# AN ANALYSIS OF THE SPANISH PUBLIC UNIVERSITIES MISSIONS IN EFFICIENCY TERMS

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**Abstract**

This paper investigates the changes of the productivity of the Spanish Public Universities during 1995-2006. The methodology to study productivity growth is the nonparametric Malmquist index. Its decomposition into technological change and efficiency change indicators allows to study the catching-up effect, the scale effect and the frontier-shift effect. Four different specifications are made to assess Spanish public universities: "general-model", "teaching-only", "research-only" and "knowledge transfer-only" model. In the four models, it can be observed an important conclusion: the importance that efficiency has as a source of growth of the productivity different from the technical progress.

*Keywords*: Productivity, Malmquist Index, Efficiency Measurement, Public University,

## 1. Introduction

In the last two decades, the Spanish Higher Education System (SHES) has seen many changes. Since the late 1980's, research activity has become an important part of the Higher Education System source of incomes due to important legal framework changes in the way teaching staff can access research funds from the different administration levels (regional, national or European). In this respect the SHES shifted from a model of pure education activity to a combination of both education and research activities. Those changes have led to serious imbalances inside the institutions.

On the other hand, the promotion of the so-called third-mission activities at the universities might be seen as one of the major strategies adopted in recent years. In this sense, a large debate is undergoing about the consequences of including this later mission among the institutional missions of universities. The third mission of universities may generally be defined as dissemination or outreach activities, including activities like popular science publications, further education, alumni endeavours, etc. Usually these activities are however excluded from

the discussion of third mission, as it focuses on commercialization of academic knowledge in the form of industry collaboration, patenting/licensing and the creation of spin-off companies. University-industry relations in the form of research contracts and industrial sponsorship of academic science have a long history, while the engagement of universities and academics in patenting, licensing and the formation of new firms is a newer trend. Third mission activities are thus a complex mix, and subsequently also the development of coherent data sets and indicators are potentially complicated and pose some difficulties.

These issues have raised lots of discussions because the effect of these changes on the ability and effectiveness of universities are ambiguous. For example, the issue of third mission might be framed as a problem of complementarities vs. substitution in outputs. The activities carried out by universities should be seen as a vector of outputs produced jointly, using the same vector of inputs. Therefore, to carry out the assessment of universities activities is complicated due to their complex nature (Bonaccorsi & Daraio, 2005; García-Valderrama, 1996; Denison, 1962).

Changes in productivity in higher education over a period of time can be calculated using the Malmquist productivity change index. This approach is a particularly attractive method since it does not require knowledge of input or output prices, nor does it require any specific behavioural assumptions of the institutions under consideration, such as cost minimization or profit or revenue maximization (Coelli & Perelman, 1999; O'Donnell & Coelli, 2003; Uri, 2003a, 2003b; Rodriguez-Alvarez, Fernandez-Blanco & Lovell, 2004; Johnes, 2005; Worthington & Lee, 2005).

The selection of inputs and outputs for the nonparametric approach to define the production function for modelling university behaviour (teaching, research and technology transfer) is complicated and not definitive (Tomkins & Green, 1988; Beasley, 1990, 1995; Johnes & Johnes, 1993, 1995; Glass et al., 1995; Athanassopoulos & Shale, 1997).

Thus, in the absence of any specific measurement to evaluate Higher Education Institutions, in this paper we have applied the Malmquist non-parametric approach to analyze the productivity change of the Spanish public universities from 1995 to 2006.

## 2. Data descriptive: Specification of inputs and outputs

The data analysed in this paper was collected from various governmental and institutional sources from the academic year 1995/96 to 2005/06 and pertain to Spanish public universities.

In 2006, there were 50 public institutions. In this study we consider 42 of them. The remaining 8 universities are excluded due to their recent creation or because there is no data available for some years of the period considered (Pablo Olavide University, Cartagena Technical University, Miguel Hernandez University, Madrid Technical University and Rey Juan

Carlos University) and due to the different structure as the National Open University (UNED), the Madrid Open University (UDIMA) and UIMP have.

We select those variables related with the inputs and outputs according to the purpose of this study: as inputs we consider the total expenditure, academic staff and non-academic staff (proxy to measure teaching, research and knowledge transfer), and as output, we include number of graduates (proxy to measure education), publication (proxy to measure research) and total amount of applied research (proxy to measure knowledge transfer).

Details definitions of the inputs and the output measures can be found in table 1.

**Table 1. Definitions of inputs and outputs**

| Variable Name | Definition |
|---|---|
| *INPUTS* | |
| Academic Staff (PDI) | The academic staff has both teaching and research duties, although there are no clear rules on research duties for academic staff. |
| Non-academic Staff (PAS) | The non-academic staff is the technical and administrative staff. |
| Total Expenses | Refers to the expenditure in academic staff, expenditure in non-academic staff, running expenses in goods and services, financial expenditures, flow of funds, capital expenses, real investment, and other expenses (financial assets plus financial liabilities). The amount is expressed in thousand Euros. |
| *OUTPUTS* | |
| Graduates | Number of people that degrees attributed between the first day of January and the last of December of each year, and corresponds to the academic year that ends up that year |
| Publications | Number of publications authored by the university, i.e. with at least one author from the university in question. Data is from the Web of Science consists of five databases. |
| Applied Research | Income from private contracts under article 83 in the LOU (Spanish Higher Education Law). |

## 2. Methodology

The methodology employed in this paper to study productivity growth in the Spanish public Universities from 1995 to 2006 is the nonparametric Malmquist index. This productivity growth method is superior to alternative indexes such as the Törnqvist index or the Fisher Ideal index, because Malmquist index is based only on quantity data and makes no assumptions regarding university's behaviour (Grifell-Tatjé & Lovell 1996).

Several different decompositions of the Malmquist index have been proposed in the literature. One of them is that proposed by Fare *et al.* (1995) which assumes constant returns to scale (CRS) technology. Other is that proposed by Ray & Desli (1997), which does not require the CRS assumption. Simar & Wilson (1998) & Zofío & Lovell (1998) extend the Ray & Desli (1997) decomposition, more concretely, the technical change component further decomposed into a "pure" technical change of the frontier plus a residual measure of the scale change of the technology. This residual measure evaluates the separation between the CRS and the variable returns to scale (VRS) technologies.

In this study, we assume constant returns-to-scale to start with, and calculate the total productivity change and decomposed into technological (or technical) change and technical efficiency change which is formed by "pure" efficiency change and scale efficiency change.

Furthermore, for studying productivity by Malmquist, it is necessary to construct a nonparametric envelopment frontier over the data points such that all observed points lie on or below the production frontier. There are two analysis options: input orientation which reduces the inputs without dropping the output levels, and output orientation which raises outputs without increasing the inputs. In education, the universities may be given a fixed quantity of resources (e.g., state financial resources, academic and non-academic loads) and asked to produce as much output as possible. Thus, we assume an output orientation.

The output-based Malmquist productivity change index *(M)* specified by Färe *et al.* (1995) may be formulated as:

$$M_o^{t+1,t}(y_t, x_{t,} y_{t+1,} x_{t+1}) = \left[ \frac{D_o^t(y_{t+1}, x_{t+1})}{D_o^t(y_{t,} x_t)} * \frac{D_o^{t+1}(y_{t+1}, x_{t+1})}{D_0^{t+1}(y_t, x_t)} \right]^{1/2}$$

where the subscript *O* indicates an output-orientation, *M* is the productivity of the most recent production point $(x_{t+1}, y_{t+1})$ (using period $t + 1$ technology) relative to the earlier production point $(x_t, y_t)$ (using period *t* technology), $D_0$ are output distance function which is the reciprocals of Farrell's (1957) technical efficiency measures. The output distance function, it is defined on the output set *P(x),* as:

$$D_o(x,y): \min \{\theta: (y/\theta) \in P(x)\}$$

Where $\theta$ is the corresponding level of efficiency. The output distance function seeks the largest proportional increase in the observed output vector *y* provided that the expanded vector $(y/\theta)$ is still an element of the original output set (Grosskopf *et al.*, 1995). If the university is fully efficient, so that it is on the frontier, $D_o(x,y)= \theta =1$, where as $D_o(x,y)= \theta <1$ indicates that the institution is inefficient.

An equivalent way of writing the Malmquist index is:

$$M_o^{t+1,t}(y_t, x_{t,} y_{t+1,} x_{t+1}) = \frac{D_o^{t+1}(y_{t+1}, x_{t+1})}{D_0^t(y_t, x_t)} \left[ \frac{D_o^t(y_{t+1}, x_{t+1})}{D_o^{t+1}(y_{t+1,} x_{t+1})} * \frac{D_o^t(y_t, x_t)}{D_0^{t+1}(y_t, x_t)} \right]^{1/2}$$

or *M=E*P* where *M* is the product of a relative efficiency change *E* under constant returns to scale which measures the degree of catching up to the best-practice frontier for each observation between time period *t* and time period $t + 1$ (term outside the square bracket) and a measure of technical progress *P* (the two ratios in the square bracket) as measured by shifts in the frontier of technology (or innovation) measured at period $t + 1$ and period *t* (averaged geometrically). Applying at the same data CRS assumption (without convexity constraint) and VRS (with convexity constraint), measures of overall technical efficiency *(E)* and "pure" technical

efficiency *(PT)* are obtained. Dividing the overall technical efficiency *(E)* by "pure" technical efficiency change *(PT)* then yields a measure of scale efficiency change *(S)*.

Recalling that *M* indicates the degree of productivity change, then if $M>1$ then productivity gains occur, whilst if $M<1$ productivity losses occur. Regarding changes in efficiency, technical efficiency increases (decreases) if and only if *E* is greater (less) than one. An interpretation of the technological change index is that technical progress (regress) has occurred if *P* is greater (less) than one.

Further details on the interpretation of these indices may be found in Charnes *et al.* (1993), Lovell (2003), Worthigton & Lee (2005).

**4. Results and discussion.**

To evaluate Spanish public universities, first, we analyze a "general model" taking into account as input total expenses, number of academic and non-academic staff, and as outputs graduates, publications and applied research. Then, in order to understand better the sources of the productivity changes three additional specifications of university productivity are examined. The first focuses on "teaching-only" productivity, the second "research-only" productivity and the third "knowledge transfer-only" productivity. Variable definitions in both instances are identical to the "general model", but the "teaching-only" specification only includes the output graduates, the "research-only" specification excludes the output graduates and applied research and the "knowledge transfer-only" model only includes applied research.

The non-parametric results reported in this study are obtained using an implementation of the software package FEAR of the R programme. See Wilson (2007).

The Malmquist index and its decomposition are presented in Table 2 by year and by university for each of the four models. These results are illustrated in figure 1 to figure 4.

Three primary issues are addressed in the computation of Malmquist indices of productivity growth over the sample period. The first is the measurement of productivity change over the period (see column M). The second is to decompose changes in productivity into what are generally referred to as a "catching-up" effect (technical efficiency change) (see column E) and a "frontier shift" effect (technological change) (see column P). The third is that the "catching-up" effect is further decomposed to identify the main source of improvement, through either enhancements in "pure" technical efficiency (see column PT) or increases in scale efficiency (see column S). It should be remarked that these indexes (and any resulting percentage changes) are relative, that is, a university may be more or less efficient, or more or less productive, but only in reference to the other forty-two universities.

The major cause of productivity improvements can be ascertained by comparing the values of the efficiency change and technological change. That is, the productivity gains described can be the result of efficiency gains, technological improvements, or both.

**Table 2. Malmquist Index by Spanish public universities and model specification (% change)**

| | General Model | | | | | Teaching Model | | | | | Research Model | | | | | Knowledge Transfer Model | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| %change | M | E | P | PT | S | M | E | P | PT | S | M | E | P | PT | S | M | E | P | PT | S |
| 95/96 | 3,4 | 3,9 | -0,4 | 5,1 | -1,2 | 5,7 | 0,8 | 4,9 | 2,6 | -1,8 | 7,8 | 2,6 | 5,1 | 6,2 | -3,4 | 24,8 | 112,8 | -41,4 | 98,6 | 7,1 |
| 96/97 | 7,5 | 7,4 | 0,1 | 5,7 | 1,6 | 8,2 | 12,8 | -4,1 | 7,1 | 5,3 | 8,1 | 19,2 | -9,3 | 14,1 | 4,4 | 27,7 | 26,4 | 1,0 | 35,9 | -7,0 |
| 97/98 | 5,2 | -0,8 | 6,1 | -5,4 | 4,9 | 4,6 | -3,9 | 8,8 | -7,0 | 3,3 | 11,9 | -2,6 | 14,9 | -2,7 | 0,0 | 9,2 | -4,3 | 14,2 | -15,9 | 13,7 |
| 98/99 | -1,8 | 2,7 | -4,4 | 3,0 | -0,3 | -3,1 | 3,9 | -6,7 | 3,8 | 0,0 | 5,7 | 10,6 | -4,4 | 8,8 | 1,7 | 13,5 | -27,5 | 56,5 | -18,8 | -10,6 |
| 99/00 | -4,5 | -2,8 | -1,8 | -1,8 | -1,0 | -6,3 | 0,5 | -6,8 | 1,7 | -1,2 | -2,8 | -2,0 | -0,8 | -4,7 | 2,8 | 5,9 | -37,6 | 69,7 | -34,6 | -4,5 |
| 00/01 | -2,0 | 8,1 | -9,3 | 4,6 | 3,3 | -2,5 | 5,9 | -7,9 | 3,4 | 2,4 | 6,7 | 15,3 | -7,5 | 6,6 | 8,1 | 14,0 | 106,8 | -44,9 | 92,0 | 7,7 |
| 01/02 | 2,4 | -11,4 | 15,5 | -5,9 | -5,8 | 3,9 | -22,4 | 33,9 | -15,8 | -7,9 | 2,0 | 0,6 | 1,4 | 3,8 | -3,0 | -6,5 | 30,6 | -28,4 | 17,1 | 11,6 |
| 02/03 | -0,6 | -7,1 | 7,0 | -2,9 | -4,3 | -6,0 | -11,0 | 5,7 | -4,8 | -6,5 | 7,0 | 11,8 | -4,3 | 10,5 | 1,2 | 12,3 | 21,3 | -7,4 | 12,8 | 7,6 |
| 03/04 | -5,7 | 25,3 | -24,8 | 15,2 | 8,8 | -11,1 | 42,2 | -37,5 | 27,3 | 11,7 | -4,0 | 6,4 | -9,8 | 6,9 | -0,4 | 6,4 | -5,0 | 11,9 | -1,1 | -3,9 |
| 04/05 | -1,2 | -5,7 | 4,8 | -5,5 | -0,3 | -6,6 | -2,8 | -3,9 | -3,1 | 0,3 | 11,7 | -4,5 | 16,9 | -6,9 | 2,6 | 17,6 | -10,4 | 31,3 | -12,8 | 2,8 |
| 05/06 | -0,3 | 6,9 | -6,7 | 4,4 | 2,4 | -3,1 | 12,9 | -14,2 | 10,2 | 2,4 | 5,1 | 3,5 | 1,5 | 0,3 | 3,2 | 11,1 | -19,3 | 37,7 | -12,0 | -8,3 |
| Average | 0,2 | 2,4 | -1,3 | 1,5 | 0,7 | -1,5 | 3,5 | -2,5 | 2,3 | 0,7 | 5,4 | 5,5 | 0,3 | 3,9 | 1,6 | 12,4 | 17,6 | 9,1 | 14,7 | 1,5 |

| | General Model | | | | | Teaching Model | | | | | Research Model | | | | | Knowledge Transfer Model | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DMU | M | E | P | PT | S | M | E | P | PT | S | M | E | P | PT | S | M | E | P | PT | S |
| 1 | -1,2 | 4,7 | -5,6 | 2,0 | 2,6 | -2,7 | 4,3 | -6,7 | 1,7 | 2,5 | 4,2 | 8,2 | -3,8 | 6,3 | 1,8 | 16,7 | 15,1 | 1,4 | 14,6 | 0,5 |
| 2 | -2,1 | 4,1 | -5,9 | 3,5 | 0,5 | -2,7 | 4,1 | -6,5 | 3,5 | 0,5 | 3,9 | 7,7 | -3,6 | 7,5 | 0,2 | 13,8 | 12,7 | 0,9 | 13,8 | -1,0 |
| 3 | 3,4 | 3,0 | 0,3 | 2,2 | 0,8 | 2,3 | 4,9 | -2,5 | 4,3 | 0,5 | 4,1 | 1,9 | 2,1 | 2,0 | -0,1 | 8,3 | 5,1 | 3,1 | 7,0 | -1,8 |
| 4 | -0,5 | 2,2 | -2,7 | 2,4 | -0,2 | -1,2 | 2,8 | -3,9 | 3,4 | -0,6 | 1,7 | 2,8 | -1,1 | 1,7 | 1,1 | 0,1 | -2,5 | 2,7 | -5,0 | 2,7 |
| 5 | 3,4 | 5,4 | -1,9 | 2,4 | 2,9 | 2,6 | 5,4 | -2,7 | 2,4 | 3,0 | 16,3 | 14,0 | 2,1 | 10,6 | 3,0 | 20,9 | 16,6 | 3,6 | 15,6 | 0,9 |
| 6 | -0,2 | 5,2 | -5,1 | 2,7 | 2,4 | -0,2 | 5,4 | -5,4 | 2,9 | 2,5 | 9,5 | 12,7 | -2,8 | 10,7 | 1,8 | 1,7 | -0,2 | 1,9 | 1,2 | -1,4 |
| 7 | 0,4 | 0,9 | -0,4 | 0,4 | 0,4 | -3,2 | 0,2 | -3,3 | 0,2 | 0,0 | 1,3 | 1,9 | -0,5 | 1,2 | 0,6 | 10,4 | 8,3 | 2,0 | 8,5 | -0,2 |
| 8 | -2,7 | 1,4 | -4,1 | 3,2 | -1,7 | -3,8 | 1,6 | -5,2 | 3,2 | -1,6 | 0,3 | 2,8 | -2,4 | 1,4 | 1,3 | 29,3 | 28,6 | 0,5 | 25,7 | 2,3 |
| 9 | -1,3 | -1,5 | 0,2 | 0,0 | -1,5 | -5,2 | -0,6 | -4,6 | 0,6 | -1,2 | -0,5 | 1,1 | -1,6 | 1,1 | 0,0 | 10,2 | 9,5 | 0,7 | 7,9 | 1,5 |
| 10 | -1,5 | -0,3 | -1,2 | -0,3 | 0,0 | -4,2 | -0,3 | -3,9 | -0,2 | -0,1 | 6,0 | 5,1 | 0,8 | 5,3 | -0,2 | 6,9 | 3,1 | 3,7 | 2,2 | 0,9 |
| 11 | -1,3 | -0,1 | -1,2 | -1,9 | 1,9 | -2,9 | 1,2 | -4,0 | -0,8 | 2,0 | -0,9 | -0,1 | -0,9 | -3,4 | 3,4 | -0,9 | -3,3 | 2,5 | -5,2 | 2,0 |
| 12 | 0,1 | 3,9 | -3,6 | 4,1 | -0,2 | -0,8 | 4,5 | -5,1 | 4,8 | -0,2 | 3,4 | 4,3 | -0,9 | 4,3 | 0,0 | 3,7 | 1,9 | 1,8 | 2,4 | -0,4 |
| 13 | 1,8 | 6,0 | -4,0 | 5,6 | 0,3 | 2,5 | 6,4 | -3,7 | 5,9 | 0,5 | 6,1 | 5,9 | 0,2 | 5,6 | 0,3 | 11,8 | 9,9 | 1,7 | 10,8 | -0,8 |
| 14 | 5,3 | 4,7 | 0,5 | 3,7 | 1,0 | 0,6 | 5,1 | -4,3 | 3,8 | 1,2 | 1,6 | 3,0 | -1,4 | 2,8 | 0,2 | 12,9 | 10,6 | 2,1 | 11,8 | -1,0 |
| 15 | -0,6 | 1,9 | -2,5 | 2,4 | -0,5 | -1,7 | 2,8 | -4,4 | 4,0 | -1,2 | 3,1 | 3,9 | -0,7 | 2,9 | 0,9 | 5,9 | 3,2 | 2,5 | 0,9 | 2,3 |
| 16 | -0,6 | 0,0 | -0,6 | 0,0 | 0,0 | -4,5 | -0,3 | -4,3 | 1,2 | -1,4 | 2,3 | 2,1 | 0,2 | 0,0 | 2,1 | -2,9 | -4,6 | 1,8 | -6,5 | 2,1 |
| 17 | 2,1 | 7,2 | -4,7 | 6,1 | 1,0 | 1,3 | 8,0 | -6,3 | 6,3 | 1,6 | 13,0 | 17,2 | -3,6 | 15,0 | 1,9 | 11,9 | 11,0 | 0,9 | 10,6 | 0,4 |
| 18 | -2,1 | 0,5 | -2,6 | -1,2 | 1,8 | -2,6 | 0,5 | -3,0 | -1,3 | 1,8 | 11,7 | 10,4 | 1,2 | 8,3 | 1,9 | 21,5 | 18,2 | 2,8 | 17,8 | 0,4 |
| 19 | 2,5 | 3,5 | -0,9 | 1,9 | 1,5 | 1,5 | 4,4 | -2,8 | 4,9 | -0,4 | 10,5 | 7,9 | 2,4 | 7,5 | 0,4 | 6,2 | 0,8 | 5,4 | -1,3 | 2,1 |
| 20 | 7,5 | 9,0 | -1,3 | 8,0 | 0,9 | 6,4 | 9,8 | -3,1 | 8,0 | 1,7 | 25,0 | 22,6 | 2,0 | 20,4 | 1,8 | 13,9 | 9,1 | 4,4 | 9,0 | 0,1 |
| 21 | -0,2 | 0,0 | -0,2 | 0,0 | 0,0 | -5,3 | -0,1 | -5,3 | -0,2 | 0,2 | 4,2 | 4,6 | -0,4 | 0,0 | 4,6 | 27,9 | 24,9 | 2,4 | 20,8 | 3,4 |
| 22 | 0,3 | 2,7 | -2,3 | 2,3 | 0,3 | -0,5 | 2,6 | -3,0 | 2,3 | 0,3 | 12,0 | 10,0 | 1,8 | 9,3 | 0,7 | 16,6 | 13,1 | 3,1 | 13,2 | -0,1 |
| 23 | -6,8 | -3,1 | -3,8 | -2,5 | -0,6 | -4,2 | -1,1 | -3,1 | -1,2 | 0,1 | 0,4 | 0,1 | 0,3 | -0,8 | 0,8 | -11,7 | -13,1 | 1,6 | -12,4 | -0,8 |
| 24 | 8,7 | 4,9 | 3,6 | 2,3 | 2,5 | 2,0 | 5,2 | -3,0 | 2,4 | 2,7 | 13,1 | 11,6 | 1,4 | 7,7 | 3,6 | 15,0 | 11,3 | 3,3 | 9,6 | 1,5 |
| 25 | 8,6 | 2,0 | 6,5 | 1,9 | 0,0 | -2,0 | -0,1 | -1,8 | 0,0 | -0,1 | 7,8 | 4,9 | 2,8 | 4,2 | 0,6 | 11,0 | 4,8 | 5,9 | 3,6 | 1,1 |
| 26 | 0,8 | -0,5 | 1,4 | 0,0 | -0,5 | -2,8 | -0,4 | -2,5 | 0,3 | -0,7 | 6,4 | 4,6 | 1,6 | 2,8 | 1,8 | 16,3 | 12,7 | 3,2 | 9,9 | 2,6 |
| 27 | -5,2 | -1,7 | -3,6 | -1,6 | 0,0 | -5,2 | -1,6 | -3,7 | -1,6 | 0,0 | 2,5 | 2,2 | 0,3 | -7,1 | 9,9 | -3,2 | -5,5 | 2,5 | -16,7 | 13,4 |
| 28 | 3,2 | 2,6 | 0,5 | 0,8 | 1,8 | 1,2 | 3,2 | -2,0 | 1,4 | 1,7 | 4,9 | 2,2 | 2,6 | 0,3 | 1,9 | 5,7 | 2,7 | 3,0 | 3,3 | -0,6 |
| 29 | -2,5 | 0,9 | -3,3 | 1,0 | -0,1 | -2,1 | 1,7 | -3,8 | 1,7 | 0,0 | 1,9 | 2,2 | -0,3 | 2,2 | 0,0 | 16,8 | 14,9 | 1,6 | 14,6 | 0,3 |
| 30 | -1,9 | 2,1 | -3,9 | 2,1 | 0,0 | -2,5 | 3,3 | -5,6 | 3,0 | 0,3 | 1,9 | 4,1 | -2,1 | 4,3 | -0,2 | -8,9 | -10,0 | 1,2 | -10,6 | 0,6 |
| 31 | -2,7 | 2,1 | -4,7 | 1,2 | 0,9 | -3,5 | 2,5 | -5,9 | 1,5 | 1,0 | 0,0 | 3,5 | -3,3 | 2,8 | 0,6 | 27,0 | 26,8 | 0,1 | 27,9 | -0,8 |
| 32 | 0,7 | 3,5 | -2,7 | 2,7 | 0,8 | 0,0 | 3,4 | -3,3 | 2,6 | 0,8 | 7,2 | 6,1 | 1,0 | 5,1 | 0,9 | 29,5 | 25,5 | 3,2 | 26,3 | -0,6 |
| 33 | 2,3 | 0,0 | 2,3 | 0,0 | 0,0 | -2,2 | 0,3 | -2,5 | 0,4 | 0,0 | 4,9 | 2,5 | 2,4 | 2,2 | 0,3 | 23,8 | 19,7 | 3,4 | 18,2 | 1,3 |
| 34 | 2,3 | 4,7 | -2,3 | 4,3 | 0,4 | -0,3 | 4,7 | -4,8 | 4,3 | 0,4 | 11,4 | 10,5 | 0,8 | 9,1 | 1,2 | 52,8 | 48,2 | 3,1 | 49,0 | -0,5 |
| 35 | -5,1 | -1,9 | -3,2 | -1,7 | -0,2 | -6,5 | -1,9 | -4,6 | -1,7 | -0,2 | -3,4 | -2,8 | -0,7 | -3,4 | 0,7 | -3,7 | -6,5 | 3,1 | -6,1 | -0,5 |
| 36 | 2,3 | 0,0 | 2,3 | 0,0 | 0,0 | 1,3 | 5,6 | -4,1 | 5,3 | 0,2 | 0,2 | 0,0 | 0,2 | 0,0 | 0,0 | 48,2 | 44,3 | 2,7 | 44,0 | 0,2 |
| 37 | 1,8 | -0,4 | 2,3 | -2,8 | 2,4 | -3,7 | -0,2 | -3,5 | -2,0 | 1,9 | 11,8 | 11,0 | 0,7 | 6,4 | 4,4 | 8,3 | 2,9 | 5,2 | -0,9 | 3,9 |
| 38 | -6,0 | -1,6 | -4,5 | 0,0 | -1,6 | -6,7 | -1,9 | -4,9 | 0,0 | -1,9 | -2,4 | 0,1 | -2,6 | -2,7 | 2,9 | 7,8 | 5,5 | 2,2 | 4,7 | 0,7 |
| 39 | -1,3 | 0,5 | -1,7 | 0,5 | 0,0 | -1,8 | 1,7 | -3,4 | 1,7 | 0,0 | 1,4 | 0,9 | 0,6 | 0,5 | 0,3 | 11,3 | 8,9 | 2,2 | 9,5 | -0,6 |
| 40 | -2,1 | 0,2 | -2,3 | -2,5 | 2,7 | -3,2 | -0,5 | -2,7 | -3,1 | 2,6 | 13,1 | 10,7 | 2,1 | 6,6 | 3,9 | 22,4 | 18,1 | 3,7 | 13,1 | 4,4 |
| 41 | -2,5 | 1,4 | -3,9 | 1,1 | 0,3 | -2,5 | 1,4 | -3,9 | 1,2 | 0,2 | 1,1 | -0,7 | 1,8 | -0,4 | -0,3 | 9,9 | 4,2 | 5,4 | 2,4 | 1,7 |
| 42 | 1,7 | 5,0 | -3,2 | 0,0 | 5,0 | 1,4 | 5,1 | -3,5 | 0,0 | 5,1 | 4,2 | 3,3 | 0,9 | 0,0 | 3,3 | 8,7 | 7,1 | 1,5 | 0,0 | 7,1 |

Table 2 shows that the "general-model" had an annual mean increase in total factor productivity (M) of 0.2 percent for the period 1995 to 2006 across the university sector. In our case, the overall improvement in productivity over the period is composed of an average efficiency increase (movement towards the frontier) of 2.4 per cent, and average technological regress (movement in the frontier) of -1.3 per cent annually. The technical efficiency can be further decomposed into pure technical efficiency (1.5) and scale efficiency (0.7). Clearly, across all Spanish public universities the sustained improvement in productivity over the period 1995-2006 is the result of movements towards the efficiency frontier rather than expansions in the frontier.

In the analysis by years, the high mean productivity improvement was in academic year 1996/1997 with 7.5 per cent, which was composed of 7.4 per cent improvement in efficiency (the second ranked in the period analyzed) and 0.1 per cent of technological gain. By way of comparison, the high technological improvement was well spread across the sector in the academic year 2001/2002 (15.5 per cent), but with a fallen in efficiency (-11.4 per cent).

Looking at the results by universities at the same table, the University #24 had a mean productivity improvement of 8.7 per cent (first-ranked) which was composed of 4.9 per cent improvement in efficiency (moving towards the efficient frontier) and 3.6 per cent technological gain (movement in the frontier). Both figures moves closed.

Focusing on the "teaching-model", the annual mean decrease in total factor productivity (M) of -1.5 per cent for the period 1995 to 2006, composed of an improvement in technical efficiency change (3.5 per cent) and a fallen of the technological change (-2.5 per cent).

In the analysis by years, the high mean teaching only productivity improvement was in academic year 1996/1997 with 8.2 per cent, which was composed of 12.8 percent improvement in efficiency (the second ranked in the period analyzed) and -4.1 per cent of technological loss. By way of contrast, the high technological improvement was in the academic year 2001/2002 (33.9 per cent), but this has been offset by a decrease in teaching efficiency (-22.4 per cent).

In the analysis by university, the first ranked university was the University #20 with a teaching only productivity of 6.4 per cent which was composed of 9.8 per cent improvement in efficiency and -3.1 per cent technological loss. The lowest level of the teaching only productivity factor over the period is observed at the University # (-6.7 per cent) cause mainly for the decrease in technological change (-4.9 per cent).

With regards of the "research-model", Table 2 shows that the annual mean increase in research only productivity was 5.4 per cent for the period 1995 to 2006, which was composed on an average efficiency increase of 5.5 per cent, and average technological progress of 0.3 per cent annually.

In the analysis by years, the highest mean research only productivity was in academic year 1997/1998 (11.9 per cent). The academic year 2004/2005 was the second ranked (11.7 per cent).

However, the lowest increased in research only productivity was in academic year 2003/2004 with a -4.0 per cent.

Looking at the results of universities, the best-ranked performers were University #20 (25.0 per cent) and University #5 (16.3 per cent), while the worst-ranked performers were University #35 (-3.4 per cent) and University #38 (-2.4 per cent).

With respect to the "knowledge transfer-model", Table 2 shows that the annual mean increase in knowledge transfer only productivity was 12.4 per cent for the period 1995 to 2006, which was composed on an average efficiency increase of 17.6 per cent, and average technological progress of 9.1 per cent annually.

In the analysis by years (Table 2), the highest mean research only productivity was in academic year 1996/1997 with a 27.2 per cent followed by the academic year 2004/2005 with a 17.6 per cent. However, the lowest increased in research only productivity was in academic year 2000/2001 with a -6.5 per cent.

Looking at the results of universities, the best-ranked performers were University #34 (52.8 per cent) and University #36 (48.2 per cent), while the worst-ranked performers were University #23 (-11.7 per cent) and University #30 (-8.9 per cent).

**Figure 1. General Model**

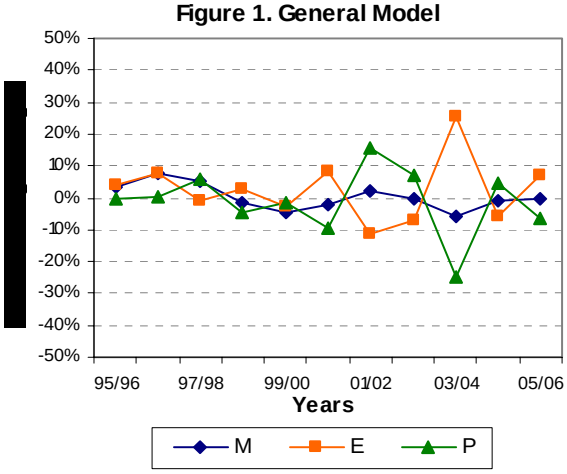



**Figure 2. Teaching Model**

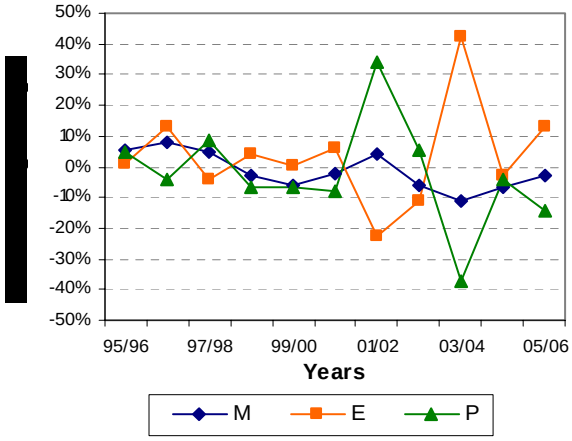



**Figure 3. Research Model**

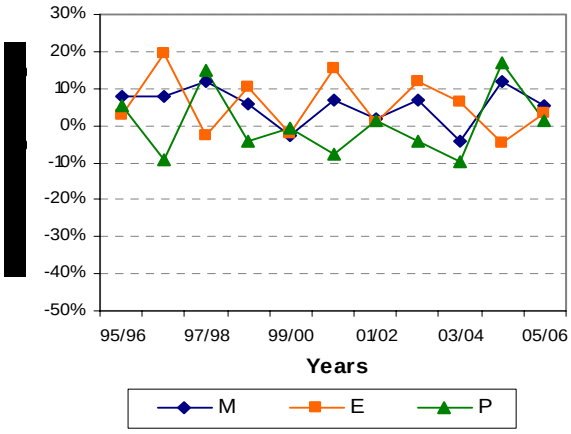
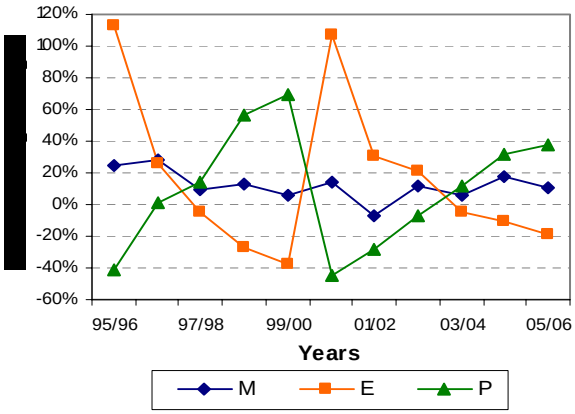



**Figure 4. Knowledge Transfer Model**



## 5. Conclusions

The results indicate that annual productivity growth average 0.2 per cent across all universities, with a range between -5.7 per cent and 7.5 per cent, and were largely attributed to efficiency improvements (2.4 per cent) rather than technological regress (-1.3 per cent).

The separate analysis of teaching-only, research-only and knowledge transfer-only productivity indicates that annual productivity growth averaged -1.5 per cent, 5.4 per cent and 12.4 per cent respectively, suggesting that most productivity growth was associated with improvements in knowledge transfer rather than teaching and research. In turn, the increase in research productivity is mainly sourced from efficiency gains and very little technological improvements, whereas the teaching losses are mostly associated with the removal of technological improvements rather than inefficiency. The interpretation of these results should be taken with care due to the overlap in teaching, research and knowledge transfer related inputs. It is clear that much of the overall productivity improvement in universities over this period is associated with gains in knowledge transfer and research productivity.

In the four specifications we consider to evaluate the evolution of Spanish public universities we can observe an important conclusion: the productivity decomposition realized warns us about of the importance that efficiency has as a source of growth of the productivity different from the technical progress.

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