TOTAL FACTOR PRODUCTIVITY MEASUREMENT AND HUMAN CAPITAL IN OECD COUNTRIES

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Abstract

This paper analyses the TFP evolution in OECD countries breaking down the productivity gains into technical change and efficiency. In order to avoid all kind of bias, we calculate Malmquist indices of productivity including human capital as an additional input. The results obtained indicate the existence of a significant effect associated with human capital and its importance for an accurate measurement of TFP.

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Key words: human capital, efficiency, technical change, Malmquist productivity index

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1.- Introduction

Typically, studies analyze total factor productivity (TFP) by estimating average production functions or by non-parametric index number approaches. In the first case, the usual practice has consisted of estimating average production functions (estimated by conventional regression methods) rather than genuine frontiers, assuming in consequence that all the units of production are efficient. Obviously the non-fulfilment of this assumption would affect the parameters estimated. In the second case, the accounting estimation of TFP also incorporates the implicit assumption that all individuals are efficient, so TFP growth is interpreted as the movement of the frontier function (technical change). However, in the presence of inefficiency, the accounting estimation of TFP would also be biassed (Grosskof, 1993)

In order to avoid such bias, it is necessary to use frontier techniques that consider the possible existence of inefficient behaviour. Such is the case of the papers by Färe et al. (1994) on the analysis of TFP growth in the countries of the OECD, and by Taskin and Zaim (1997) who show the importance of efficiency gains as a source of labour productivity convergence in OECD countries during the period 1975-1990. In both cases it is assumed that production is carried out using physical capital and labour exclusively, without considering the role of human capital.

However, the literature on the relationship between human capital and growth has a long tradition. Schultz himself (Schultz, 1962) clearly sets out how investment in human capital constitutes one of the main explanatory elements of economic growth. It is responsible, to a large extent, for the divergence observed between the growth of the product and that of the quantity of productive factors used, giving rise to a qualitative improvement of the labour factor which increases its productive capacity and generates economic growth. Previous studies provide extensive positive empirical evidence of the human capital importance[1].

Consequently, the studies which take into account inefficiency, although they use frontier techniques, do not include human capital as an additional productive factor. So its estimation of TFP may well be biassed too. This paper solves previous problems by including human capital for the first time as an additional input and analysing its importance by means of frontier techniques. This avoids the possible bias deriving from non-incorporation of efficiency and that deriving from the omission of a relevant input.

The paper is organised as follows. The second section describes briefly the technique

[1] See Baumol, Blackman and Wolff (1989), Barro (1991), Mankiw, Romer and Weil (1992), Lichtenberg (1994),

used. The third section describes the database used and presents the results relating to efficiency, technical progress and productivity, and tests the significance of human capital as productive input. Finally the main conclusions of the paper are presented in section four.

2. The measurement of productivity growth by means of the Malmquist index

In this study the Malmquist productivity index (Malmquist, 1953) is used to measure the growth of the productivity of the countries of the OECD. The basic idea of this method is to construct a best practice frontier for the countries of the OECD on the basis of which the relative distances of each country in a certain period *t* with respect to the frontier corresponding to that period *t* and to the period/s preceding it (*t-1*) and/or following it (*t+1*). More specifically, the index will establish that a particular country has experienced improvements in productivity from period *t* to period *t+1* when a country's distance in *t+1* from the frontier in *t* is greater than it was in *t*.

Following Shephard (1970) or Caves et al. (1982), the "distance function in outputs" of an individual in *t* relative to the technology of *t* (F^t) can be expressed as $D_0^t(x^t,y^t)=inf\{\vartheta^t:(x^t,y^t/\vartheta^t)\in F^t\}$, where y^t is the vector of outputs, x^t denotes the vector of inputs and (F^t) the technology corresponding to period *t*. This function D_0^t is defined as the reciprocal of the maximum expansion to which it is necessary to subject the vector of outputs of period *t* (y^t), given the level of inputs (x^t), so that the observation stands at the frontier of period *t*. On the basis of the above concepts, the Malmquist productivity index based on outputs to analyze productive change between periods *t* and *t+1*, taking the technology of period *t* as reference, is defined as

$$M_o^t\left(x^{t+1},y^{t+1},x^t,y^t\right)=\frac{D_o^t\left(x^{t+1},y^{t+1}\right)}{D_o^t\left(x^t,y^t\right)} \quad [1]$$

If $M_o^t>1$ indicates that the productivity of period *t+1* is higher than that of period *t*. On the other hand, $M_o^t<1$ indicates that productivity has descended between periods *t* and *t+1*.

When we wish to analyze the productive change of a longer time series, the use of a fixed technology may cause problems the further we get from the base year. To attempt to solve these problems it is usual to calculate two indices based on pairs of consecutive years which take as base the technology of the two periods *t* and *t+1* and to calculate the geometric mean of the two. Re-writing the geometric mean it is possible to break down the Malmquist productivity index into the

Barro and Lee (1994), Engelbrecht (1997) and Murthy and Chien (1997).

catching-up effect and technical change (Färe et al. ,1994) :

$$M_o\left(x^{t+1}, y^{t+1}, x^t, y^t\right) = \frac{D_o^{t+1}\left(x^{t+1}, y^{t+1}\right)}{D_o^t\left(x^t, y^t\right)}\left[\left(\frac{D_o^t\left(x^{t+1}, y^{t+1}\right)}{D_o^{t+1}\left(x^{t+1}, y^{t+1}\right)}\right)\left(\frac{D_o^t\left(x^t, y^t\right)}{D_o^{t+1}\left(x^t, y^t\right)}\right)\right]^{1/2} \quad [3]$$

The catching-up effect or change in relative efficiency between periods *t* and *t+1* is represented by the first ratio, which will be higher than unity if there has been an increase in efficiency. Similarly, the geometric mean of the two ratios between brackets measures the technical change or movement of technology between periods *t* and *t+1*[2].

3. Data and Results

The sample used for the estimation of the frontier production function consists of the countries of the OECD in the period 1975-90 using the Summers and Heston database (Penn World Table, Mark 5.6)[3] and Barro and Lee (1993)[4]. The variables for each country are: 1) aggregated output measured by real Gross Domestic Product (GDP), expressed in international prices; 2) aggregated labor input measured by total employment; 3) total capital stock calculated from the non-residential capital per worker; and 4) human capital stock calculated as the number of schooling years completed by the occupied population obtained as a product of the average schooling years of the population over 25 years of age[5] (proxy of the per capita endowment of human capital), and the number of workers.

Using the approach described in section 2, USA is consistently efficient over the whole period as in Färe et al. (1994) and Taskin and Zaim (1997). Table 1 shows the growth rate of TFP and its breakdown into technical change and changes in efficiency of the countries of the OECD considering, as well as labour and physical capital, human capital given its importance as an additional productive factor[6].

Looking first at the results of the weighted average of OECD countries, the average

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[2] The Malmquist index can be calculated in several ways (Caves et al. 1982). In this study, we calculate the Malmquist index using the DEA non-parametric technique of linear programming.

[3] This is an updated version of Summers and Heston (1991).

[4] The sample used consists of Canada, USA, Japan, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, UK, Australia and New Zealand. Luxembourg is excluded because of lack of data on human capital.

[5] Barro and Lee (1993) only offer this datum every five years. The intermediate years have been estimated by interpolation.

[6] In order to test empirically the significance of human capital in the DEA model the Banker test (Banker, 1996) was used, indicating that human capital is statistically significant.

change in the Malmquist productivity index was less than 1 percent per year (column 1). On average, that growth was due to innovation (column 2) rather than improvements in efficiency (column 3). Focusing on USA, Japan and the European-Union (EU), important differences are observed. Thus, Japan has the highest productivity growth at 1.36 percent per year on average, almost half of which is due to improvements in efficiency, while in EU the contribution of efficiency gains to TFP growth is very low.

With the aim of testing the possible bias remarked upon in the estimation of productivity gains when the role of human capital is not explicitly considered, figure 1 compares the cumulative evolution of TFP and efficiency for the USA, Japan, EU and OECD, excluding or including human capital. The results indicate that excluding human capital causes an important change in the relative position of Japan, improving its productivity considerably when we consider human capital. The breakdown of TFP into technical change and efficiency allows it to be appreciated that this change in relative positions is due to the higher rate of efficiency gains in Japan when we explicitly consider human capital as an additional productive factor, which shows the importance of this factor for the correct evaluation of the behaviour of productivity and of its sources of growth.

Why does measuring human capital make such a big difference for Japan? Japan is the OECD country with highest growth rate of the physical capital stock during this period (4.32% p.a. as against 2.87% p.a. in the USA, for example). However, the accumulation of human capital is more modest and does not differ from the general pattern of the OECD (2.31% p.a. as against 2.75% p.a. for the USA). The evolution of capital in the broad sense (including physical and human capital) is more modest, so Japan´s TFP growth rate increases significantly when human capital is incorporated.

4. Conclusions

This note has confirmed the importance of human capital in the measurement of TFP growth in the OECD, explicitly incorporating into the analysis the importance of efficiency as a source of variation in TFP other than technical progress.

Indeed, the analysis of the breakdown of TFP growth into technical change and variations in efficiency shows the importance of considering human capital as an additional productive factor. Thus, non-consideration of human capital causes an important change in the relative positions of the USA and Japan, the position of Japan improving considerably in terms of productivity and efficiency when we consider human capital as input. Furthermore, the breakdown of change in TFP into technical change and variations in efficiency allows it to be appreciated that this modification of relative positions is due to Japan's higher rate of efficiency change when we explicitly consider human capital.

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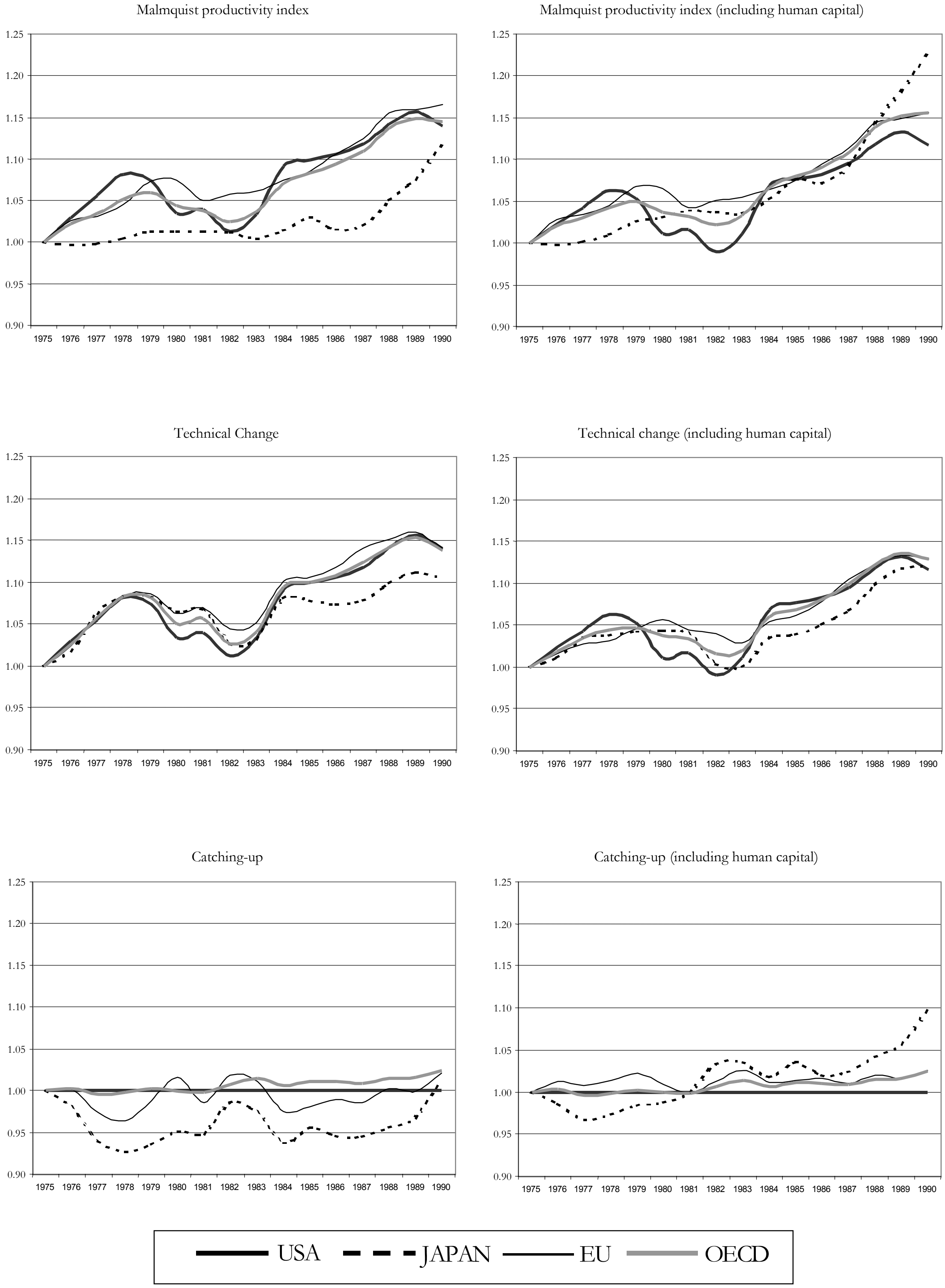
Table 1: Malmquist index decomposition. Average annual growth rate (%)

	(1) TFP	(2) Tecnical Change	(3) Efficiency Change
USA	0.74	0.74	0.00
JAPAN	1.36	0.76	0.60
EU	0.96	0.81	0.17
OECD	0.96	0.81	0.16

Figure 1: Cumulated results: Total factor productivity, technical change and catching-up (1975 = 1.00)



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"Total Factor Productivy Measurement and Human Capital in OECD Countries" (by Joaquín Maudos, Jose M. Pastor and Lorenzo Serranao)

Valencia, September 7, 1998

Dear professor Maskin,

I enclose two copies of the revised version of the paper "Total factor productivity measurement and human capital in OECD countries", of which I am co-author with Jose M. Pastor and Lorenzo Serrano. As you will see, we have incorporated all the comments of the referee.

We are looking forward to hearing from you. Sincerely yours,

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