Productivity of the Service Sector: A Regional Perspective

JOSÉ L. NAVARRO and JOSÉ A. CAMACHO

In this article we analyse the evolution of productivity in the service sector for the Spanish Regions during the period 1986–94. The study environment has been limited to marketed services. Within this group of activities, we set out an analysis for different branches of activity – credit and insurance, transports and communications, and other marketed services. The methodology used includes tools such as data envelopment analysis to measure technical efficiency, the Malmquist indexes to determine the evolution of the productive change and the break-up of total efficiency into intra-sectorial efficiency and composition efficiency. The results at a national level show a tendency to drop of total efficiency until 1990 and a later recovery until the end of the analysed period. This evolution is explained by the behaviour of the composition efficiency, while the intra-sectorial efficiency maintains quite a uniform growth in this period.

INTRODUCTION

The continuous growth of services in the current economies and the role that these play in the process of modernisation of the productive structures justifies the analysis of the productive efficiency of these activities. The progressive integration of the services in the rest of the productive sectors reinforces its role in the thrust of the process of economic growth [Del Río, 1992; Illeris and Philippe, 1993; Eurostat, 1997; González, 1997; Camacho, 1999]. In the industrial sector [Prior, 1990; Maudos et al., 1998; Pedraja, Ramajo and Salinas, 1999] researchers have carried out numerous surveys to evaluate productive efficiency and the advance of total productivity. In the case of the services the studies frequently reduce the analysis of some of their branches using specific data for these activities. Among the Spanish

José Luis Navarro Espigares and José Antonio Camacho Ballesta are at the Facultad de Ciencias Economicas, Universidad de Granada, Campus U. de Cartuja, E-18071 Granada, Spain.

PUBLISHED BY FRANK CASS, LONDON
authors we can find several analyses referring to the financial services [Grifell et al., 1994; Pastor, 1995; Pastor et al., 1997] and health services [Prior and Sola, 1993; Barber and González, 1996; Prior and Sola, 1998; Navarro, 1998; 1999a; 1999b].

This article begins an investigation line which is centred on the efficiency and the productive change of the service sector and its different activity branches; it does not introduce theoretical contributions in the field of the analysis of efficiency, although, it presents two novelties. On the one hand, we try to advance knowledge by introducing the year 1994 into the analysis, once the series corresponding to this year for the capital stock have been published. Secondly, we have carried out a disaggregated analysis of the production of the services sector where we distinguish between the behaviour of two activity branches, Credit and Insurance and Transports and Communications.

We have analysed the evolution of productivity in the service sector for Spanish Regions during the period 1986 and 1994. The study scope has been limited to marketed services. Inside this group of activities we outline an analysis differing for some activity branches – credit and insurance, transports and communications, and other marketed services. Using the realised classification by Gadrey [1996] which differentiates three evaluation levels, this work should be located in the micro and macroeconomic levels. However, the utilised methodology, in our opinion, reduces the inconveniences pointed out by Gadrey for the evaluations of this type. The realised evaluation is not centred in the productivity of the labour input calculated, starting from synthetic indexes, but in the analysis of a global indicator of productivity obtained, starting from the indexes of technical efficiency, where the indexes of prices and quantities do not intervene in any way. The methodology used (non parametric frontier) includes tools like data envelopment analysis to measure technical efficiency, the indexes of Malmquist to determine the evolution of productive change, and the break-up of the total efficiency in intra-sectorial efficiency and composition efficiency.

The most frequent explanation of the growth of productivity is the factor of technical progress; it is production technology that allows a transformation of the inputs into outputs and, consequently, the factor responsible for the results reached in the rates of productivity. In this sense, the sector where it may be more feasible to introduce the factor of technical change, will have more opportunities for the growth of productivity. This approach allows us to classify the economic activities as progressive or stagnated, but it suffers from a certain determinism when linking the evolution of the productivity with exogenous variables to the internal organisation of the production. This means forgetting that the productivity does not only depend on technical
progress, but that it also varies according to changes in productive efficiency and, even, for modifications of the environment in which the production process is carried out. Thus the evolution of the service enterprises can be explained as much by the processes of organisational learning as by the innovation activities [Sundbo, 1997].

The conventional techniques of measurement of productivity [De Bandt, 1990; Griliches, 1992; Cuadrado, 1998] identify the growth of this with the increment of the output that is not due to an increment associated with the inputs, and they suppose, therefore that the real output is on the production frontier, that is to say that the productive unit acts efficiently. However, whether organisations act in market structures that move away from perfect competition, because of the divergence in the functions of proprietors’ utility and managers, or for any other reason, what is certain is that in a large number of the organisations it is easy to detect production costs above the minimum obtainable costs with the available technology, that is to say, inefficiency (organisational slack, technical inefficiency).

A correct evaluation of the evolution of the service sector, based on the growth of productivity, should establish the differences among the different sources or causes that have induced that growth. We should not forget that improvements in productivity could be reached without technical progress, reducing the margin of technical inefficiency. Emphasising the environment variables, we will associate the changes in production technology with displacements of the production frontier, and the changes in technical efficiency with the distance between the real output and the potential. This way, the technical efficiency is reached when it is not possible to increase the output volume with the available inputs.

Measuring technical efficiency involves a few difficulties, one of the most important among them being the determination of the production frontier. That production limit is relative and not absolute, since it is obtainable from the observations that show the best results among all those included in the sample. The internal learning, the diffusion of new technologies, the management and the adjustment capacity to those external shocks are expressive elements of a bigger technical efficiency in economic organisations. An index that is extremely useful to measure the changes in productivity which incorporates technical inefficiency is the Malmquist indexes.

The sequence continued in our study has been:

1. Calculation of the global technical efficiency – GTE – (constant returns to scale) using the added data corresponding to marketed services both at a regional level and a national level as well. The calculation has been carried out for each of the years from 1986 to 1994.
2. The same calculation of the previous phase is carried out for each of the branches in those that we have divided into the for sale services sector: Transport and Communications, Credit and Insurance, and other marketed services. This break-up of the GTE will allow us to analyse the position of relative efficiency in each of the years for the three activity branches.

3. Applying the methodology of efficiency by groups we have proceeded to calculate the intra-sectorial (IE) efficiency. In our case, it consists of calculating the levels of production obtainable for each region in the sector of marketed services once we have eliminated the inefficiencies of each one of the three considered activity branches. The relationship between the level of potential production and the already generated GVA provides us with the measure of the intra-sectorial efficiency for each region in each of the years studied.

4. Substituting the data of real GVA for the potential production obtained in the previous phase, the GTE of the service sector is calculated again for sales for each region in every year. The results obtained in this new study indicate to us the value of the composition efficiency (CE).

5. The product of the values IE and CE allow us to know the measure of total productivity of the marketed services starting from data disaggregates for three activity branches.

6. Comparison of the results with those obtained in the phase 1.

7. Analysis of the evolution of composition efficiency.

8. Dynamic analysis of the productive change. This analysis is carried out by means of two different procedures, the Malmquist indexes, on the one hand, and a pluri-annual frontier, on the other, in both cases using aggregate data for the service sector for sales for each region.

METHODOLOGY

The analysis of the productivity in some branches of activity of the services sector that we carry out uses three conceptual blocks:

- The analysis of efficiency by means of a non-parametric frontier (data envelopment analysis).
- The indexes of Malmquist.
- The efficiency by groups (break-up of the total efficiency in intra-sectorial efficiency and composition efficiency).
We will try to give a brief description of each one of these techniques that have been treated in depth in numerous works.

*Data Envelopment Analysis (DEA)*

The fundamental characteristic of the so-called frontier models consists of measuring the efficiency of each unit in relation to the frontier of efficient production. This way, and according to the established suppositions, individual efficiency measures can be obtained for each evaluated unit, or a measure of the level of average inefficiency of an industry or for a group of production units.

Starting from a group of observations we can define two frontier types:

a) The absolute frontier is defined as that in which all the firms or companies use a certain technology.

b) The frontier of best practice, is defined starting from a sample of firms that use the same technology. In this frontier type, any variation in the sample can mean a variation in the frontier.

This methodology has the advantage that it is not necessary to know or to suppose a certain production function that ties the different outputs with the different inputs. What is actually measured is the comparative efficiency of each unit, and the values that are used as a reference for the comparison come from the units presenting the highest values for the outputs/inputs global relationship; these units are the ones that define the frontier of observed efficiency.

Farrell [1957] opens a line of investigation analysing the efficiency that is based on measuring the distance between the various measurements carried out and the efficient frontier of production. Starting from the position of Farrell, in recent years two diverse ways for the measurement of efficiency have been developed:

1. Not defining a production function *a priori* (measures non parametric efficiency);

2. Defining a certain production function previously.

We will centre ourselves on the first option, that is to say, in the model of evaluation, deterministic and non-parametric. The qualifying deterministic implies that the production or costs frontier of each company lacks aleatory elements. We do not take into consideration the good or bad luck that increases or reduces the frontier of production possibilities. The non-parametric character means that it is not necessary to specify a certain functional form of the frontier function. These models are known by the name of data envelopment analysis (DEA) and they come from the environment of operative investigation, since they
are in the definitive problems of mathematical programming generally lineal.

The DEA consists of a method of mathematical programming which generalises that the measure of the technical efficiency of Farrell, for an input and an output, to the case of multiple inputs and outputs by means of the construction of an indicator of the relative efficiency in ratio form between the output and the virtual input. The original model was developed by Charnes, Cooper and Rhodes in 1978 with Constant Returns to Scale (CRS) and it was extended by Banker, Charnes and Cooper [1984] including Variable Returns to Scale (VRS). Therefore, the two basic models of DEA are known as CCR and BCC, according to the initials of their respective creators.

The key of the analysis resides in finding the best virtual producer for each true producer. If the virtual producer is better than the original producer, because it gets more output with the same input or because it elaborates the same output with less input, then the original producer is inefficient.

The procedure of finding the best virtual producer can be formulated as a lineal program. To analyse the efficiency of $n$ producers supposes a group of $n$ problems of lineal programming. The following formulation is one of the standard methods for the DEA from the optics of the inputs. Lambda ($\lambda$) is a vector that describes the percentages of the other producers that are used to build the virtual producer. $X$ and $Y$ are the inputs and outputs vectors for the compound producer (virtual). $X_0$ and $Y_0$ describe the inputs and outputs of the analysed producer or evaluated producer. The value of $\theta$ is reflective of the efficiency of the evaluated producer.

$$
\begin{align*}
\text{Min } & \quad \theta \\
\text{s.t. } & \quad Y\lambda - Y_0 \\
& \quad \theta X_0 - \lambda X \leq 0 \\
& \quad \theta \text{ free}, \quad \lambda \geq 0
\end{align*}
$$

The DEA has been applied in activities of very diverse nature such as: public health (hospitals, clinical), education (schools, universities), banks, factories, fast food restaurants, etc. The characteristics of simultaneity and heterogeneity of services should not lead us to reject the usefulness indicators of efficiency [Klassen, Russell and Chrisman, 1998].

Due to its wide application the DEA can be a powerful tool when it is used correctly. The main advantages are:

- It can manage models with multiple inputs and outputs.
- It does not require previous establishment in a functional way that relates inputs with outputs. The only maintained hypothesis is that the
space of the production technology is convex; that is to say that a studied sum of inputs and outputs of two productive units is in a 'virtual unit' of feasible technology.

- The units of decision are compared directly against a partner or a combination of partners.

- The inputs and the outputs can be expressed in very different units.

The same characteristics that make the DEA a powerful tool can also create problems. Analysts must keep these limitations in mind when they are deciding whether to use the DEA or not, as well as when they interpret the results that they have obtained of their application:

- Since the DEA is a technique of extreme accuracy, noise (even the symmetrical noise with an average of zero) as well as measuring errors, can cause important problems. The formation of the frontier is very sensitive to outliers so the study units should be homogeneous and it would be helpful to check the presence of influential observations. The general problem is finding a form of controlling the heterogeneity of the decisions maker units. The general solution consists of adding restrictions that limit the group of units to those structurally comparable or to select those that operate in a similar environment.

- The DEA is a good way of estimating the relative efficiency of a producer but it converges very slowly toward absolute efficiency. In other words, you can tell how well you achieve in comparison with your partners but not in comparison to the theoretical maximum.

- Since the DEA is a non-parametric technique, it is not possible to apply statistical tests relative to the kindness of the adjustment. Also, their non-parametric character will only make the number of decision making units and variables (input and output) conditional on the frequency of efficient units. To increase sample size, *ceteris paribus*, the fewer efficient units; to increase the number of variables, *ceteris paribus*, the more efficient units. With the result that any direct comparison among the results of the DEA corresponding to different groups of units or with different variables is inadequate.

*The Malmquist Index*

Using the methodology proposed by Berg, Forsund and Jansen [1992] and, later on, used by Grifell and Lovell [1993] it is possible to estimate the productive change using the Malmquist index. The use of this index makes possible the break-up of the productive changes experienced by companies.
in approaches to the frontier (catch-up) and in displacements of their own frontier (technical change).

The frontier shift or technical change should be understood as technological progress, that is to say changes in the production frontier due to the improvement of available technology. At the same time, the approaches of companies to the efficient frontier represent the part of the variation of global productivity not directly attributable to technological progress, which can be due to the effect of learning, diffusion of the knowledge in the application of technology, improvement of the organisation, etc.

These indexes use the distance function notion, for its calculation requires the previous estimate of the corresponding frontier.

We can find a pioneer application of this process referred to in the Spanish Bank System in Pastor [1995] where the technical DEA is used to evaluate the technical efficiency of each entity through the distance that separates it from the production frontier and, later on, it evaluates the productive change and the technical change between two periods by means of the use of the Malmquist index.

The index of Malmquist, the same as the DEA, allows its application with two focuses. The first one analyses the differences in productivity as the differences in the maximum output obtainable given an input level, the Malmquist productivity index is output oriented. On the other hand, the Malmquist productivity inputs-oriented index analyses the differences of productivity as well as the differences in the minimum inputs level that allows the production of some levels of certain outputs. Caves et al. [1982] demonstrate that both indexes provide identical results only in cases where the returns to scale are constant.

To illustrate the calculation of the Malmquist index, we represent the transformation function that describes the technology of the companies in every period as:

\[ F_t(y^t, x^t) = 0 \quad t=1,\ldots, T \]

where \( y_t \) is the outputs vector and \( x^t \) is the vector of corresponding inputs, both in a period \( t \).

The technology can be represented in a more convenient way through the ‘function of input distance’ used by Caves et al. [1982]:

\[ D^1(y^2, x^2) = \text{Max} \mu_{12} [\mu_{12} : F_1(y^2, x^2/\mu_{12}) = 0] \]

where \( \mu_{12} \) is the maximum deflation of the vector of inputs of the period 2 \( (x^2) \) such that the vector of inputs deflated resultant \( (x^2/\mu_{12}) \) and the outputs vector \( (y^2) \) are in the same frontier of the period 1. When the values of \( t \) coincide, each company is compared with the frontier from the period to
which belongs. In this case the function input distance is \( D^i(y^i, x^i) \geq 1 \), being equal to the unit in case the evaluated company is efficient and, therefore, is at the frontier. On the contrary if \( t = 1 < 2 \) the function distance can take inferior values to the unit, since the observation belongs to one period different from that of the frontier with which it is comparing it to (the reference frontier).

The Malmquist productivity inputs-based index, taking the technology of the period 1 like reference, can be defined as:

\[
M_1(y^2, x^2, y^1, x^1) = \frac{D^1(y^1, x^1)}{D^1(y^2, x^2)}
\]

A \( M_1 > 1 \) indicates that the productivity of period 2 is superior to that of period 1, (since the necessary deflation of the vector of inputs of period 1 in order to be in the frontier of period 1 is superior to the one applicable to the vector of inputs of period 2) so that it will be in the frontier of period 1. On the contrary a \( M_1 < 1 \) indicates that the productivity has descended between periods 1 and 2. Similarly, it is possible to build the same Malmquist index taking the technology of period 2 as a reference:

\[
M_2(y^2, x^2, y^1, x^1) = \frac{D^2(y^1, x^1)}{D^2(y^2, x^2)}
\]

The Malmquist index does not need relative data of prices, which is a great advantage, mainly in those cases in which there are serious statistical deficiencies, or simply in cases in which the existence of price regulations makes its use inadvisable, which is the case in any activity of the public sector.

Although the first works used parametric estimates of the production function, starting from the work of Berg et al. [1992], for their estimate, the technique non-parametric determinist DEA is used. This estimated type was also used by Grifell et al. [1993] to analyse the productive change in the Spanish Savings Banks.

The referred break-up of the Malmquist index in the catch-up effect and the displacement of the frontier can be expressed as:

\[
M_1(y^2, x^2, y^1, x^1) = \frac{D^1(y^1, x^1)}{D^1(y^2, x^2)} = \frac{D^1(y^1, x^1)}{D^1(y^2, x^2)} \cdot \frac{D^2(y^2, x^2)}{D^2(y^2, x^2)} \cdot \frac{D^1(y^2, x^2)}{D^1(y^2, x^2)}
\]

The first quotient represents the approach from the companies to the frontier that took place between periods 1 and 2, while the second term shows the relative displacement of the frontier among the two periods.
If the company is in both periods in its respective frontiers, the first term will be equal to 1 and the experienced productive change between the two periods will only be explained by the movement of the frontier. On the contrary, if the second term is 1 (the frontier has not moved), the changes of productivity for $M_I$ will only be explained by the changes in the efficiency of the companies in both periods (catch-up). In the other cases, the productive changes reflected in $M_I$ will be a mixture of changes in the efficiency and displacements of the frontier.

Färe and Lovell [1978] formalised the existent relationship between the input distance function and the measures of Farrell inputs savings methods $E_{II} (y^l, x^l)$, and demonstrated that the distance function is similar to the inverse of the Farrell inputs-oriented technical efficiency measurement:

$$D^I (y^l, x^l) = [E_{II} (y^l, x^l)]^{-1}$$

For the case of constant returns to scale, the Malmquist index can be expressed as:

$$M_I (y^2, x^2, y^1, x^1) = \frac{D^I (y^1, x^1)}{D^I (y^2, x^2)} = \frac{E_{12}}{E_{11}}$$

which in this case was reduced to a simple ratio of indexes of productivity of periods 1 and 2. If we decompose the previous index in their two components (catch-up and frontier displacement) we will obtain the following expression:

$$M_I (y^2, x^2, y^1, x^1) = \frac{D^I (y^1, x^1)}{D^I (y^2, x^2)} = \frac{E_{12}}{E_{11}} \cdot \frac{E_{12}}{E_{22}}$$

where the catch-up or relative approach to the frontier which took place between periods 1 and 2 would be $(E_{22} / E_{11})$ and the displacement of the frontier between the two periods would be expressed by $(E_{12} / E_{22})$.

**Efficiency by Groups**

The development of our analysis starts from the use of data envelopment analysis from the viewpoint of the outputs. It is concerned with the evaluation of the technical efficiency of each Spanish region in comparison with a virtual producer that gives a GVA the same or bigger using the same quantities of factor labour and capital.
Max $\Theta^n_i$

s.a.

$$\sum_{r=1}^{R} \lambda_r Y^n_r \geq Y^n_i \Theta^n_i \quad r = 1 \ldots R$$

$$\sum_{r=1}^{R} \lambda_r X^n_{rm} \leq X^n_{im} \quad m = 1 \ldots M$$

$\lambda_r \geq 0$

where $\Theta^n_i$ represents the indicator of the inefficiency of the region $i$ in the sector $n$, that is to say, the production increment that could take place without having to increase the consumption of resources

$$\Theta^n_i = \frac{\sum_{r=1}^{R} \lambda_r Y^n_r}{Y^n_i} = \frac{Y^n_i}{Y^n_i}$$

$Y^n_i$ represents the output of the region $i$ in the sector $n$

$\hat{Y}^n_i$ represents the maximum attainable output for region $i$ in sector $n$

The aggregate production of the region $i$ one can be obtained by the production of the different sectors or branches of activity.

$$Y_i = \sum_{n=1}^{N} Y^n_i$$

The evaluation of a region $i$ at aggregate level presents the problem of the undervaluation of the productive inefficiency of this region. The undervaluation arises as a consequence of considering feasible the linear combination of any sort of resource type to obtain a certain level of aggregate production, being concerned with the limitations imposed by the existence of a certain productive structure that in any event will suppose a restriction to the hypothesis of convexity in the productive space. To avoid this problem we propose that the evaluation of the regional efficiency may be carried out starting from the sectorial data or activity branches data, and not starting from the aggregate production data.

The level of productive efficiency of a certain region will depend on two approaches. On the one hand, it will depend on the level of efficiency of each one of their productive sectors or activity branches of activities (intra-
sectorial efficiency, IE). On the other hand, it will depend on the sectorial composition of aggregate production, that is to say, of the relative size of the most efficient sectors, and of the relative size of the less efficient sectors inside the evaluated region regarding the reference group (composition efficiency, CE).

We can represent the level of efficiency of the aggregate production for a region \( i \) as:

\[
\hat{Y}_i = \sum_{n=1}^{N} \hat{Y}_i^n = \sum_{n=1}^{N} Y_i^n \Theta_i^n = \text{Maximum attainable production for the region } i \text{ once having eliminated their intra-sectorial inefficiency}
\]

Nevertheless, there is the possibility that a region is efficient in each one of its productive sectors and yet may not be efficient at aggregate level. The intra-sectorial efficiency does not guarantee the total efficiency. An efficient region should observe the requirement of intra-sectorial efficiency, but it should also present the most appropriate composition in its productive structure, that is to say, it should also be efficient in its composition.

We will represent the level of total efficiency as:

\[
\Theta_i = \frac{\hat{Y}_i^*}{Y_i} = \frac{\hat{Y}_i^*}{\hat{Y}_i} \cdot \frac{\hat{Y}_i}{Y_i} = \Theta_i^{CE} \cdot \Theta_i^{IE}
\]

Where

\( \hat{Y}_i^* = \text{Maximum attainable production for the region } i \text{ once having eliminated their intra-sectorial inefficiency and the composition inefficiency.} \)

The calculation of the two components by means of the DEA will be carried out in two phases. The first phase, starting from the real production of each sector in each region, will provide us with the level of intra-sectorial efficiency. Later on, using the values obtained in the first phase, we transform the real production into potential production once intra-sectorial inefficiency has been eliminated. With these last values, that is to say, supposing that all the sectors of all the regions are efficient, we execute the program again and we obtain the scores of composition inefficiency.

**DATA AND RESULTS**

The evaluation of the productive change in some branches of activity of the services sector carried out in this work takes as a starting point the
calculation of the production frontier by means of the application of the data envelopment analysis. The elected variables to represent the outputs and inputs were the gross added value, the employment volume and the stock of private capital respectively. From an analytical point of view the analysis would be enriched however by the introduction of some additional inputs that qualify the use of resources or the quality of the same ones. It could offer, without a doubt, a special interest by utilising the decisive paper of the labour input production of knowledge [De Bandt, 1999]; however, from the operative environment we have considered it of top priority to maintain the proportion that the technical DEA recommends among the number of variables (X+Y=3) and the number of evaluated units (N=17). The general recommendation suggests to use, as a minimum, a number of units three times superior to the number of variables [Banker et al., 1989]. The general problem of the degrees of freedom in DEA and the quality of the data offered by this technique has been recently analysed [Pedraja, Salinas and Smith, 1999].

The used data maintain the necessary disintegration according to the required position, that is to say, the data of added value and employment used refer to two specific activity branches (Credit and Insurance, and Transport and Communications) within the attaché of Marketed services offered by Regional Accounting. The relative data of the stock of private capital have been obtained from the last publication of the Foundation BBV in which they are included in the series corresponding to the exercises 1993 and 1994. This publication offers data disaggregates as much sectorial as regionally. The data corresponding to the stock of public capital have not been included in the analysis.

The period 1986–94 is taken. The election of the time period has been conditioned by the existence of a homogeneous series and, obviously, for the last data published for the three variables used in the model.

In the commentary of the results obtained we will follow the order previously indicated in the introductory section. In Figure 1 we have represented in a zero to a hundred scale the results at a national level of the technical efficiency of the service sector for sale and have the results of those of the three activity branches in which we have divided it (Transport and Communications, Credit and Insurance, other marketed services) for each one of the studied years.

- The first evidence that one obtains of the analysis is that the level of efficiency of the Marketed services has maintained levels very close to 85 per cent during the analysed period. Although a small increase in the positions of each year starting from 1987 can be noticed, (a year that was exceptionally low in the series). This comment is equally valid for the
branch ‘other marketed services’. We have also calculated a difference among the total of Marketed services and the branches Transport and Communications and Credit and Insurance. However, in the activity branches of Transport and Communications, on the one hand, and Credit and Insurance, on the other, we find very singular evolutions in terms of efficiency. A characteristic common to both is that they present inferior values of efficiency to the sectorial ones during the whole period studied. Also, both branches start from levels close to 73 per cent, that is to say, significantly below the level of sectorial efficiency. In the case of the branch of Transports and Communications the values of efficiency present a growing tendency, especially noticeable in the period 1986–92 which makes it rise from the initial 73 per cent to 79.8 per cent in 1994. In the branch of Credit and Insurance the levels of efficiency at the end of the period of study are very similar to those of departure, nevertheless their situation has not been stable. Starting from 1988 a fall takes place in the values of efficiency which drops to its lowest level in 1990 and from this year on a recovery begins that lasts until 1994.

The previous comments are valid for most of the Spanish regions, individually considered. Nevertheless it is worthwhile pointing out some important peculiarities. Regarding the levels of efficiency reached, it is necessary to highlight the case of Madrid that presents frontier values during the nine years studied. Also the regions of Baleares and País Vasco present GTE values of the same or near to 100 per cent in most of the years. On the contrary, the regions of Galicia and Extremadura present levels of sectorial efficiency quite below the national average. Regarding the evolution followed by the sectorial efficiency in the
different regions, the behaviour of Galicia and Canarias moves away from the norm where a noticeable descent in efficiency takes place until 1990, followed by a later recovery that, nevertheless, does not allow them to reach the departure values in 1994.

- In the branch of Transports and Communications, it is Baleares region that ranks itself in the efficient frontier during each of the analysed years. Madrid, Canarias, Comunidad Valenciana and País Vasco are the regions that have the highest levels of technical efficiency in this activity branch. The case of Comunidad Valenciana presents a certain singularity, in which this branch of activity is ranked during the whole period above the level of sectorial efficiency. This circumstance is also found in Baleares, but not in every year. Andalucía, Cataluña, Murcia and Navarra are the regions with profiles of efficiency more similar to the national average. The most reduced levels of efficiency for the branch of Transport and Communications in the national context can be found in Castilla-León, Castilla-La Mancha, Extremadura and Galicia.

- Except in País Vasco, where the branch of Credit and Insurance is ranked in the efficient frontier during the whole studied period, in the rest of the regions a fall is always found in the values of the GTE during the years 1989 and 1990. In most of the regions, this activity branch is the least efficient of the three that we have considered within the marketed services. Singular cases are those of Asturias and Castilla-León, where the efficiency of the branch of Credit and Insurance overcomes the sectorial levels starting from 1991 on. It should also be highlighted how in the regions of Madrid, Baleares and Canarias (where the profiles of sectorial efficiency are the highest), nevertheless, the efficiency of this branch remains around the national average, very far from the rest of the services. Extremadura and La Rioja are the least efficient communities in this activity branch, where, again, Andalucía and Cataluña present the most similar profiles to the national average.

Once the level of inefficiency of each activity branch in each one of the regions is known, the potential production of the services sector was calculated. The relationship between the potential production and the real one in each region shows the value of intra-sectorial (in)efficiency. These values can be observed in Table 1, as well as those corresponding to the composition efficiency and to the total productivity.

Figures 2, 3 and 4 will be a great asset in the interpretation of these data. Figure 2 shows the evolutions of these new concepts of efficiency in the national aggregate. The series corresponding to the GTE have also been inserted. The break-up of total productivity presents two effects: intra-
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Andalucía</td>
<td>CE</td>
<td>0.9573</td>
<td>0.9719</td>
<td>0.9352</td>
<td>0.9268</td>
<td>0.9067</td>
<td>0.9183</td>
<td>0.9298</td>
<td>0.9283</td>
<td>0.9421</td>
</tr>
<tr>
<td>Andalucía</td>
<td>IE</td>
<td>0.7463</td>
<td>0.7412</td>
<td>0.7694</td>
<td>0.7412</td>
<td>0.7566</td>
<td>0.7625</td>
<td>0.7679</td>
<td>0.7653</td>
<td>0.7666</td>
</tr>
<tr>
<td>Asturias (Principado de)</td>
<td>CE</td>
<td>0.7145</td>
<td>0.7204</td>
<td>0.7196</td>
<td>0.6870</td>
<td>0.6860</td>
<td>0.7002</td>
<td>0.7140</td>
<td>0.7105</td>
<td>0.7223</td>
</tr>
<tr>
<td>Asturias (Principado de)</td>
<td>IE</td>
<td>0.9793</td>
<td>0.9490</td>
<td>0.9535</td>
<td>0.9484</td>
<td>0.9409</td>
<td>0.9450</td>
<td>0.9516</td>
<td>0.9481</td>
<td>0.9568</td>
</tr>
<tr>
<td>Baleares (Islas)</td>
<td>CE</td>
<td>0.8328</td>
<td>0.8550</td>
<td>0.8541</td>
<td>0.8550</td>
<td>0.8366</td>
<td>0.8394</td>
<td>0.8697</td>
<td>0.8682</td>
<td>0.8859</td>
</tr>
<tr>
<td>Baleares (Islas)</td>
<td>IE</td>
<td>0.8039</td>
<td>0.8114</td>
<td>0.8144</td>
<td>0.8109</td>
<td>0.7872</td>
<td>0.7932</td>
<td>0.8276</td>
<td>0.8232</td>
<td>0.8477</td>
</tr>
<tr>
<td>Castilla y León</td>
<td>CE</td>
<td>0.9343</td>
<td>0.9362</td>
<td>0.9362</td>
<td>0.9198</td>
<td>0.8971</td>
<td>0.9115</td>
<td>0.9333</td>
<td>0.9314</td>
<td>0.9451</td>
</tr>
<tr>
<td>Castilla y León</td>
<td>IE</td>
<td>0.9564</td>
<td>0.9542</td>
<td>0.9506</td>
<td>0.9440</td>
<td>0.9324</td>
<td>0.9361</td>
<td>0.9477</td>
<td>0.9460</td>
<td>0.9569</td>
</tr>
<tr>
<td>Extremadura</td>
<td>CE</td>
<td>0.9675</td>
<td>0.9674</td>
<td>0.9506</td>
<td>0.9458</td>
<td>0.9272</td>
<td>0.9361</td>
<td>0.9468</td>
<td>0.9441</td>
<td>0.9608</td>
</tr>
<tr>
<td>Extremadura</td>
<td>IE</td>
<td>0.6911</td>
<td>0.7398</td>
<td>0.7396</td>
<td>0.7398</td>
<td>0.7484</td>
<td>0.7481</td>
<td>0.7354</td>
<td>0.7259</td>
<td>0.7417</td>
</tr>
<tr>
<td>Galicia</td>
<td>CE</td>
<td>0.9857</td>
<td>1.0000</td>
<td>0.9752</td>
<td>0.9756</td>
<td>0.9636</td>
<td>0.9635</td>
<td>0.9689</td>
<td>0.9607</td>
<td>0.9644</td>
</tr>
<tr>
<td>Galicia</td>
<td>IE</td>
<td>0.8197</td>
<td>0.8450</td>
<td>0.8603</td>
<td>0.8450</td>
<td>0.8497</td>
<td>0.8638</td>
<td>0.8686</td>
<td>0.8673</td>
<td>0.8779</td>
</tr>
<tr>
<td>Madrid (Comunidad)</td>
<td>CE</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
</tr>
<tr>
<td>Madrid (Comunidad)</td>
<td>IE</td>
<td>0.9110</td>
<td>0.9054</td>
<td>0.9397</td>
<td>0.9054</td>
<td>0.9009</td>
<td>0.9122</td>
<td>0.9221</td>
<td>0.9121</td>
<td>0.9291</td>
</tr>
<tr>
<td>Murcia (Región de)</td>
<td>CE</td>
<td>0.9548</td>
<td>0.9655</td>
<td>0.9349</td>
<td>0.9296</td>
<td>0.9135</td>
<td>0.9273</td>
<td>0.9433</td>
<td>0.9384</td>
<td>0.9504</td>
</tr>
<tr>
<td>Murcia (Región de)</td>
<td>IE</td>
<td>0.9036</td>
<td>0.7610</td>
<td>0.7785</td>
<td>0.7610</td>
<td>0.8046</td>
<td>0.8130</td>
<td>0.7983</td>
<td>0.7842</td>
<td>0.7848</td>
</tr>
<tr>
<td>Navarra (Comunidad Foral)</td>
<td>CE</td>
<td>0.9373</td>
<td>0.9301</td>
<td>0.9379</td>
<td>0.9243</td>
<td>0.9010</td>
<td>0.9194</td>
<td>0.9414</td>
<td>0.9234</td>
<td>0.9246</td>
</tr>
<tr>
<td>Navarra (Comunidad Foral)</td>
<td>IE</td>
<td>0.8634</td>
<td>0.8973</td>
<td>0.9073</td>
<td>0.8973</td>
<td>0.9039</td>
<td>0.8627</td>
<td>0.8843</td>
<td>0.8826</td>
<td>0.8895</td>
</tr>
<tr>
<td>País Vasco</td>
<td>CE</td>
<td>0.9053</td>
<td>0.9208</td>
<td>0.8909</td>
<td>0.8707</td>
<td>0.8666</td>
<td>0.8722</td>
<td>0.8766</td>
<td>0.8720</td>
<td>0.8753</td>
</tr>
<tr>
<td>País Vasco</td>
<td>IE</td>
<td>0.8370</td>
<td>0.8516</td>
<td>0.8495</td>
<td>0.8473</td>
<td>0.8443</td>
<td>0.8587</td>
<td>0.8566</td>
<td>0.8532</td>
<td>0.8570</td>
</tr>
<tr>
<td>Rioja (La)</td>
<td>CE</td>
<td>1.0000</td>
<td>0.9887</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
<td>1.0000</td>
</tr>
<tr>
<td>Rioja (La)</td>
<td>IE</td>
<td>0.8094</td>
<td>0.7677</td>
<td>0.8098</td>
<td>0.7777</td>
<td>0.7971</td>
<td>0.8402</td>
<td>0.8511</td>
<td>0.8503</td>
<td>0.8622</td>
</tr>
</tbody>
</table>

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.
sectorial and composition efficiency offers us lower levels of efficiency than those obtained with data aggregate at sectorial level during the whole period of survey. But the main difference is not found in low efficiency values, but what appears to be the most important thing is that it changes the profile of the curve.

Tendency lines have been adjusted to the curves obtained from the original series. These lines allow an easier interpretation of the results. In the first place, we can observe that the tendencies of the GTE and of the line IE, are practically identical, although with a displacement downwards for the efficiency line IE. This result corresponds totally with the theoretical forecast. The calculation of the efficiency with data disaggregates at the level of activity branches provides lower values to those obtained with sectorial data, since we are incorporating the specific character of certain activities. The specific character of an asset is measured by its loss of value between the current use and its best alternative. The specificity may be of localisation (particular situation in a geographical area that only makes it a useful asset for a small number of buyers or salespersons), physics (machine or tool that it is good for a single client), in human resources (very specialised knowledge for a type of very concrete activity), or of dedication (discrete investment in general capacity of production that would not be made without the sale perspective from a significant quantity to a particular client). In other words, we are incorporating the difference among the real flexibility for the combination of the productive resources and the hypothesis of convexity of the productive space incorporated in the DEA, according to which any combination is feasible.

The main contribution of the methodology of efficiency by groups consists of the incorporation of the denominated composition efficiency. This component of total productivity introduces the differences of efficiency due to the different productive structure of the regions. The obtained results show a descending tendency in the levels of composition efficiency until 1990, and a later recovery up to 1994. At the end of the period, the situation is worse than that at the beginning as a consequence of the growth in the relative size of those less efficient branches inside the sectorial group that took place between 1986 and 1994.

When combining the intra-sectorial and structural components of efficiency we obtain the curve corresponding to the values of total productivity. In this curve, it is possible to notice clearly the effect that the efficiency composition introduces and the fall in the levels of total productivity until 1990, as well as their later recovery up to 1994. Finally, the calculation of productivity starting from disaggregated data enriches the results with regard to the analysis with added data, since this procedure tells us for each region if the reasons for their low level of production are due to
an inadequate productive structure or due to low levels of efficiency in each one of their branches of activity. Logically, although in this work the group refers to a sector and the components to activity branches, the methodology is equally valid when the group refers to the national product and the components represent productive sectors.

The logical chain of reasoning indicates to us that the intra-sectorial efficiency is below the GTE calculated with added data, and the total productivity is smaller than the intra-sectorial efficiency, which implies that the composition efficiency is smaller than 100 per cent. Furthermore, with time the composition efficiency declines; this means that the most inefficient activity branches are winning relative positions in the productive system. In order to contrast this argument, in our case, we have analysed the evolution in the rates of variation of the GVA in the marketed 'for sale' service sector and in each one of the activity branches in those that we have divided it. Equally, we have studied what the composition of the sectorial GVA has been in percentage terms along the period of study. Figures 3 and 4 show how the Credit and Insurance branch shows evidence of higher rates of growth than the sectorial ones up to 1990, allowing it to go from 12.91 per cent in 1986 to 14.96 per cent in 1990. We should remember at this time that the technical efficiency of this branch turned out to be the most reduced one and that, it also kept descending from 1986 to 1990.

We consider that since the behaviour of the branch Credit and Insurance is sufficiently explanatory of the behaviour continued by the composition efficiency, from 1986 until 1990, the branch Credit and Insurance loses positions in technical efficiency and it gains in relative size. From 1990 to 1994, the Credit and Insurance branch, although continuing to be the less
efficient one, nevertheless its level of technical efficiency keeps growing at the same time as its relative size returns to the departure position. This deterioration in the composition of the ‘for sale’ service sector until 1990 has prevented the total productivity of the sector from growing as much as was expected according to the technical efficiency registered by each one of its branches.

- The analysis carried out up to now corresponds to the results at national level. In the regional level we should point out some peculiarities. The regions of Madrid, País Vasco and La Rioja present singularities worthy of comment.

- In Madrid the Credit and Insurance branch does not gain relative positions, although the participation in the services is very high (18–19 per cent) in comparison with the national average (12 per cent). The rate
of growth of the GVA in this branch does not actually overcome the sectorial average in the period studied. Starting from 1992 it grows less than the rest of the services and its participation percentage in the sectorial GVA decreases until 16.8 per cent. This peculiar behaviour of the Credit and Insurance branch is due to the fact that this region is located in the efficient frontier in its structural component, that is to say, the composition efficiency takes values of 100 per cent during each one of the studied years.

- In País Vasco the Credit and Insurance branch presents similar behaviour to that of the national group, that is to say, it gains relative positions in the service sector. However, in this community, the above mentioned branch reaches values of efficiency of 100 per cent and this circumstance causes the composition efficiency to reach very superior values to those of the national group and next to the efficient frontier.

- In La Rioja, the behaviour of this branch is similar to the one observed in the community of Madrid. In this case also the values of the composition efficiency reach 100 per cent. In this region, the values of technical efficiency of the Credit and Insurance branch are much lower than in that of Madrid, for which a decrease of the relative size of the branch supposes an important benefit in terms of efficiency at sectorial level.

- It is necessary to highlight the uniqueness shown by the insular regions (Baleares and Canarias), where the percentage of the GVA generated by the services corresponding to the Credit and Insurance branch is greatly reduced in comparison with the national average. Nevertheless, their behaviour and evolution along the studied period are similar to that of the rest of regions. The great distance that exists between the technical efficiency of this branch and that of the total of the services motivates the fact that in this region the intra-sectorial efficiency is situated above the composition efficiency in some years.

The method used until now to study the productivity of the Marketed services has been based on the results obtained when applying the DEA in an independent way to the data of every year between 1986 and 1994. As we have already indicated, the DEA is a technique of extreme accuracy that compares each real producer with a constructed virtual producer model starting from the linear combination of the best producers found in the reference group. The results obtained by a productive unit are in a function of those obtained by their competitors. With regard to it, the data that we have presented up to now should not be interpreted as values of efficiency referring to their own production frontier, but rather values referring to different frontiers. When we compare data of two serial exercises for each productive
unit it may be the case that the productive efficiency of the unit that we are evaluating has increased and, yet, the score obtained when executing the DEA is smaller. This phenomenon has only one explanation given the productivity of the remaining units, they have experienced an increase in its level of efficiency greater than the evaluated unit. Therefore, in that new frontier of production this productive unit has lost relative positions and it is now further from the maximum value than in the previous period.

Obviously, it interests us to know the evolution of the productivity of the regions during the analysed period. It also interests us to know what part of the productive change is due to the technical progress (displacement of the frontier) and what to the increase of the efficiency in the productive units (Catch-up). The Malmquist index calculated using the data obtained in the static analysis tells us to what extent they have influenced both the technical change and the efficiency in the productive change.

![Figure 5](image_url)

- In Figure 5 we can observe the evolution of the productive change of the ‘for sale’ services sector (Malmquist index, and their two components Displacement and Catch-up) in the national sector. The information that these figures offer is not quite as promising as one might have hoped for. Starting from 1988 the Malmquist index adopts a descending slope until 1994. This indicates to us that in spite of experiencing a development, the rate of variation of productivity in the services is smaller every time. Also, in most of the studied period, the gains in productivity can be explained by the displacement of the efficient frontier, that is to say, by the incorporation of technical change in the productive process. The contribution of technical progress was growing up to 1990 and falling
starting from 1990 onwards. The variation of the efficiency has had a practically null effect when being situated very closely to the unit starting from 1990.

- The behaviour of each one of the regions is very similar to the national average, except in the cases of Madrid, Baleares and País Vasco whose values are undervalued by the Malmquist index. These three regions are located in the efficient frontier for a large part of the studied period, and so the components of the index do not pick up the growth experienced by the rest, since it is reduced to a quotient of unitary values. This circumstance causes the undervaluation of the increment average experienced for the national group. The annual mean value for the Malmquist index for the period 1986–94 reaches 6.33 per cent. If we exclude the three previously mentioned regions from the calculation of the average, the final value rises up to 7.34 per cent.

The classic alternative to the Malmquist indexes is the construction of a pluri-annual frontier where the efficiency of each region is evaluated with itself and with the other ones during every year. This possibility allows us to know the magnitude of the productive change, although it does not establish distinctions among changes due to the displacement of the frontier and changes due to variations in the efficiency of each productive unit. However, through the pluri-annual frontier we are able to avoid the undervaluation of the productive change that the Malmquist indexes introduce regarding the units that are located on the efficient frontier.

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>COMPARED INDEXES OF EFFICIENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Technical Change</td>
</tr>
<tr>
<td>And</td>
<td>1.0720</td>
</tr>
<tr>
<td>Ara</td>
<td>1.0756</td>
</tr>
<tr>
<td>Ast</td>
<td>1.0741</td>
</tr>
<tr>
<td>Bal</td>
<td>1.0272</td>
</tr>
<tr>
<td>Can</td>
<td>1.0714</td>
</tr>
<tr>
<td>Cta</td>
<td>1.0700</td>
</tr>
<tr>
<td>Cle</td>
<td>1.0734</td>
</tr>
<tr>
<td>Cla</td>
<td>1.0716</td>
</tr>
<tr>
<td>Cat</td>
<td>1.0737</td>
</tr>
<tr>
<td>Cva</td>
<td>1.0723</td>
</tr>
<tr>
<td>Ext</td>
<td>1.0767</td>
</tr>
<tr>
<td>Gal</td>
<td>1.0768</td>
</tr>
<tr>
<td>Mad</td>
<td>1.0000</td>
</tr>
<tr>
<td>Mur</td>
<td>1.0737</td>
</tr>
<tr>
<td>Nav</td>
<td>1.0769</td>
</tr>
<tr>
<td>Pva</td>
<td>1.0216</td>
</tr>
<tr>
<td>Lri</td>
<td>1.0688</td>
</tr>
<tr>
<td>ESPAÑA</td>
<td>1.0630</td>
</tr>
</tbody>
</table>
In Table 2 we can observe the mean values for the period 1986–94 resulting for each region. The annual average increment of productivity resulting from the pluri-annual frontier of productivity in the ‘for sale’ service sector is 7.16 per cent. This value is very similar to the one that we obtained using the Malmquist indexes when we do not include in the average the values corresponding to the three more efficient regions (7.34 per cent). The coincidence of the data contributed by the index and for the pluri-annual frontier has been verified in numerous works [Navarro, 1999b; Pedraja, Ramajo and Salinas, 1999].

In Figure 6 we can observe the difference between both estimates. According to the obtained data of the pluri-annual frontier the region that experienced a bigger productive increment during the observed period was La Rioja (8.43 per cent), followed by Castilla-La Mancha, Aragón, Cataluña and Extremadura. The regions whose productivity grew less were Murcia (5.34 per cent) and Canarias (5.79 per cent).
CONCLUSIONS

In accordance with the initial planning of this article, an analysis of the productivity of the service sector based on the non-parametric frontier methodology (DEA) has been carried out. Starting from this analysis the following magnitudes have been quantified: global technical efficiency (GTE), composition effect (CE), intra-sectorial efficiency (IE), total productivity, Malmquist index and pluri-annual frontier.

The application of this methodology for the service sector highlights that the total efficiency on a national scale shows a tendency to diminish until 1990 and is then followed by a later recovery until the end of the analysed period in 1994. This evolution is explained by the behaviour of the composition efficiency, while the intra-sectorial efficiency maintains quite a uniform growth in the period. The fall in the levels of composition efficiency up to 1990 and their later recovery coincides with the expansion tendency of the Credit and Insurance branch of the economy until that same year. This activity branch displays a fall in its average technical efficiency until 1990 and then an upturn in 1994, always very below the technical efficiency average for the group of marketed services and of the Transport and Communications branch. Starting from 1988 the Malmquist index national average of marketed services shows a fall explained by a smaller and smaller displacement of the production frontier and maintenance of levels of efficiency. Nevertheless, for the analysed period the annual average productive change is around six per cent. This change is somewhat bigger if it is calculated using a frontier of combined production for every year. The difference in the evaluation of the productive change is due to the behaviour of three Regions (Baleares, Madrid and País Vasco) which have stayed in the efficient frontier for several years, causing the Malmquist index to undervalue its growth, and consequently the national average.

The most important conclusion to be drawn is the evident enrichment of the analysis that allows the methodology of calculation of the efficiency by groups, by means of the disintegration in branches of activity of the sectorial efficiency.

In any case it can be considered that the present work contributes a global and closed treatment of the problem of efficiency and productive change in the services sector. In fact we have worked with a marginal breakdown, in the sense that the two studied activity branches represent approximately 25 per cent of the marketed services. A bigger disintegration of the activity branches would undoubtedly reveal the existence of singular regional situations, as it happens in this analysis for the regions of Madrid, País Vasco and La Rioja for the Credit and Insurance branch. The need for later developments is evident and, in any event, promising.
Again the similarity of results is verified between the Malmquist indexes and the pluri-annual frontier. In general the results obtained coincide with those published in previous works. Concretely, the fact that Madrid presents values of efficiency of 100 per cent for every analysed year and that Baleares and País Vasco are regions with a high level of efficiency in the services is in accordance with the results recently obtained [Maudos et al., 1998].

Lastly, we should remember the need for caution in the interpretation of the results. We are using a methodology (non-parametric frontier) devised for the analysis of technical efficiency, where the hypothesis of convexity of the productive space remains. This caution should not put a stop to a continuation of analysing the productivity of the service sector from different perspectives, searching for results that allow a thorough knowledge of the reality of the tertiary sector.

NOTES
1. In this work the intra-sectorial efficiency should be understood as efficiency activity intra-branch. We have maintained the qualifying intra-sectorial to consider it the most intuitive concept.
2. It consists of identifying possible differences, in particular in the efficiency, that can be attributed to the association from the productive units to a group or program. It is based on the development elaborated by Charnes, Cooper and Rhodes [1981]. In our case, the grouping follows a geographical approach.

REFERENCES


