noticing that the latter result is rather similar to the one estimated by non-parametric techniques by Navarro and Martín (2011). The fact that TS appear to be more efficient than MS seems counterintuitive. To a certain extent, this result is the reflection of the measurement problems experienced by non-market services presented in Section 1. Most countries have only recently begun to directly quantify the volume of outputs for health, education and other public services that will eventually provide information on more appropriate measurements of non-market services productivity[15]. However, since these initiatives are not yet fully implemented, difficulties in quantifying output influences the degree of technical efficiency measured in TS. This result also calls for further and deeper analysis by services sub-sectors, in order to uncover the diverse behaviour of efficiency across service branches.

The number of economies included in our sample is relatively small (N=16) but, on the other hand, we consider a reasonable long time period (T= 27). According to Schmidt and Sickles (1984), under these preconditions, the estimation results are more reliable for comparison than for determining levels. In other words, higher trust can be put on the country comparisons inferred within each aggregate, than on the inefficiency values. This could also be at the basis of the efficiency discrepancies across service aggregates observed above.

Figure 1 displays the technical efficiency scores for each country in our sample. First thing noting is that country rankings are similar regardless the specification of the production function. In fact, ranking correlation for the Cobb-Douglas and

Translogspecification is 0.996 and 0.978 in TS and MS, respectively. This suggests that the country rankings found are relative robust. While Belgium emerges as the most efficient nation in the provision of TS and MS, Japan displays the lower efficiency scores in both cases.

Figure 1. Technical efficiency country rankings



Three groups of countries, as regards the pattern of efficiency scores, can be recognised. Some Central-Nordic European economies (Belgium, Denmark, Netherlands, Sweden and Finland) are relatively more efficient in both TS and MS provision, displaying efficiency scores between 60 and 100%[16]. On the other hand, some countries from Continental Europe (Germany, Austria), the Mediterranean economies included in the sample (Italy and Spain) and Anglo-Saxon nations (Australia, United States, United Kingdom) behave around the average efficiency (scores between 40 and 60%). Eastern European countries (Hungary, Czech Republic and Slovenia) and Japan are comparatively the least efficient in total and market services production presenting efficiency scores below 40%.

The clusters of countries found show a strong geographic and socio-economic determination. To a certain extent, the configuration of efficiency across countries relate to the varieties of service economies models already identified by Gadrey (2007 and 2009). Based on three main criteria, such as the employment structure of the service sector, job quality and skill levels in services, as well as the relative importance of market and non-market services, Gadrey (2009) recognised four service models[17] or "worlds" across OECD economies: liberal (or Anglo-Saxon); Nordic; European Continental; and familialist[18]. Burger and Stare (2010) and Daniels et al. (2011) have recently stressed that there are more varied service models in the enlarged Europe. Varieties of service economies across Europe have also been recently identified by Di Meglio et al. (2012). Different national conventions on equality, solidarity, gender and family;as well as differences in the institutional organization of production underlie this diversity of worlds in developed economies and may also play a role in explaining patterns of efficiency in services across countries.

COLS Analysis

Releasing the time invariance assumption, we can explore the behaviour of efficiencyacross countries over time by the means of the corrected ordinary least squares approach presented in Section 2.3. We estimated the models presented making use of data relative to two time periods: 1996 and 2006. In this second phase of the analysis, our attention is therefore focused on the trends obtained by the comparison of the (countries specific) residuals over time. Table 2 displays the results of the estimations of equations VI and VII in both sectors, TS and MS.

As the table shows, the mean inefficiency (mean of $\hat{u}_c$) is, once more, higher for MS than for TS. The same justifications presented above hold. Nevertheless, it can also be noted how the average technical inefficiencies obtained by the panel data estimation are nearly twice the values found here. This outcome supports the caution with which the panel data estimations levels have to be interpreted. The mean inefficiency can also be interpreted as a measure of the unexploited potentials of the countries included in the sample. Indeed it measures the average distance between each country and the most efficient one. Therefore it can be interpreted as an index of the potential efficiency gains attained if all countries converged to the leaders' efficiency levels. In this sense, it can be stated that during the period under analysis a slow convergence process is in act in TS, while a minor divergence over time takes place in MS.

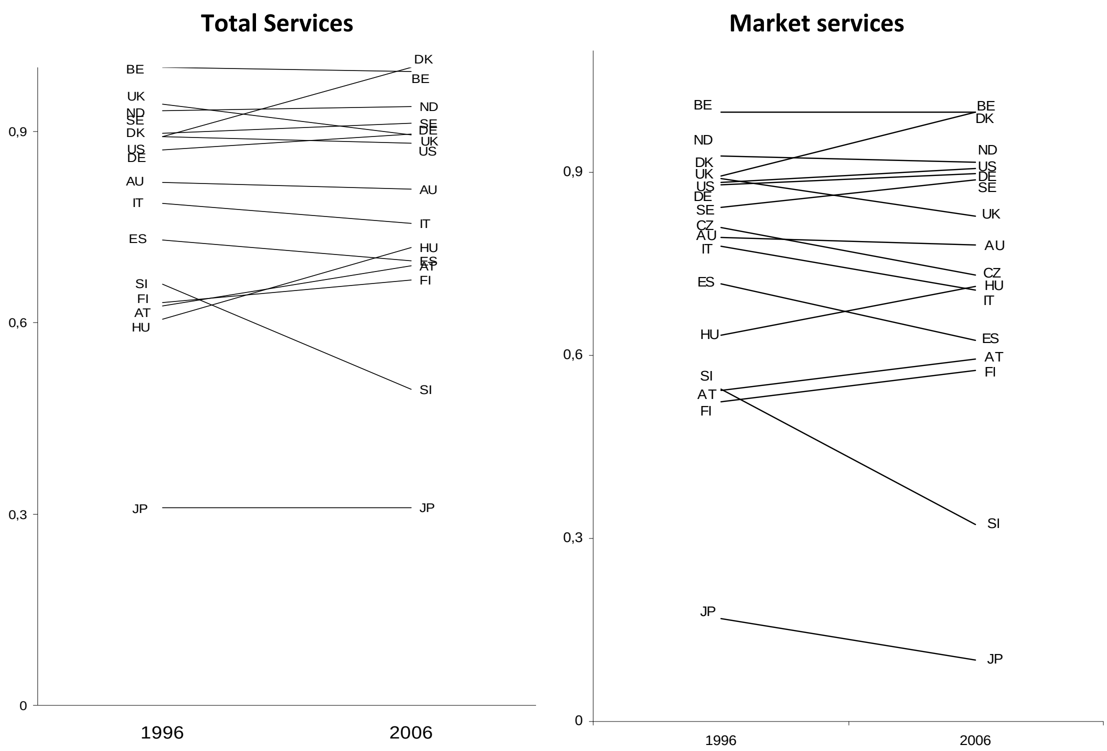
Table 2 Coefficients estimates for the frontier of total services and market services production function, 16 countries, 1996 and 2006

	Total services (TS)		**Marketservices (MS)**	
	1996 VI	2006 VII	1996 VI	2006 VII
ln*l*	0.57047***	0.74818***	0.49774***	0.68082***
	(0.08622)	(0.07080)	(0.08690)	(0.7504)
Ln*k*	0.37048***	0.23181***	0.41427***	0.26841***
	(0.07523)	(0.06543)	(0.06906)	(0.6758)
Constant	1.89240***	1.29850**	2.28971***	1.74969**
	(0.43496)	(0.49003)	(0.54478)	(0.65072)
R^2	0.98618	0.98418	0.97998	0.96787
Mean of $\hat{u}_c$	0.227859	0.225739	0.260177	0.275753
StdDev $\hat{u}_c$	0.175110	0.184375	0.211386	0.243801
N	16	16	16	16

Notes: ***, **, * means significance at 1%, 5%, 10% level. Standard deviations in brackets.

In Figure 2, the dynamics of country efficiency scores between 1996 and 2006 are shown. Since most countries in our sample follow the same pattern (e.g. a decrease or increase of efficiency scores) for both, TS and MS sectors, we are able to identify two large groups of economies. The first one is composed by those nations experiencing an improvement in relative efficiency in both sectors between 1996 and 2006. It is the case of Denmark, Hungary, Finland, Austria, Sweden and Germany. The other group consists of countries undergoing a relatively decline in TS and MS technical efficiency: Slovenia, Spain, Italy, United Kingdom and Australia. Other economies do not behave homogeneously across sectors as they gain relative efficiency in TS while losing it in MS (The Netherlands) or vice versa (United States).

Figure 2.Technical efficiency country rakings: 1996 and 2006 comparison



Conclusions

This paper adds a contribution to efficiency research on services at aggregate level by means of a parametric approach. It does so by measuring and comparing the efficiency in services production at aggregate level in 16 developed countries over a period of approximately 30 years. The paper applies two different econometric approaches, which can be defined as deterministic frontier models, on two different services aggregates, total services and market services.

The research also represents a step forward towards providing benchmark figures which are useful for cross country and time comparison; and, ultimately, for policy analysis and policy evaluation. The quantified inefficiency can be interpreted as a measure of the potential gains in production that could be attained if all the countries converged to the efficiency levels exhibited by the best performing economies. Our results reveal potential gains between 23% and 28%, when analysing cross-country data for the last decade. The level of potential gains is larger for the case of panel data; however, these values should be interpreted with caution, as we have explained in previous sections. Instead, panel data analysis is more useful for comparing cross-country patterns of efficiency scores. According to our results, three clusters of countries are found on the basis of the behavior of efficiency scores: high performers, average performers and low performers. The former is composed by Central-Nordic European countries, namely Belgium, Denmark, Netherlands, Sweden and Finland, which can be identified as the most efficient services markets, displaying efficiency scores between 60 and 100%. As average performers, we found countries from Continental Europe (Germany, Austria), Mediterranean economies (Italy and Spain) and Anglo-Saxon nations (Australia, United States, and United Kingdom). Finally, Eastern European countries, (Hungary, Czech Republic and Slovenia) and Japan are included in the group of low performers, since they show efficiency scores below 40%. To a certain extent, the configuration of efficiency across countries show a strong geographic and socio-economic pattern and relates to the varieties of service economies models already identified in the literature.

The study of the evolution of efficiency scores can serve for benchmarking countries across time. This can be useful when evaluating and comparing the effectiveness of economic policies adopted during the time span analysed.When time trends are observed between 1996 and 2006, we are able to identify a winner and a looser group. The first one is composed by those nations experiencing an improvement in relative efficiency: it is the case of Denmark, Hungary, Finland, Austria, Sweden and Germany. The other group consists of countries undergoing a relatively decline: Slovenia, Spain, Italy, United Kingdom and Australia.

Further analyses are needed in order to push forward the results achieved in this paper.In particular, the heterogeneity of services sector calls for sub-sector specific efficiency studies. Theymay serve to deepen our understanding of the results found at aggregate level and may also provide useful data in order to evaluate the impact of policies at sectoral level. Additionally, an econometric analysis of the determinants of efficiency scores may be useful to assess the influence of diverse factors (economic, institutional or social) on the potential unexploited gains in services production. Lastly, another interesting avenue of future research is application of non-parametric techniques to our data set in order to be able to compare the estimations of services efficiency scores and, eventually, provide further robustness to the results of our study.

Acknowledgement

The authors gratefully acknowledge funding through the ServPPIN project: *The Contribution of Public and Private Services to European Growth and Welfare, and the*

Role of Public-Private Innovation Networks, Socio-Economic Sciences and Humanities Programme of the EU 7th Framework.

Notes

[1] Some scholars argue that the growing importance of services is a myth supported by the definition of this sector in national accounts statistics, in which sectoral classification of activities is based on the nature of work rather than on output use (Jansson, 2006 and 2009).

[2] This has not been the case of Europe. See Timmer et al. (2010) for a detailed analysis of EU services productivity patterns.

[3] Efficiency research at firm level is extensive and comprehensive reviews on this argument can be found in the Fried et al (2007).

[4] Australia (Au), Austria (At), Belgium (Be), Czech Republic (Cz), Denmark (Dk), Finland (Fi), Germany (De), Hungary (Hu), Italy (It), Japan (Jp), the Netherlands (Nl), Slovenia (Si), Spain (Es), Sweden (Se), United Kingdom (Uk) and the United States (Us).

[5] See Table A1 in the Appendix for a detailed description of the sectors covered.

[6] Figures based on World Development Indicators, World Bank.

[7] Earlier studies in this line are represented by Debreu (1951) and Koopmans (1951).

[8] Murillo-Zamorano (2004) provides a comprehensive review of this literature and remarks that ‘no approach is strictly preferable to any other’ (page 31).

[9] See section 3 for an exhaustive description of the dataset employed.

[10] Note that $TE_c = {y_{ct}}/{f(x_{ct},\beta)}$ and thus $0 < TE_c(y_{ct}, x_{ct}) \le 1$.

[11] For these countries methodological consistent data at industry level are available since 1995.

[12] See Table A2 in the Annex for a detailed description of data availability.

[13] One could think that this correction could be made by using nominal exchange rates. Nevertheless, nominal rates fall short in comparing economies or sector where low level of international integration are attained, such as several service activities.

[14] Estimations are similar for the Translog model.

[15] See Atkinson (2005) and Djellal and Gallouj (2008) for recent extensive discussions on measurement problems in public services.

[16] In the case of market services, Finland shows efficiency scores slightly below 60%.

[17]Esping-Andersen (1990) and Sapir (2006) constructed an international typology like this but based on social models and welfare state characteristics.

[18] Liberal grouping comprises the United States, Canada, United Kingdom and Australia. Nordic model comprises Sweden, Norway, Denmark and Finland. European Continental includes France, Germany, Belgium and the Netherlands, while familialist includes Italy, Portugal, Spain, Greece and Japan. Belgium and the Netherlands can be grouped together with the Nordic depending on the criteria used.

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