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Technical efficiency and the role of information technology: A stochastic production frontier study across OECD countries

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CENTRE FOR PLANNING AND ECONOMIC RESEARCH

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ΠΕΡΙΛΗΨΗ

Σκοπός της παρούσας μελέτης είναι να εξετάσει τις επιπτώσεις των Τεχνολογιών Πληροφορικής και Επικοινωνιών (ΤΠΕ) στην τεχνική αποτελεσματικότητα (technical efficiency), σε επίπεδο εθνικών οικονομιών. Με βάση τα πρόσφατα συμπεράσματα της διεθνούς αρθρογραφίας οι ΤΠΕ είχαν ισχυρή επίδραση στην παραγωγικότητα και στην ανάπτυξη των οικονομιών τόσο των ΗΠΑ όσο και αρκετών ευρωπαϊκών χωρών. Δεν υπάρχει ωστόσο συναίνεση μεταξύ των οικονομολόγων όσον αφορά στην επίδραση των ΤΠΕ στην συνολική παραγωγικότητα των συντελεστών (total factor productivity). Η παρούσα μελέτη συμβάλλει προς αυτή την κατεύθυνση, εξετάζοντας τις επιπτώσεις των ΤΠΕ στην τεχνική αποτελεσματικότητα (η οποία αποτελεί μέρος της συνολικής παραγωγικότητας) των χωρών του ΟΟΣΑ.

Η συνεισφορά της παρούσας εργασίας στη σχετική βιβλιογραφία είναι πολυδιάστατη. Πρώτον, σε σύγκριση με παρόμοιες μελέτες, η εργασία μας υιοθετεί έναν ευρύτερο ορισμό των επενδύσεων σε ΤΠΕ, ο οποίος συμπεριλαμβάνει τις επενδύσεις σε υλικό, λογισμικό και επικοινωνίες. Δεύτερον, η παρούσα μελέτη δεν αντιμετωπίζει τις επενδύσεις σε ΤΠΕ ως έναν συμβατικό συντελεστή που επηρεάζει την παραγωγικότητα μέσω του συνηθισμένου διαύλου της εμβάθυνσης κεφαλαίου (capital deepening). Αντί αυτού, εκτιμούμε την παραγωγική επίδραση των ΤΠΕ κάνοντας τη ρητή παραδοχή ότι οι ΤΠΕ είναι ένα ιδιαίτερο είδος τεχνολογικού και γνωστικού κεφαλαίου, οι επιπτώσεις των οποίων θα πρέπει να αποτιμηθούν στην συνολική παραγωγικότητα μέσω του διαύλου της τεχνικής αποτελεσματικότητας. Τέλος, η συγκεκριμένη εργασία αποτιμά την ποσοστιαία συμβολή των ΤΠΕ στην αποτελεσματικότητα κάθε χώρας ξεχωριστά, χρησιμοποιώντας τη μεθοδολογία των Coelli et al (1999).

Σε επίπεδο χάραξης πολιτικής, η μέτρηση της τεχνικής αποτελεσματικότητας μπορεί να είναι ιδιαίτερα χρήσιμη για τον προσδιορισμό των τρόπων με τους οποίους μπορεί να επιτευχθεί οικονομική μεγέθυνση. Για παράδειγμα, ένα χαμηλό επίπεδο τεχνικής αποτελεσματικότητας για μια συγκεκριμένη χώρα, θα σήμαινε ότι η οικονομική μεγέθυνση θα μπορούσε να επιτευχθεί μέσω της πιο αποτελεσματικής χρήσης των ήδη υπαρχόντων παραγωγικών πόρων. Αντιθέτως, μια χώρα που έχει ήδη επιτύχει ένα υψηλό επίπεδο τεχνικής αποτελεσματικότητας θα πρέπει να εστιάσει περισσότερο στην τεχνολογική πρόοδο και στην καινοτόμο δραστηριότητα, προκειμένου να επιτύχει υψηλότερους ρυθμούς οικονομικής ανάπτυξης.

Η παρούσα εργασία χρησιμοποιεί τη μεθοδολογία ενός στοχαστικού υποδείγματος παραγωγής προκειμένου να ποσοτικοποιήσει τις επιπτώσεις των ΤΠΕ στη τεχνική αποτελεσματικότητα των χωρών. Η συγκεκριμένη προσέγγιση εφαρμόζεται σε ένα δείγμα 17 χωρών του ΟΟΣΑ (Αυστραλία, Αυστρία, Βέλγιο, Δανία, Φινλανδία, Γαλλία, Γερμανία, Ελλάδα, Ιρλανδία, Ιταλία, Ιαπωνία, Ολλανδία, Πορτογαλία, Ισπανία, Σουηδία, Ηνωμένο Βασίλειο, Ηνωμένες Πολιτείες), για την περίοδο 1990-2005.

Τα ευρήματα της συγκεκριμένης μελέτης συνοψίζονται ως εξής: Η επίδραση των ΤΠΕ στην τεχνική αποτελεσματικότητα των χωρών του ΟΟΣΑ είναι κατά μέσο όρο θετική και σημαντική. Συγκεκριμένα, τα αποτελέσματα δείχνουν ότι οι ΤΠΕ συνέβαλαν πάνω από 5% στην αύξηση της τεχνικής αποτελεσματικότητας των χωρών του δείγματος. Οι εκτιμήσεις δείχνουν ότι οι πλέον αποτελεσματικές χώρες είναι το Βέλγιο και η Ολλανδία, ενώ ακολουθούν οι Ηνωμένες Πολιτείες. Η Ελλάδα είναι 15η στην κατάταξη σε σύνολο 17 χωρών. Σε γενικές γραμμές, όλες οι χώρες του ΟΟΣΑ έχουν κατορθώσει να αυξήσουν το μέσο επίπεδο της τεχνικής αποτελεσματικότητάς τους την περίοδο 1990-2005. Στις περισσότερες από αυτές έχει αυξηθεί από το επίπεδο του 75% σε επίπεδο ακόμη και πάνω από το 85%. Παρά τη σημαντική αύξηση της αποτελεσματικότητάς τους, αρκετές χώρες της νότιας Ευρώπης (όπως η Ισπανία, η Ελλάδα και η Ιταλία) δεν έχουν ακόμη επιτύχει να συγκλίνουν με τις υπόλοιπες χώρες του ΟΟΣΑ.

Η εργασία είναι δομημένη ως εξής. Η πρώτη ενότητα περιέχει την εισαγωγή, αναφέρει τη συνεισφορά της εργασίας στη σχετική βιβλιογραφία και συνοψίζει τα βασικά αποτελέσματα. Η δεύτερη ενότητα συνοψίζει τα αποτελέσματα της σχετικής βιβλιογραφίας. Η τρίτη ενότητα εισάγει το θεωρητικό υπόβαθρο και στην τέταρτη ενότητα αναλύεται το οικονομετρικό υπόδειγμα. Η πέμπτη ενότητα παρουσιάζει τα στατιστικά στοιχεία που χρησιμοποιήθηκαν στην εμπειρική ανάλυση και η έκτη ενότητα περιγράφει τα αποτελέσματα. Το έβδομο (τελευταίο) τμήμα περιέχει τα συμπεράσματα της εργασίας.

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ABSTRACT

This paper investigates for possible Information and Communication Technology (ICT) effects in reducing aggregate technical inefficiency. A stochastic production frontier is simultaneously estimated with a technical inefficiency model using a panel of 17 OECD countries in the period 1990-2005. Clear evidence is found for a significant ICT impact in the reduction of cross country inefficiencies. In particular, the results show that, on average, ICT contributed by more than 5% in the increase of technical efficiency across countries and over time. The efficiency estimates indicate that the most efficient countries are Belgium and Netherlands, followed by the USA. However, it seems that several south European countries are less efficient and have not yet converged to the efficiency levels of the most developed OECD countries.

JEL classification: O30, O47, O50.

Keywords: Technical Efficiency. ICT, Stochastic Production Frontier, Panel Data.

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1. INTRODUCTION

Technological progress is considered as the most important factor that fosters long run economic growth (Grossman and Helpman 1991). Information and Communication Technology (ICT) is considered as the latest major technological breakthrough which has broad applicability across many sectors of the economy, has many and varied uses and allows for a wide range of technological complementarities (Bresnahan and Trajtenberg 1995). Some essential features of ICT include the trade of services at low cost through Internet, the effective management of information flows and the low transaction costs. Although it seems that ICT requires costly adjustment at initial stages of development, it is expected that the long run growth impact of ICT will be highly important.

According to OECD (2008) the share of ICT investment in gross fixed capital formation has increased substantially in most OECD countries and has reached levels above 20 % in countries like the USA, United Kingdom, Finland, Sweden etc. Now, it is almost certain that ICT had a significant impact on labor productivity growth in the USA and EU and accounts for a part of the faster productivity growth witnessed in USA during the late 90s (Van Ark et al. 2003). There is less consensus, however, among the economists on its impact on technical progress and Total Factor Productivity (TFP) growth (see Gordon 2000). According to the findings of Stiroh (2002), ICT is correlated with labor productivity growth but not correlated with TFP growth in US manufacturing industries.

We wish to contribute towards this direction by examining the impact of ICT capital (which constitutes a part of TFP) on the technical efficiency of OECD countries. The existing literature has concentrated more on the ICT effects on growth or productivity and, although an essential relationship exists between efficiency and productivity (Grosskopf 1993), the question on whether ICT affects the level of technical efficiency has been examined in few firm level samples (Lee and Barua 1999; Milana and Zeli 2002; Becchetti et al. 2003) and recently in two cross country studies (Thompson and Garbacz 2007; Repkine 2008). We contribute to the relevant literature in several ways. As compared to other cross country studies, our study employs a much broader cluster of ICT inputs which includes hardware, software and communications. We believe that the essential characteristic of ICT is the match of computers and chips with sophisticated software and communication networks. In this way we treat ICT as an entire cluster of interrelated assets, the impact of which we intend to test on technical efficiency. Secondly, this study does not treat ICT as a conventional type of input affecting output through traditional channels of capital deepening. Instead, we evaluate the ICT impact by explicitly assuming that ICT is a special type of technology and knowledge capital, the impact of which should be evaluated on TFP through the channel of technical efficiency. Finally and more importantly, we evaluate the percentage contribution of ICT in reducing cross country inefficiencies by using a framework developed by Coelli et al. (1999). At the aggregate cross country level, the measurement of technical efficiency might be particularly useful in identifying ways to promote economic growth. A low level of technical efficiency, for an individual country, would imply that higher economic development could be achieved by efficiently producing more output with the same level of inputs. On the other hand, a highly efficient country should lie more on technical progress and innovative activity in order to achieve higher economic growth.

We use stochastic frontier analysis to quantify the impact of ICT in cross country technical efficiency. A relatively recent production frontier approach is used which simultaneously estimates a stochastic production frontier with a technical inefficiency function (Battese and Coelli 1995).

We apply this approach by looking into the effects of ICT on technical inefficiency across a panel of 17 OECD countries (Australia, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Portugal, Spain, Sweden, United Kingdom, United States) in the period 1990-2005.

Clear evidence is found for a significant ICT impact in the reduction of cross country inefficiencies. In particular, the results show that, on average, ICT contributed by more than 5% in the increase of technical efficiency. The efficiency estimates indicate that the most efficient countries are Belgium and Netherlands, followed by the USA.

The rest of this paper is organized as follows. Next section summarizes the results of the relevant literature. Section 3 introduces the theoretical background and section 4 discusses the econometric specification of the model. In section 5 the data are described and some descriptive statistics are presented, while section 6 provides the empirical results. Finally, section 7 concludes.

2. A SURVEY OF EMPIRICAL LITERATURE

A number of techniques has been developed in order to estimate production frontiers, measure efficiency levels and identify sources of technical inefficiency. The range of their application has been broadly spread among sectors and levels of economic activity. In this section, we will focus either on studies carried out at the cross country level, or on studies which examine the impact of ICT or ICT components on technical efficiency (see table 1 for a brief presentation of the relevant literature).

Fare et al. (1994) has analysed productivity growth of 17 OECD countries for the period 1979-1988. They used non parametric methods and decomposed productivity into technical change and efficiency improvement. Their results showed that the US productivity growth was based mainly on technical change while Japan's productivity growth was based on efficiency change. Koop et al. (1999) used the same sample of countries during the same time period to analyse the components of output growth. However, they used a Bayesian stochastic frontier framework and showed that efficiency change was a significant component in explaining output growth of OECD countries.

Recent cross country studies have focused on several factors related to technical efficiency. Adkins et al. (2002) used a broad set of 73 developed and developing countries during the period 1975-1990 to simultaneously estimate a stochastic production function and the sources of cross country inefficiencies. Their results showed that institutions that promote economic freedom in turn promote efficiency. Milner and Weyman-Jones (2003) analysed the impact of trade openness and country size on aggregate national efficiency by using non parametric methodologies in a group of 85 developing countries during the period 1980-1989. After having estimated the efficiency levels of countries, the regression analysis showed that trade openness indeed has a positive and significant impact on country efficiency. With respect to the country size, the results indicate a negative but not always significant effect on national efficiency.

Jayasuriya and Wodon (2005) used a panel dataset to estimate a production frontier of 71 countries for the 1980-1998 period. They also analysed the impact of urbanization on productive efficiency and showed a positive and significant impact attributed to the presence of spillover effects and scale economies. Kneller and Stevens (2006) investigated whether human capital and R&D have any impact on productive efficiency. They used a dataset for nine industries in twelve OECD countries for the period 1973-1991. The results are in favour of a positive and significant impact of human capital in reducing productive inefficiency. In contrast, the results are less robust with respect to R&D.

The most recent cross country study which examines technical efficiency is that of Henry et al. (2009). They used a sample of 57 developing countries during the period 1970-1998 and their results indicated significant differences in efficiency levels across countries and over time. Furthermore, they showed a significant influence of trade and trade policy in raising output through embodied technology improvements as well as through efficiency improvements.

To our knowledge there exist at least five published studies which examine the impact of ICT or ICT components on technical efficiency. The three of them focus on the firm level and the rest two analyze the impact of telecommunications on cross country technical efficiency. With respect to the firm level studies, Lee and Barua (1999) examined the impact of Information Technology (IT) by using a stochastic frontier framework in a sample of manufacturing firms in 1978–1984. Their results showed that the firm level inefficiencies were reduced with the increase in the IT intensity. Milana and Zeli (2002) examined the impact of ICT on technical efficiency in a wide range of Italian firms for the year 1997. They measured technical efficiency of each individual firm by using the non parametric technique of data envelopment analysis. As a second step, they used regression analysis to model the impact of ICT on technical efficiency and found that a positive relationship could not be rejected in the entire group of firms. Becchetti et al. (2003) analyzed the impact of IT on productivity and efficiency on a sample of small and medium sized Italian firms. Their results showed a positive effect of software investment on firm efficiency for the period 1995-1997.

At the cross country level, on which this study focuses, Thompson and Garbacz (2007) used measures of penetration rates of telecommunication services to evaluate their impact on technical efficiency. They used a sample of 93 developed and developing countries for the period 1995-2003 and the obtained results indicate that penetration rates of telecommunication services significantly improve the efficiency for the whole group of countries. The effects are quite important for low income countries that operate below the frontier. In contrast, these effects are insignificant for OECD countries since they already operate or are close to the frontier. Finally, Repkine (2008) constructed a measure of telecommunication capital and estimated its impact on technical efficiency. A sample of 50 developed and developing countries was used for the period 1980-2004. The results indicated that telecommunications' capital positively affects efficiency of production in developing countries. In contrast such effects do not exist in developed countries, because any efficiency gains have been exhausted.

3. THEORETICAL BACKGROUND – CHANNELS OF ICT IMPACT ON TECHNICAL EFFICIENCY

Technological progress is considered as the most important factor for long run economic growth (Grossman and Helpman 1991). Particularly, economic theory and historical evidence support that general purpose technologies play a catalyst role in the process of economic growth (Bresnahan and Trajtenberg 1995).

ICT is considered as a technological breakthrough which shares all the characteristics of GPTs (Bresnahan and Trajtenberg 1995). Although the ICT revolution is mainly driven by the computer, the economic implementation of this technology requires the development of a wide range of complementary products, such as software, networks, products incorporating hard coded chips etc. Furthermore, ICT is a technology which has a wide applicability in many uses and sectors of the economy. Some relevant examples include the process of product designing, the production control, marketing and finance and distribution of products. Although the rapid change and wide reach of ICT requires costly adjustment (capital obsolescence creation of complementary products and skills training) at initial stages of development (the case of the US economy constitutes a representative example with TFP and labor productivity losses in the 80s and the first part of the 90s), it is expected that the long run economic impact of ICT will be highly important.

Changes in telecommunication technology and Internet now allow the trading of services at low cost and led to increases in economic activity. Such developments lead to economic gains through trade specialization, greater scale economies, and the realization of comparative advantage (Harris 1995). Furthermore, the creation of firm specific networks facilitates higher flexibility and enhances movement of economic activity throughout the world. Service transactions between parties of a multinational firm can now be mediated over vast distances electronically both instantaneously and at low cost.

ICT allows the more effective management of information flows than workers do and this has eliminated the need for extra human resources and has led firms to major management reorganizations. At the first stages of computer introduction, it is quite possible to witness lower productivity, since this new technology requires skills improvement and workplace reorganization (Bresnahan et al. 2002). Thus, ICT investment is likely to move together with organizational changes and with improvement in the firms' skill mix.

An additional feature of ICT is its scale economies and the low marginal cost of production. It would be quite plausible to expect for a firm that wants to distribute products via the Internet, to invest enough money in order to build the necessary infrastructure. However, as soon as this infrastructure is implemented, the firm can trade with its customers at low marginal costs. Thus, the production of network products is generally involved with large fixed costs, but low marginal costs. A final characteristic of ICT is its network nature. This means that the value of ICT grows as the number of users increases. We expect that, through these channels, the diffusion of ICT's will raise productive efficiency and will enhance productivity.

4. ECONOMETRIC SPECIFICATION

Two broad methodologies have been used for production frontier estimation: non parametric methods (data envelopment analysis or free disposal hull) and stochastic frontier techniques. The main advantage of non parametric methods is that they do not impose any restrictions on production technology. On the other hand the main disadvantage is that such methods are unable to disentangle inefficiency effects from white noise. Stochastic methods on the other hand are able to distinguish the error component from the non negative component of inefficiency, however this approach has the disadvantage that it imposes the same functional form and same production technology to all countries.

Earlier studies frequently used to follow a two stage estimation procedure, where the production frontier and efficiency levels were estimated at the first stage by OLS and then the efficiency levels were regressed on a number of explanatory variables. However, this two stage estimation procedure has several drawbacks. According to Kumbhakar et al. (1991), inefficiency might be correlated with the inputs, while the use of OLS in the second stage does not take into account the fact that the dependent variable of inefficiency takes only positive values. Both drawbacks lead to inconsistent estimates for inefficiencies and second stage parameters. Therefore, we follow the specification proposed by Battese and Coelli (1995). In their setting, they incorporate a technical inefficiency model in the stochastic frontier model to perform a simultaneous one-stage approach.

Production frontier modelling

One of the main assumptions in frontier analysis is that all producers share a common production structure and, therefore, face an identical production function. Given the high degree of economic integration and the liberalization of most OECD economies, we make the assumption that OECD countries have access to common production technologies and face the same production function:

$$Y_{it} = A\, e^{\lambda t}(L_{it})^{\alpha}(K_{it})^{\beta}\, \mathrm{e}^{(V_{it}-U_{it})} \qquad (1)$$

The subscripts of i and t denote country and year, respectively while Y measures GDP of each country. A is the level of technology in which all countries have identical access, λ is the rate of technical change and t is a time trend which captures technical progress over time. V_{it} is the random variable assumed to be independently and identically distributed $N(0,\sigma_v^2)$ and independent of U_{it}. The later is the nonnegative random error, associated with technical inefficiency of production. This error term is assumed to be independently distributed of V_{it} and has a half normal distribution equal to the upper half of the $N\,(0,\sigma_u^2)$ distribution.

In this study, we measure labor input (L) in hours worked since the variable of the number of workers might hide changes in hours worked caused by part time work or variations in overtime. The parameters α and β are the output elasticities of labor (L) and physical capital (K). After taking a logarithmic transformation, output in each industry can be expressed as a function of labor and physical capital:

$$\ln(Y_{it}) = c + \lambda t + \alpha \ln(L_{it}) + \beta \ln(K_{it}) + V_{it} - U_{it} \qquad (2)$$

Following Battese and Coelli (1995), the technical inefficiency effects are assumed to be a function of a set of explanatory variables z_{it} and can be defined as:

$$U_{it} = \delta + \sum_{j=1}^{n} \delta_j z_{j,it} + W_{it} \qquad (3)$$

where z_{it} is a vector of variables assumed to influence inefficiency and δ_j*'s* are parameters to be estimated. The random variable W_{it} is defined by the truncation of the normal distribution. The technical efficiency of country *i* at time *t* is estimated as:

$$TE_{it} = \exp(-U_{it}) \quad (4)$$

Furthermore, by estimating the parameters $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2 / \sigma_v^2 + \sigma_u^2$, we can test whether $\gamma=0$[1]. A rejection of the null hypothesis that $\gamma=0$, against the alternative that γ is positive, implies that deviations from the frontier are due to inefficiency effects.

Inefficiency variables-the role of ICT

Modeling the impact of ICT might be a complex task. Particularly our main concern relates to whether ICT should be treated as a separate production input which affects output by the traditional channel of higher capital deepening, or should it be modeled in a way that affects technical progress or technical efficiency? According to the theory of GPT, ICT is a technology that has broad applicability in all sectors, improves the flow of information, reduces transaction costs and finally raises TFP. Empirically, Van Ark et al. (2003) have argued that higher TFP observed in USA during the late 90s is linked to intensive use of ICT in some service (wholesale and retail trade, financial securities) and manufacturing (ICT producing) industries.

Since the focus of the present study is on the impact of ICT on technological progress, ICT is not treated here as a conventional capital but, rather as a special type of technology input that gives rise to the technical efficiency of countries. We wish to test this formally by estimating the technical inefficiency model of equation 3, in which ICT as a share of GDP is used as an explanatory variable.

We will further include a variable to proxy human capital as another factor influencing technical efficiency. This variable is measured as the share of hours worked by high skilled persons. We should note that there is some debate with respect to the role of human capital in economic growth. Mankiw et al. (1992) argue that human capital should enter the production function as a separate input. On the contrary, Benhabib and Spiegel (1994) and Pritchett (2001) argue that human capital influences growth indirectly through total factor productivity. Clearly, it is beyond the

[1] The parameter σ^2 is the overall variance of the error term, σ_v^2 is the variance of V_{it}, while σ_u^2 is the variance of the inefficiency term U_{it}.

scope of this paper to address this issue. However, since our interest mainly lies on the determinants of technical efficiency, we will evaluate its impact on technical efficiency by assuming that human capital plays a significant role in the absorptive capacity and technology transfer across countries (Kneller and Stevens 2006) and, therefore, in their level of technical efficiency.

We also use the volume of international trade of each country as another explanatory variable in equation 3. Higher trade volumes allow countries to specialize and gain comparative advantage which in turn lead to scale economies and higher efficiency. International trade is, also, considered as an important channel of technology transfer through imports of intermediate inputs and capital equipment (Feenstra et al. 1992). Furthermore, international trade is expected to affect the level of efficiency through higher competition and removal of rent seeking activities (Bhagwati and Krueger 1973). We expect that the impact of this variable on inefficiency will be negative.

The parameters of the production function (2) as well as of the inefficiency function (3) are estimated simultaneously at one stage by maximum likelihood and by using the computer program FRONTIER 4.1 which is developed by Coelli (1996).

5. DATA AND DESCRIPTIVE STATISTICS

This analysis is based on a panel of 17 OECD countries (Australia, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Portugal, Spain, Sweden, United Kingdom, United States) in the period 1990-2005. Table 2 presents a detailed description of the data and their sources. The data concerning GDP, volume of international trade and the number of hours worked were taken from OECD (2008), while the data regarding hours worked by high skilled persons were provided by the EU KLEMS (2007) database. Initial data on capital stock were taken from Penn World Tables (Heston and Summers 1991), while capital stock estimates for the subsequent years are calculated by adding for each year the gross fixed capital formation (World Development Indicators 2008) and subtracting capital depreciation (IMF 2008).

The ICT investment data are provided by OECD (2008). We should acknowledge that ICT investment assets are subject to rapid technological change and quality improvement. Thus, we need to have accurate price indices in order to correctly measure ICT investment series. These should be constant quality price indices that reflect price changes for a given set of characteristics of ICT (Schreyer et al. 2003). For this reason, we use harmonized price indices for ICT assets which are currently used in the computation of growth in capital services presented in the OECD productivity database[2]. Additionally, these harmonized deflators are purchasing power parity adjusted and this helps us to improve the international comparability of ICT investment across countries. Although no claim is made that the harmonized deflator is necessarily the correct price index for a given country, Schreyer et al. (2003) suggest that the possible error due to using a harmonized price index is smaller than the bias arising from using national deflators[3].

All the value variables are expressed in purchasing power parity in order to make the data compatible across countries. It should be made clear that the choice of countries and time period is dictated by the availability of data for all variables used in this empirical study. With this in mind, first a description of the data is made and then follows the econometric analysis. Table 3 contains some descriptive statistics for all variables that will be employed in our econometric analysis, while table 4 displays the estimated GDP shares of ICT investment across individual countries for the period 1990-2005. It deserves to mention the cases of Australia and the USA, being by far the most ICT intensive countries (3.63% of GDP in Australia and 3.56% of GDP in USA) in 2005, followed by Sweden, UK, Denmark and Japan. On the contrary, Ireland, Portugal, Greece and Italy present very low rates of ICT investment.

6. EMPIRICAL RESULTS

Econometric results

Table 5 contains the maximum likelihood estimates of the stochastic production frontier for the panel of 17 OECD countries in the period 1990-2005. The proposed production function includes a time trend and the inputs of physical capital and labor, measured in hours worked. The technical inefficiency equation is simultaneously estimated using as regressors the ratio of ICT investment to GDP, a proxy for human capital (measured as the share of hours worked by high skilled persons) and the volume of international trade of each country as a share of GDP.

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2 We wish to thank the Productivity Department of OECD for kindly providing us with appropriate ICT deflators.

3 Large differences that have been observed between computer price indices in OECD countries are likely a reflection of differences in statistical methodology. In particular, those countries that employ hedonic methods to construct ICT deflators tend to register a larger drop in ICT prices than countries that do not.

As we can see from the baseline results reported in column 1, physical capital and labor have a significantly positive effect on output. The results are plausible and compare well with those provided by the empirical growth literature. The coefficient on time trend appears to be insignificantly negative and indicates that the time trend might not be a good proxy for technological progress[4]. To determine whether deviations from the estimated frontier are due to inefficiency effects, a test of the null hypothesis that $\gamma=0$, against the alternative that γ is positive, is used. As it is evident, the parameter γ is significantly different from zero, and this implies that inefficiency effects are present and that we should proceed with the estimation of parameters related to the sources of inefficiency.

The technical inefficiency results indicate that a rise in the share of ICT in GDP contributes significantly in reducing inefficiencies among countries. In particular, the estimates of column 1 imply that doubling the share of ICT investment in GDP would on average reduce the inefficiency level of a country by 6%, ceteris paribus. With respect, to the variables of human capital and the volume of international trade, we can distinguish a significantly negative, and quite sizeable in magnitude, association with technical inefficiency.

Although the arguments in section 4.2 were in favor of including ICT and human capital variables into the inefficiency function, we would prefer to check the robustness of our results across alternative specifications. For this reason, we reestimate our model by considering human capital as directly affecting output through the production function (column 2) and by allowing for additional effects of ICT as a traditional production input (column 3). In this way we can test for additional direct effects of ICT and human capital through their inclusion into the production function.

From the reported results in column 2, we can see that when human capital enters the production function, its direct effect on output is positive and significant. We believe that this result (combined with its negative effect on technical inefficiency) complements those from previous studies which support that either human capital should be included as an input in the production function (Mankiw et al. 1992) or that human capital affects output indirectly through TFP (Benhabib and

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4 Ideally, we should have included measures of R&D or innovative activity in order to account for technological progress. However such data are available for fewer countries and years and their use would lead to a severe reduction in the size of the sample.

Spiegel 1994; Pritchett 2001). Our study indicates that this indicator of human capital has direct as well as indirect effects on growth for the particular sample of countries and for this specific time period. The results with respect to the remaining variables do not change significantly.

In column 3, we report estimates after having included ICT as a factor of production. Since ICT enters directly the production function, its measure should be denoted in physical capital terms[5]. As it is evident, the elasticity of ICT capital is highly positive and significant, implying a strong and positive association of ICT with output. Importantly, it seems that the ICT impact is quite sizable given that the share of ICT in total non residential gross fixed capital formation was about 15-20% in most OECD countries during the period under investigation (OECD 2008). This result compares well with the growth accounting results obtained from Colecchia and Schreyer (2002) for a sample of OECD countries during the 90s which show that the ICT contribution was about 15%-20% of output growth. With respect to the impact of ICT on technical inefficiency, we can see that its impact remains significantly negative but lowers slightly in magnitude.

Efficiency scores across countries and over time - contribution of ICT to efficiency

Table 6 presents average efficiency measures for the 17 OECD countries, in 1990-1995, 1995-2000, 2000-2005 and the entire period 1990-2005. The most efficient countries in the sample are Belgium and Netherlands followed by the USA and other north European economies. On the other hand, the least efficient countries in the sample are Greece, Japan and Portugal. The efficiency rankings, in general, show that the north European countries and the USA lead in terms of technical efficiency, while the south European countries are relatively less efficient. This sounds reasonable enough given the fact that the latter are comparatively less developed (in GDP per capita terms). In general, the efficiency ranks are in

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[5] Our estimates of ICT capital stock are based on ICT investment data provided by OECD (2008). In order to estimate initial ICT capital stock, we choose the steady state method, which is frequently used in several recent studies (e.g. Henry et al. 2009). Particularly, the initial value of capital stock is given by $ICT = \frac{I}{g + \Delta}$, where I is investment in the initial period, g is the average annual growth rate of investment over the sample period and Δ is the depreciation rate. The depreciation rates for hardware, software and communications are reported by EU KLEMS and are equal to 0.315, 0.315 and 0.115, respectfully. After having obtained I, g and Δ we can proceed with the estimation of initial ICT capital stocks. The perpetual inventory method is used for the construction of ICT capital in the subsequent years.

accordance with the negative linkage established between ICT and technical inefficiency, since the majority of the least ICT intensive countries (table 4) are also among the less efficient ones.

In general, all OECD countries have managed to increase their average level of technical efficiency between 1990 and 2005, with the majority of them moving from the level of 75% to levels close or even above 85%. It should be noted that no country included in this sample has witnessed a decrease in its level of technical efficiency. However, there exist significant disparities in the level of technical efficiencies across countries. Despite the significant increase in their efficiency levels, several south European countries (like Spain, Greece or Italy) have not yet achieved to converge with other OECD countries. On the contrary, their levels of technical efficiency seem to be close to the initial efficiency levels (in the beginning of the 90s) of several north European countries. As an extreme example, we should mention the case of Portugal, of which the level of technical efficiency has only slightly improved from 60% to 64%.

In this section, we will also evaluate the contribution of ICT on technical efficiency for each country and across time. According to the framework introduced by Coelli et al. (1999), we calculate the contribution of ICT to technical efficiency as the difference between gross efficiency and efficiency net of the impact of ICT. According to Battese and Coelli (1993), technical efficiency of each country i is calculated as:

$$TE_{it} = E[\exp(-u_{it}) \mid \varepsilon_{it}] = \left\{ \exp\left[-\mu_{it} + \frac{1}{2}\bar{\sigma}^2 \right] \right\} \cdot \left\{ \Phi\left[\frac{\mu_{it}}{\bar{\sigma}} - \bar{\sigma} \right] / \Phi\left[\frac{\mu_{it}}{\bar{\sigma}} \right] \right\} \quad (5)$$

where Φ is the standard normal distribution function, $\varepsilon_{it} = V_{it} - U_{it}$, $\mu_{it} = (1-\gamma) \cdot \left[\delta + \sum_{j=1}^{n} \delta_j z_{j,it} \right]$ - $\gamma\varepsilon_{it}$ and $\bar{\sigma}^2 = \gamma(1-\gamma)\sigma^2$.

By replacing the unknown parameters in equation (5) with the maximum likelihood estimates we obtain estimates of technical efficiency of country *i* at time *t*. The obtained technical efficiencies in equation (5) are gross measures which include the impact of ICT. To obtain measures of net technical efficiency (net of ICT influences), we replace the term $\sum_{j=1}^{n} \delta_j z_{j,it}$ in equation (5) with

$\min\left[\sum_{j=1}^{n}\delta_j z_{j,it} - \delta_{ICT} ICT\right]$ and recalculate efficiency predictions. These predictions may be interpreted as net efficiency scores because they involve predictions of efficiency when all countries are assumed to face identical and the most favorable ICT effects (Coelli et al. 1999). The differences between net and gross efficiency scores represent the contribution of ICT to efficiency of each country.

The results reported in table 7 show that ICT in general contributed significantly in the improvement of technical efficiencies across countries and over time. The highest contribution is observed for countries which operate quite below the frontier, such as Greece, Japan, Italy, etc. On the other hand, we observe a zero or even slightly negative contribution for countries close to the frontier such as Belgium, Netherlands, UK and USA. The policy implication of these findings is direct for countries quite below the world technology frontier wishing to achieve technological convergence to the most developed countries. The impact of ICT on the improvement of technical efficiency was positive across time with the highest contribution observed in the early 90s.

Discussion

Recent developments in ICT seem to have altered the global economic environment. Efficient collaboration and coordination, up to date and accurate information as well as information availability and accuracy are essential for economic success (Gholami et al. 2006). In this way, ICT seems to have facilitated efficiency by making many business processes and transactions more effective (Jorgenson, 2001). Moreover, ICT has offered the chance for countries to free themselves from the limitations of geography (Gholami et al. 2006), allowing the flow of information to the most remote economies and making knowledge accessible to anyone. Goods and services are now offered on the global market efficiently through the use of ICT, leading to substantial efficiency gains in production and distribution of goods and services.

Overall, we expect that the direct impact of ICT on technical efficiency will be reflected to higher levels of economic development and higher growth rates in GDP. The reported figures of table 8 reveal a very high correlation coefficient between the level of efficiency of each country and its level of economic development (measured in GDP per capita terms). The same holds for the association between efficiency change and GDP per capita growth (table 9), which is indicative of the fact that, on average, the most highly growing countries are those with the highest efficiency improvement. Table 10 shows that efficiency change is significantly correlated with TFP growth in several OECD countries like Austria, Finland, France, etc. For other countries however, there does not exist such a relationship. Nevertheless, it is not necessary for a country to be efficient and at the same time be a technological leader, in the sense that we may expect technological convergence in laggard countries but not always in countries which innovate and lead the world technology frontier (Bernard and Jones 1996).

It should be noted that the evidence of this study partially differentiates with the results provided by two recently published cross country studies (Thompson and Garbacz 2007; Repkine 2008). These studies indicate that no ICT effects exist in technical efficiency of OECD countries, since they have found that these countries operate close to the production frontier. In contrast to these studies, the present work shows that there is considerable scope for improvement and that ICT has significantly reduced cross country inefficiencies in OECD countries. The critical point that differentiates the present study from others is the fact that our sample is relatively homogeneous and it does not include countries that operate at different stages of economic development and under heterogeneous macroeconomic environments. Consequently, we have imposed a common production function in countries quite close to each other and in this way we believe that the findings of this study are closer to reality. The findings of several studies for firms operating either in USA (Lee and Barua 1999) or Italy (Milana and Zeli 2002; Becchetti et al. 2003) confirm our results since they have established a positive link between ICT and technical efficiency of production.

7. CONCLUSION

This paper applies a production frontier approach to simultaneously estimate a technical inefficiency model within a production function framework. The main subject under investigation is the role of ICT in reducing inefficiencies across countries. A panel of 17 OECD countries in 1990-2005 is utilised for this purpose.

Overall, the production frontier results, as well as the inefficiency estimates, provide strong evidence for a significant ICT impact in reducing country inefficiencies. At a comparative level, Belgium and Netherlands were ranked as the most efficient countries in the sample, followed by the USA and other north European countries. Furthermore, it seems that several south European countries are relatively inefficient and have not yet converged to the efficiency levels of the most developed OECD countries.

The estimates generally indicate that the most developed OECD counties have already achieved a high level of technical efficiency. This implies their dependence on technological progress, in order to promote higher economic development. The policy implication for the laggard countries is that they should accelerate their adoption of information technologies, and technical advances in general, and should enhance their efficiency by more trade and competition and higher levels of human capital.

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Table 1. Summary of related literature

STUDY	COUNTRY SAMPLE	TIME PERIOD	VARIABLE OF INTEREST	IMPACT ON EFFICIENCY
ICT RELATED STUDIES				
Lee and Barua (1999)	US manufacturing firms	1978-1984	IT capital	Positive and significant
Milana and Zeli (2002)	Italian firms	1997	ICT investment	No evidence for insignificant effects
Becchetti et al. (2003)	Italian firms	1995-1997	ICT investment	Positive and significant effect of software
Thompson and Garbacz (2007)	93 developed and developing countries	1995-2003	Difusion of telecommunications	Positive and significant in developing countries, no effect in OECD countries
Repkine (2008)	50 developed and developing countries	1980-2004	Telecommunications' capital	Positive and significant in developing countries, no effect in developed countries
OTHER CROSS COUNTRY STUDIES				
Fare et al. (1994)	17 OECD countries	1979-1988		Significant contribution of efficiency change to Japan's productivity growth, significant effect of technical progress to U.S. productivity growth
Koop et al. (1999)	17 OECD countries	1979-1988		Significant contribution of efficiency change to output growth
Adkins et. al (2002)	73 developed and developing countries	1975-1990	Institutions, freedom	Positive and significant
Milner and Weyman-Jones (2003)	85 developing countries	1980-1989	Trade openness, country size	Positive and significant for trade openness
Jayasuriya and Wodon (2005)	71 developed and developing countries	1980-1998	Urbanization	Positive and significant
Kneller and Stevens (2006)	9 industries in 12 OECD countries	1973-1991	Human capital, R&D	Positive and significant for human capital
Henry et al. (2009)	57 developing countries	1970-1998	Trade, trade policy	Positive and significant for both variables

Table 2. Definitions and sources of variables

VARIABLE NAME	DEFINITION	SOURCE
Y	GDP in constant PPP dollars	OECD Factbook 2008: Economic, Environmental and Social Statistics
t	Time trend	
K	Capital Stock	Initial Values from Penn World Tables; Figures of Gross Fixed Capital Formation from World Development Indicators
L	Hours Worked	OECD Factbook 2008: Economic, Environmental and Social Statistics
H	Share of hours worked by high skilled persons	EU KLEMS Growth and Productivity Accounts
ICT	ICT Investment as a Share of GDP	ICT Investment Figures from OECD Factbook 2008: Economic, Environmental and Social Statistics
OPEN	Volume of International Trade as a share of GDP	OECD Factbook 2008: Economic, Environmental and Social Statistics

Table 3. Descriptive statistics of variables

Variable*	Obs	Mean	Std. Dev.	Min	Max
Y**	272	27.08	1.29	24.84	30.15
K**	272	27.20	1.27	24.69	29.96
L**	272	23.53	1.25	21.59	26.28
ICT**	272	2.49	0.81	0.78	4.86
H	272	21.53	1.43	18.98	25.13
OPEN	272	34.13	18.65	8.10	92.20

* The countries included in the sample are Australia, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Portugal, Spain, Sweden, United Kingdom, United States

** Variables in logs.

Table 4. ICT investment as a share of GDP

	1990	1995	2000	2005
AUSTRALIA	2.57%	3.17%	4.03%	3.63%
AUSTRIA	1.74%	1.75%	2.33%	1.90%
BELGIUM	3.05%	2.55%	3.87%	2.73%
DENMARK	2.77%	2.85%	3.07%	3.32%
FINLAND	2.37%	2.56%	2.73%	2.82%
FRANCE	1.75%	1.71%	2.66%	2.35%
GERMANY	2.35%	1.88%	2.55%	1.85%
GREECE	0.84%	1.05%	1.86%	1.73%
IRELAND	0.87%	1.17%	1.43%	0.82%
ITALY	2.01%	1.80%	2.27%	1.72%
JAPAN	2.19%	2.39%	3.42%	3.10%
NETHERLANDS	2.51%	2.36%	3.12%	2.79%
PORTUGAL	1.60%	1.66%	2.17%	1.64%
SPAIN	2.60%	2.01%	2.66%	1.98%
SWEDEN	2.71%	3.33%	4.75%	3.49%
UK	2.59%	3.12%	4.30%	3.29%
USA	2.86%	3.36%	4.86%	3.56%

Source: OECD Factbook (2008), Economic, Environmental and Social Statistics.

Table 5. Maximum likelihood estimates

	(1)		(2)		(3)	
Production Function						
	coef.	t-stat	coef.	t-stat	coef.	t-stat
c	2.06*	6.40	0.29*	3.09	1.97*	3.37
t[†]	0.00	-1.32	0.00	-1.26	-0.02*	-5.19
K	0.33*	11.82	0.33*	14.64	0.28*	10.85
L	0.70*	24.47	0.71*	19.73	0.62*	19.35
H			0.07*	4.28		
ICT					0.14*	5.42
Inefficiency Function						
c	3.43*	8.67	1.49*	10.45	2.63*	5.31
ICT	-0.06*	-4.80	-0.05*	-5.37	-0.04*	-2.59
H	-0.09*	-5.85			-0.06*	-3.05
OPEN	-0.33*	-11.20	-0.31*	-13.52	-0.30*	-11.32
σ^2	0.01*	9.93	0.01*	11.98	0.01*	8.94
γ	0.52**	1.87	0.10	0.20	0.03	0.09
Log likelihood	210.06		207.70		228.39	
Observations	272		272		272	

[†] See table 3 for the definitions of variables.
* Significant at the 5% level.
** Significant at the 10% level.

Table 6. Average efficiency scores

COUNTRY*	RANK	1990-1995	1995-2000	2000-2005	1990-2005
BELGIUM	1	0.89	0.93	0.96	0.92
NETHERLANDS	2	0.88	0.93	0.95	0.92
USA	3	0.84	0.90	0.92	0.89
IRELAND	4	0.74	0.89	0.95	0.86
UK	5	0.77	0.84	0.88	0.83
FRANCE	6	0.76	0.82	0.87	0.81
SWEDEN	7	0.73	0.80	0.86	0.80
DENMARK	8	0.72	0.78	0.82	0.77
AUSTRIA	9	0.72	0.76	0.82	0.77
GERMANY	10	0.71	0.75	0.81	0.76
SPAIN	11	0.71	0.77	0.79	0.75
AUSTRALIA	12	0.69	0.75	0.79	0.74
ITALY	13	0.71	0.75	0.77	0.74
FINLAND	14	0.66	0.73	0.79	0.72
GREECE	15	0.63	0.67	0.74	0.68
JAPAN	16	0.61	0.65	0.68	0.65
PORTUGAL	17	0.60	0.63	0.65	0.63

* Countries are sorted in descending order according to their average efficiency scores.

Table 7. Contribution of ICT to efficiency

ACROSS COUNTRIES				ACROSS TIME			
	NET EFFICIENCY	**GROSS EFFICIENCY**	**CONTRIBUTION OF ICT**		**NET EFFICIENCY**	**GROSS EFFICIENCY**	**CONTRIBUTION OF ICT**
GREECE*	77.32%	67.71%	9.61%	**1990**	79.41%	71.96%	7.45%
JAPAN	73.25%	64.71%	8.54%	**1991**	79.68%	72.02%	7.67%
ITALY	81.57%	73.90%	7.67%	**1992**	79.81%	72.09%	7.72%
AUSTRALIA	81.97%	74.34%	7.64%	**1993**	79.79%	72.15%	7.65%
DENMARK	84.66%	77.08%	7.58%	**1994**	80.55%	73.60%	6.95%
PORTUGAL	70.09%	62.72%	7.37%	**1995**	81.17%	75.12%	6.05%
FRANCE	87.51%	81.36%	6.16%	**1996**	81.67%	76.13%	5.54%
AUSTRIA	82.67%	76.70%	5.97%	**1997**	82.43%	77.86%	4.57%
SPAIN	80.96%	75.35%	5.61%	**1998**	82.82%	79.03%	3.79%
FINLAND	77.70%	72.29%	5.41%	**1999**	83.51%	80.36%	3.16%
GERMANY	79.09%	75.56%	3.53%	**2000**	84.30%	82.64%	1.66%
IRELAND	88.72%	85.80%	2.93%	**2001**	84.45%	82.43%	2.02%
SWEDEN	82.55%	79.67%	2.88%	**2002**	84.72%	81.85%	2.87%
USA	91.16%	88.48%	2.68%	**2003**	84.91%	81.64%	3.28%
UK	83.70%	82.99%	0.71%	**2004**	85.46%	82.61%	2.84%
NETHERLANDS	90.85%	91.77%	-0.92%	**2005**	85.68%	83.53%	2.16%
BELGIUM	89.13%	92.39%	-3.27%				

* Countries are sorted in descending order according to the average contribution of ICT.

Table 8. GDP per capita - efficiency

	GDP PER CAPITA ($ PPP international)			EFFICIENCY (in levels)			CORRELATION
	1990-95	1995-00	2000-05	1990-95	1995-00	2000-05	
AUSTRALIA	23562.92	26761.00	30195.42	0.69	0.75	0.79	0.97
AUSTRIA	27050.14	29908.86	32715.32	0.72	0.76	0.82	0.99
BELGIUM	25835.31	28272.04	31000.77	0.89	0.93	0.96	0.96
DENMARK	26505.39	29826.36	32199.33	0.72	0.78	0.82	1.00
FINLAND	21711.08	24647.81	28947.87	0.66	0.73	0.79	0.92
FRANCE	25341.62	27263.10	29890.99	0.76	0.82	0.87	0.98
GERMANY	26999.34	28998.94	30961.24	0.71	0.75	0.81	0.99
GREECE	17684.24	19021.45	22784.66	0.63	0.67	0.74	0.96
IRELAND	19057.89	26577.38	35422.02	0.74	0.89	0.95	0.94
ITALY	24355.11	26276.31	28083.32	0.71	0.75	0.77	0.91
JAPAN	26875.86	28143.39	29138.03	0.61	0.65	0.68	0.93
NETHERLANDS	27120.18	30885.98	34034.66	0.88	0.93	0.95	0.98
PORTUGAL	16441.08	18688.03	20559.36	0.60	0.63	0.65	0.93
SPAIN	20307.41	22842.04	26259.86	0.71	0.77	0.79	0.89
SWEDEN	24051.53	26456.76	30334.04	0.73	0.80	0.86	0.96
UK	23924.74	27112.96	30693.32	0.77	0.84	0.88	0.95
USA	32745.22	36426.32	40003.06	0.84	0.90	0.92	0.96

Table 9. GDP per capita growth – efficiency change

	GDP PER CAPITA GROWTH			EFFICIENCY CHANGE			CORRELATION
	1990-95	1995-00	2000-05	1990-95	1995-00	2000-05	
AUSTRALIA	1.14%	3.13%	1.85%	1.13%	2.01%	0.62%	0.40
AUSTRIA	1.55%	2.79%	0.90%	0.41%	1.90%	0.82%	0.75
BELGIUM	1.26%	2.48%	1.14%	0.29%	1.30%	0.16%	0.89
DENMARK	2.01%	2.43%	0.97%	1.28%	1.41%	1.02%	0.74
FINLAND	-1.16%	4.50%	2.25%	1.93%	2.29%	1.51%	0.45
FRANCE	0.77%	2.44%	1.00%	0.44%	2.14%	0.61%	0.89
GERMANY	1.66%	1.87%	0.51%	0.67%	2.10%	1.02%	0.85
GREECE	0.34%	2.91%	4.02%	-0.06%	2.45%	1.65%	0.56
IRELAND	4.06%	8.32%	3.64%	3.24%	3.66%	0.39%	0.62
ITALY	1.23%	1.87%	0.29%	1.22%	1.43%	0.14%	0.67
JAPAN	1.22%	0.77%	1.16%	-0.12%	1.76%	1.63%	0.69
NETHRLANDS	1.62%	3.43%	0.72%	0.68%	1.15%	0.12%	0.81
PORTUGAL	1.46%	3.68%	0.25%	0.10%	1.65%	-0.07%	0.81
SPAIN	1.23%	3.65%	1.73%	0.44%	1.84%	0.00%	0.61
SWEDEN	0.10%	3.26%	2.21%	0.71%	2.75%	1.18%	0.70
UK	1.40%	2.91%	2.00%	1.60%	1.89%	0.57%	0.56
USA	1.17%	2.94%	1.36%	0.76%	1.63%	0.20%	0.78

Table 10. TFP growth – efficiency change

	TFP GROWTH			EFFICIENCY CHANGE			CORRELATION
	1990-95	1995-00	2000-05	1990-95	1995-00	2000-05	
AUSTRALIA	1.55%	1.78%	1.29%	1.13%	2.01%	0.62%	-0.16
AUSTRIA		1.63%	0.45%	0.41%	1.90%	0.82%	0.75
BELGIUM	1.57%	1.31%	0.74%	0.29%	1.30%	0.16%	0.42
DENMARK	1.80%	0.44%	0.23%	1.28%	1.41%	1.02%	0.59
FINLAND	1.41%	2.56%	1.66%	1.93%	2.29%	1.51%	0.76
FRANCE	1.10%	1.44%	0.90%	0.44%	2.14%	0.61%	0.62
GERMANY	1.45%	1.28%	0.67%	0.67%	2.10%	1.02%	0.51
IRELAND	3.02%	5.39%	2.55%	3.24%	3.66%	0.39%	0.39
ITALY	1.20%	0.34%	-0.62%	1.22%	1.43%	0.14%	0.59
JAPAN	0.97%	0.83%	1.47%	-0.12%	1.76%	1.63%	0.13
NETHERLANDS	1.74%	0.77%	0.37%	0.68%	1.15%	0.12%	-0.46
PORTUGAL		2.53%	0.02%	0.10%	1.65%	-0.07%	0.59
SPAIN	0.74%	-0.22%	0.08%	0.44%	1.84%	0.00%	-0.20
SWEDEN	0.85%	1.49%	2.24%	0.71%	2.75%	1.18%	0.32
UK	1.39%	1.25%	1.17%	1.60%	1.89%	0.57%	0.22
USA	0.69%	1.33%	1.69%	0.76%	1.63%	0.20%	-0.33

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