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Productivity Change in the Telecommunications Industries of 13 OECD Countries

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Abstract

This paper focuses on the evolution of productivity in the telecommunications industries for 13 OECD countries over the period 1979-1998. It uses Data Envelopment Analysis, a non-parametric approach that allows decompositions of changes in productivity into variations in efficiency and technical change. Moreover, it tests the existence of convergence in labor and total factor productivity levels among the 13 OECD countries by means of a cross-section technique.

Key words: labor productivity; total factor productivity; data envelopment analysis; convergence

JEL classification: D24

1. Introduction

Over the last 20 years, the world economy has been characterized by constant progress in the development of information and communication technologies. This has triggered a complex pattern of social and economic change. This technological revolution is shaping the process of globalization by providing new tools and infrastructures with which to capture global opportunities. In particular, the technological progress and deregulation of the telecommunications industry has considerably lowered the marginal cost of communications. Furthermore, the growth of the telecommunications industry has allowed a huge increase in the amount of cross-border information flows, reducing transaction costs and stimulating consumer demand for world-class products, services, and brands [see Leff (1984)]. The central role of the telecommunications industry is confirmed by the growth of investments in telecommunications networks across OECD countries, which reached a value of US$ 151 billion in 1997, with mobile investments accounting for 26% of total investments [see OECD (1999)].

Investment in communications does not always increase the size of overall

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communication infrastructure. In some countries, investments in mobile communication networks, boosted by the rapid market growth, are partially substituting for investments in the fixed network. This is the recent state of evolution in the Scandinavian countries, where the extent of substitution seems to be sufficient to offset the growth in demand for fixed network internet access services. Moreover, in countries like Japan and Italy, the high cost of joining the fixed network with respect to a mobile subscription caused a substitution effect [see OECD (1999)]. Therefore, measuring the telecommunications industry performance and its impact on the economies of different countries through the evolution of the telecommunications infrastructure [see Madden and Savage (1999) and Koski and Majumdar (2000)] by means of variables such as the main lines in operation could be misleading for countries characterized by a rapid take-up of the mobile market [see Jha and Majumdura (1999)].

In order to overcome this kind of bias in our paper we have employed a volume measure obtained by dividing total telecommunications revenue, expressed at 1990 prices, by the Purchasing Power Parity (PPP). We use evidence from 13 OECD countries (Australia, Belgium, Canada, Denmark, Finland, France, Italy, Japan, Netherlands, Norway, United Kingdom, and United States) over the period 1979-1998 to analyze the evolution of productivity. Germany has not been included since it has not been possible to separate total telecommunications revenues before the unification date. In analyzing performance, we consider both labor productivity (LP) and total factor productivity (TFP) in order to identify the differential effects of capital accumulation and technological change.

According to the seminal paper by Solow (1956), a change in LP could be caused by two separate factors: technical change, i.e., improvements in knowledge, methods, etc., and capital deepening, i.e., a rise in the amount of capital per unit of labor. In order to estimate technical change, neoclassical growth literature usually employs the TFP obtained through both parametric techniques—regression analysis—and nonparametric—Data Envelopment Analysis (DEA)—techniques. In our paper, we have adopted the DEA approach by means of the software program developed by Coelli (1996) to compute TFP.

We have also analyzed questions such as convergence in the telecommunications industry. The empirical test of convergence, developed by the growth literature, can be divided into two categories: cross-section and time series techniques. The cross-section technique analyzes the correlation between initial productivity levels and subsequent growth rates. The existence of negative correlation implies that, on average, countries with low productivity levels grow faster than those with high initial levels of productivity. The time series technique analyzes the long-run differences in the productivity levels of different countries. The absence of a unit root implies the presence of convergence. In other words, time series techniques assume that productivity data are generated by industry near their steady state. Thus, time series tests may have poor power properties when applied to productivity data from industries in transition [see Bernard and Durlauf (1996)]. Over the past twenty years, the telecommunications industry has been characterized by changes both in technological and in market structures; thus we have employed the cross-section technique.

The paper is organized as follows. Section 2 explains various features of the methodology employed to compute the TFP. Section 3 shows the empirical results and proves the existence of a convergence process in LP and TFP. Finally, Section 4 concludes.

2. Methodology

2.1 The Efficient Frontier

Computation of productive efficiency is among the most important factors in the analysis of the performance of firms, industry sectors, and the economy as a whole. The computation of productive efficiency derives directly from the notion of a production function. In the literature, the production function has been estimated both by means of parametric techniques, via regression analysis, and non-parametric techniques, via DEA. The former reflects "average" behavior or "central tendency" of observations, while the latter deals with best performance and evaluates all performances by deviation from the frontier line. Thus the two techniques may provide different approaches to improvement.

One of the advantages of the non-parametric technique, based on linear programming, is that *a priori* specification of functional form is not required. In other words, with linear programming, the efficiency of a productive unit is established in comparison with the optimum, i.e., an "ideal" productive unit which provides maximum output with a minimum of input. Analogously we can consider the dual problem; that is, identifying the "ideal" productive unit providing the most output with a minimum input.

In the literature there are different DEA models according to the type of envelopment surface and orientation. Three types of envelopment surfaces are associated with assumptions of returns to scale: Constant Returns to Scale (CRS), Variable Returns to Scale (VRS), and Non-Increasing Returns to Scale (NIRS). The CRS model assumes that there is a proportional growth between inputs and outputs. Once the frontier has been created, the input efficient measure, in the sense used by Farrell (1957), is represented by the maximum reduction in inputs, given the outputs, reaching the efficient frontier. More formally, let us consider a set I ≡ {i = 1, 2, …, I} of productive units, called decision making units (DMUs). The CRS model compares I DMUs with M outputs denoted y_m, m = 1, 2,…, M, and N inputs denoted x_n, n = 1, 2, …, N. If $y = (y_i)$, i = 1, 2, …, I, is the vector of output values and $x = (x_i)$, i = 1, 2, …, I, is the vector of input values, then the efficiency score, θ_{i_0}, for DMU i_0 can be evaluated as shown in model (1) [see Coelli (1996) and Lovell (1993) for mathematical details about the DEA models].

$$\begin{aligned} &\min_{\theta_{i0}\lambda} \theta_{i0} \\ &st: -y_{i0} + Y\lambda \geq 0, \qquad\qquad i = 1, 2, \ldots, I, \\ &\theta_{i_0} x_{i0} - X\lambda \geq 0,\ \lambda \geq 0 \end{aligned} \tag{1}$$

where X is an M by I matrix, Y is an N by I matrix, and λ is an I by 1 vector of constants. The value θ_{i_0} obtained from the solution of relations (1) gives the Overall Technical Efficiency, O_{i0}, of unit i_0. Note that the linear programming problem must be solved I times in each period t, once for each productive unit in the sample. (To conserve notation we omit the subscripts 0 throughout.)

A value of O_i less than one indicates overall technical inefficiency for productive unit i. The VRS and the NIRS models are obtained by imposing $\sum_{i=1}^{I}\lambda_i^t = 1$ and $\sum_{i=1}^{I}\lambda_i^t \leq 1$ in the minimization problem (1) respectively. By means of the CRS and VRS models, it is possible to decompose the Overall Technical Efficiency into its components, Scale Efficiency S_i and Pure Technical Efficiency P_i. In particular, for each unit i, the efficiency measure can be written as follows:

$$O_i = S_i \times P_i \qquad i = 1, 2\ldots, I. \tag{2}$$

In other words, an overall technical inefficiency, $O_i < 1$, for a productive unit can be caused by an inefficient input-output configuration, $P_i < 1$, as well as by the size of the operation, $S_i < 1$.

2.2 Measuring Total Factor Productivity Rate

Once a measure of efficiency has been obtained for each productive unit in each period, it is possible to compute the Malmquist productivity index. The Malmquist productivity index allows changes in productivity to be broken down into changes in efficiency and technical change. Moreover, it can be estimated using DEA. Leaving aside the analytical mathematical formulation [see Coelli (1996) among others], the TFP change for each productive unit can be expressed as follows:

$$M_i^t = OC_i^t \times TC_i^t \qquad i = 1, 2,\ldots, I, t = 1, 2,\ldots,T, \tag{3}$$

where OC_i^t measures the Overall Technical Change and TC_i^t measures the Technological Change between t and $t + 1$. A value of OC_i^t greater than one indicates an efficiency improvement, and a value of TC_i^t higher than unity indicates technical progress for productive unit i. Moreover, from (2), the Malmquist index can be further decomposed to take into account the Scale Efficiency Change, SC_i^t, and Pure Technical Efficiency Change, PC_i^t:

$$M_i^t = SC_i^t \times PC_i^t \times TC_i^t \qquad i = 1, 2,\ldots, I, t = 1, 2,\ldots,T. \tag{4}$$

Values of the M_i^t, PC_i^t, SC_i^t, or TC_i^t greater than one indicate efficiency improvement or technological progress, while, conversely, values lower than one indicate efficiency decline or technological regress. Thus, if for productive unit i between period t and $t + 1$ technological change has not occurred, no movement of CRS efficient frontier ($TC_i^t = 1$)—the variation of the TFP measured by the Malmquist index—is due to the change of technical efficiency of the productive unit,

OC_i^t, which in its turn can be caused by scale, SC_i^t, and/or pure technical, PC_i^t, movements. Conversely, if between period t and $t + 1$ the productive unit has not changed its technical efficiency, $OC_i^t = 1$, the variation of TFP can only be explained by the movement of the CRS frontier. Clearly, in most cases, the variation of TFP is caused by both efficiency and frontier movements.

3. Empirical Results

The main sources of data used in this analysis are the World Telecommunication Industry (WTI) database of the International Telecommunication Union (2000) and the Purchasing Power Parity (PPP) and Real Expenditure Statistics of the Organization for Economic Cooperation and Development [see OECD (1999)]. Since physical data (number of subscribers, total national traffic, etc.) present significant gaps for the considered time period, we have employed a volume measure deflating total telecommunications revenues, expressed at 1990 prices for each country, by the PPP for transportation, communication, and storage. We have considered two inputs: labor volume, measured by the total number of full-time staff, and the number of main lines in operation, a proxy for capital input.

3.1 Measuring Total Factor Productivity

Figures 3 and 4 show the evolution of TFP and its components over time in the telecommunications industry for the 13 OECD countries as a whole, measured using the geometric mean of the Malmquist index for each country. Figure 3 shows that TFP increases steadily over the considered period. Indeed, the value of the Malmquist index each year is always greater than one. Average growth in TFP in the telecommunications industries stands at 4.87% per year for the 13 OECD countries. This value is remarkable if compared with the average growth of total industry (1.2%) and of the manufacturing industry (2%) for the period 1980-1997 for these countries (the geometric mean of the TFP is estimated by OECD in the Intersectorial Database). However, two periods have been characterized by rapid growth in TFP: 1988-89 and 1991-98. In both periods, the increase in productivity can be explained by the rapid diffusion of the mobile services. In fact, the number of cellular mobile subscribers in the 13 OECD countries increased, on average, by 65% in the first period and by 43% in the second.

Looking at the breakdown of TFP, it can be seen that technological change has been the most important factor. Indeed, TC has caused an improvement of 4.83% compared with 0.04% scored by OC. The low value of OC (1.004) suggests that, on average, inputs employed in the telecommunications industry could be reduced by a very slight amount, namely, –0.04% = 100(1 – 1.004).

Fig. 3. Geometric mean of Total Factor Productivity (TFP), Overall Technical Efficiency (OC), and Technological Change (TC) for 13 OECD countries

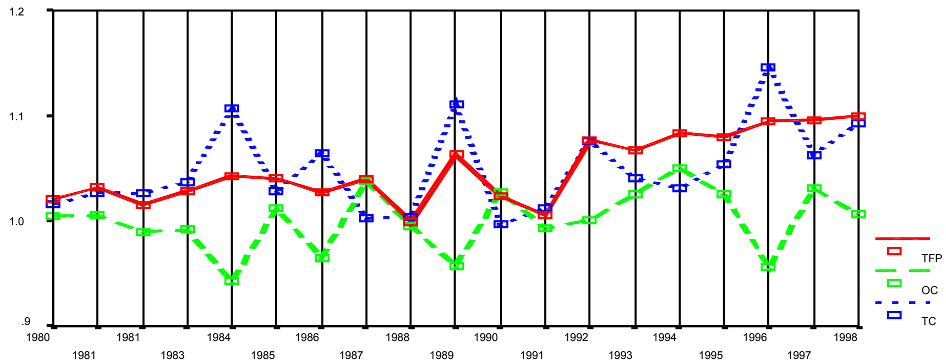


Fig. 4. Geometric mean of Overall Technical Efficiency (OC), Scale Efficiency Change (SC) and Pure Technical Efficiency Change (PC) for 13 OECD countries

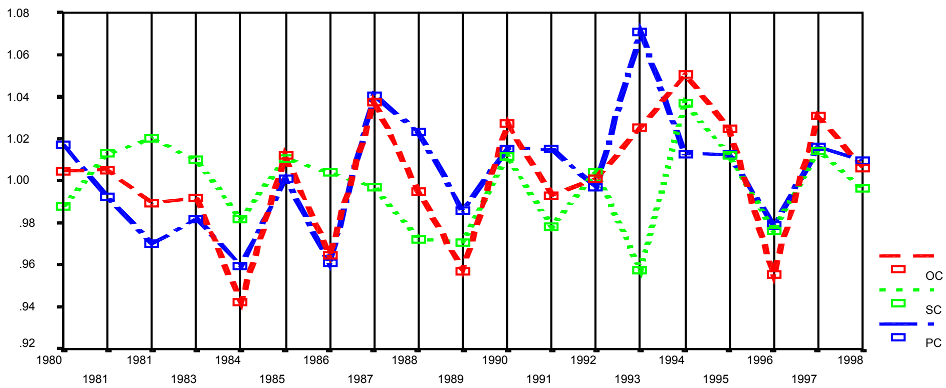


Figure 4 shows the decomposition of OC into its two components: Pure Technical Efficiency Change (PC) and Scale Efficiency Change (SC). PC contributed 0.30% to the change compared with –0.25% scored by SC. This result suggests that, on average, the source of inefficiency lies in the input-output configuration rather than in the size of the operation.

Finally, it should be noted that the Malmquist index obtained by DEAP software computes the distance function by means of VRS, CRS, and DEA and, consequently, assumes the existence of a diminishing return technology [see Chang (1999)]. Thus, our analysis could underestimate the efficiency of some national telecommunications industries in periods close to the major technological change. However, the increased pace of technological innovation in the telecommunications industry recorded in recent years could be offset, as has been argued for the economies of scale, by the market liberalization process [see Starannczak et al. (1994)].

3.2 Measuring Labor Productivity

Once TFP has been measured, the next step is to compute LP for each country. This is done by dividing the volume measure by the full-time telecommunications staff. According to Wolff (1991), a rough measure of the contribution of technical change to labor productivity growth can thus be obtained by dividing the TFP growth rate by the LP growth rate. The remaining portion of the ratio of TFP to LP measures the capital deepening, which represents the impact of capital accumulation on labor productivity.

Table 1. Average Labor Productivity, Total Factor Productivity and Capital Deepening Growth Rates, 1979-1998

Country	Labor Productivity (LP) Annual Growth	Total Factor Productivity (TFP) Annual Growth	Capital Deepening Annual Growth
Australia	0.103	0.049	0.524
Belgium	0.074	0.032	0.568
Canada	0.069	0.055	0.206
Denmark	0.059	0.058	0.017
Finland	0.075	0.044	0.413
France	0.048	0.044	0.074
Italy	0.070	0.065	0.067
Japan	0.081	0.075	0.073
Netherlands	0.062	0.060	0.029
Norway	0.062	0.020	0.678
Sweden	0.077	0.062	0.194
United Kingdom	0.076	0.031	0.591
United States	0.056	0.038	0.318

The values of the average LP, TFP, and capital deepening are shown in Table 1.The averaged LP growth rate varies from 10.3% in Australia to 4.8% in France, while the maximum and the minimum average TFP growth rates are scored by Japan (7.5%) and Norway (2%) respectively. Comparison between the average LP and the average TFP allows us to highlight some important characteristics of the telecommunications industries of the 13 OECD countries considered. As pointed out in the introduction, growth in LP can be caused either by capital investments—which make workers more productive—or by better technology—which makes workers more productive without additional capital investment. Capital deepening averaged 33% with the remaining portion due to the contribution of technical change. However there are great differences among the 13 telecommunications industries included in the sample. Australia, Belgium, Canada, Finland, Norway, United Kingdom, United States, and Sweden all exert a significant growth in capital intensity. Capital accumulation in the above group of countries varies from a minimum of 19% in Sweden to a maximum of 68% in Norway. The remaining countries (Denmark, France, Italy, and Japan) show a smaller growth in capital deepening with France scoring 7.4% and Denmark posting only 2%. The results highlight, given a similar TFP experience, that differences in LP growth rates in the various countries are due to different patterns of capital accumulation.

3.3 Catching-up and Convergence

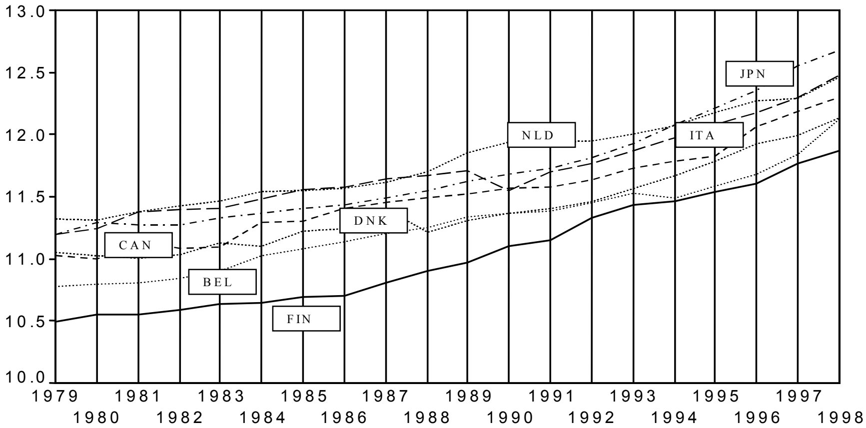
According to empirical literature on international productivity convergence, the catching-up hypothesis is one of the most important factors of the convergence process [see Abramowitz (1982)]. According to the above hypothesis, industries should experience higher growth rates when they are initially located far below the production frontier. In another words, the catching-up hypothesis implies a negative relationship between initial efficiency/productivity levels and subsequent productivity growth rates. However, as noted by Lichtenberg (1994), most of these traditional tests establish necessary, but not sufficient, conditions for convergence. In fact, if analysis productivity rate dispersion is applied, it is not possible to determine whether the levels of productivity converge in the long run. In order to investigate the convergence more deeply, it is necessary to compute the level of productivity of the TFP rate obtained by means of the DEA model. While there are not computational problems for the LP level, in determining the per-period TFP level, it has been necessary to estimate the initial level. Indeed, the parametric technique employed only produces the growth rate. Thus, in order to estimate the initial level of TFP, it is necessary to assume the existence of constant return to scale. This can be measured by means of a Cobb Douglas production function:

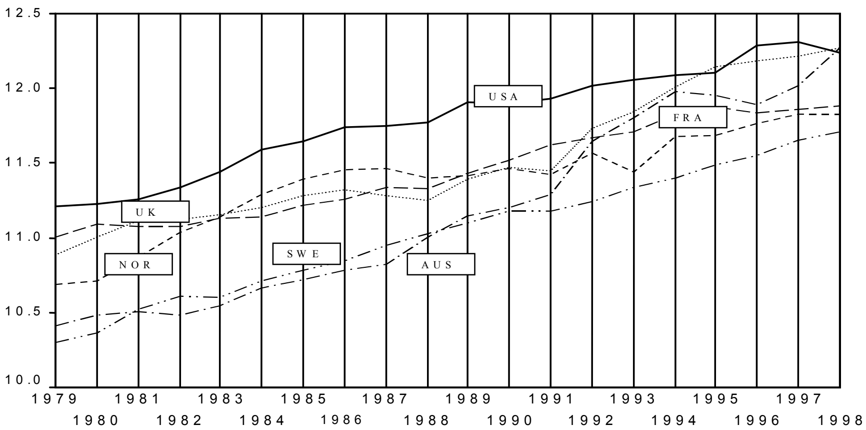
$$lnTFP_{i,1979} = \alpha_{i,1979} ln(\frac{Q_{i,1979}}{L_{i,1979}}) + (1-\alpha_{i,1979}) ln(\frac{Q_{i,1979}}{K_{i,1979}}) \qquad i = 1, 2, \ldots, I \qquad (5)$$

where $Q_{i,1979}/L_{i,1979}$ is the Labor Productivity, $Q_{i,1979}/K_{i,1979}$ is the Capital Productivity, and $\alpha_{i,1979}$ is the labor share of each country in 1979 (reference is made to the labor share computed by OCSE in the Intersectoral Database for the communications industry in 1979). Thus the TFP value obtained for 1979 should be considered a lower bound of the real growth in the TFP measure [see Nadiri and Shankeman (1981) and Denny et al. (1981)].

Figures 5 and 6 outline LP and TFP logs per country respectively. Figure 5 shows that the labor productivity has progressively increased for all countries. By comparing labor productivity logs of the Netherlands, the most productive country, and Sweden, the least productive country, it can be seen that the spread in 1979 was equal to 1.02. Similarly, by comparing the same values for Japan, the new productivity leader, and Sweden, the 1998 spread was 0.97.

Fig. 5. Labor Productivity

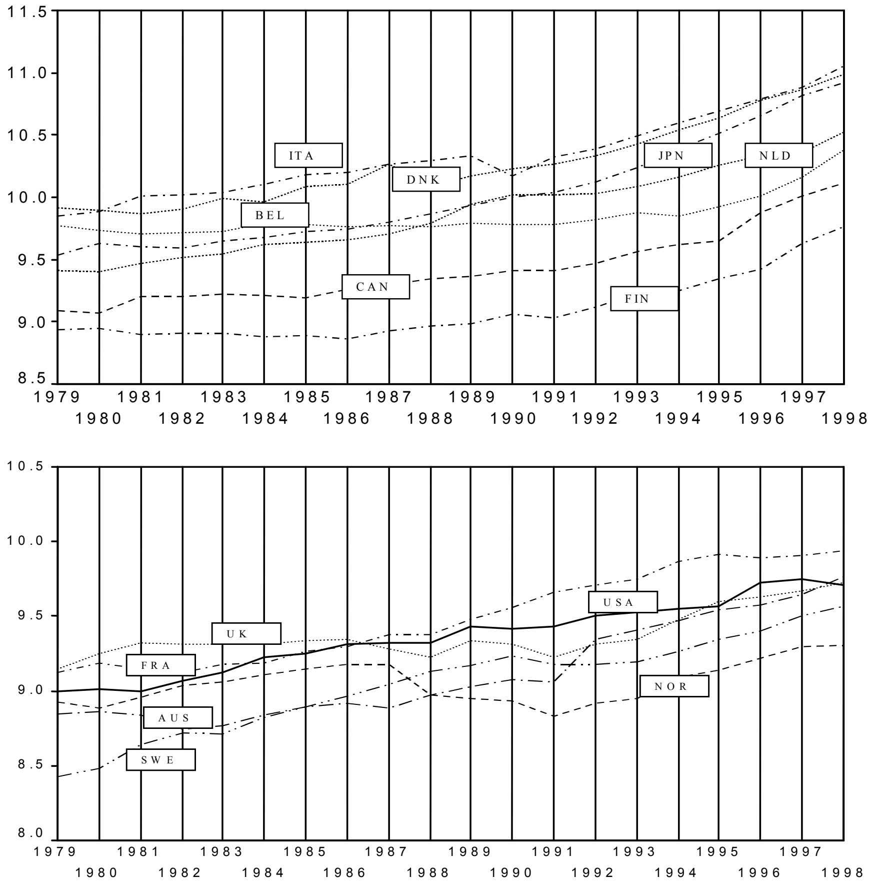




After nineteen years, the gap between the most productive and the least productive country was only very slightly reduced. Yet the TFP evolutions in Figure 6 show a different pattern. In 1979 the difference in TFP, measured by logarithms, between Denmark and Sweden stood at 1.49. Nineteen years later, the spread between the most productive country, Italy, and the least productive nation, Norway, stood at 1.75. An important relationship thus becomes apparent. There is not a reduction in the technology difference between the 13 OECD telecommunications industries.

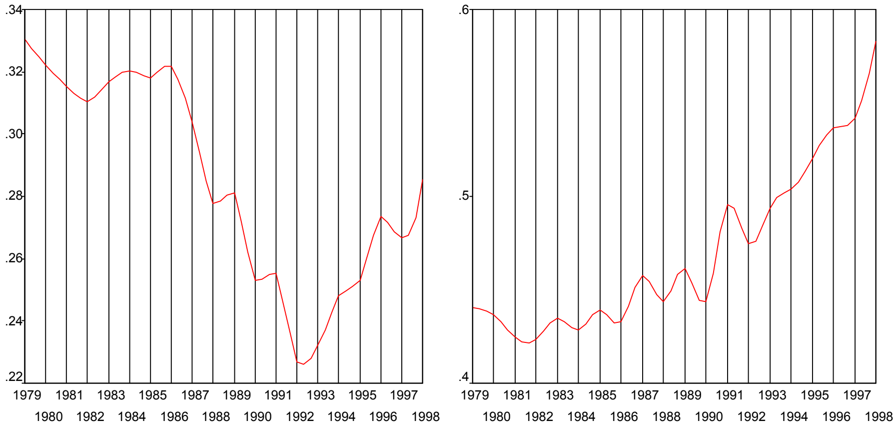
At this point, following the empirical work on convergence, the above LP and TFP results were further investigated by means of the cross-section technique. The first test conducted was an analysis of the variance between the logarithms of the two measures: σ-convergence. According to the hypothesis of σ-convergence, the variance in the productivity logarithm decreases as the production techniques become more similar. In other words, the reduction of dispersion predicts that industries characterized by initial poor performance perform better, on average, when compared to the initial high performance (*catch-up*). Dispersion of the LP and TFP logarithms are shown in Figure 7.

Fig. 6. Total Factor Productivity



The cross-section dispersions of LP and TFP show different evolutions. LP dispersion values decreased from 0.33 to 0.23 over the period 1979-1993, yet increased from 0.23 to 0.29 in 1998. The growth in dispersion values which commenced in 1992 was due to the rise in the mobile communications market in the European region. In 1992, the mobile penetration rate (number of subscribers per 1000 inhabitants) stood at 13.77 in Italy and 25.98 in the United Kingdom. In 1997, the mobile penetration rates of the same countries were 204.07 and 150.20 respectively. In the same year, Finland and Sweden scored a mobile penetration rate of 420.16 and 358.18 respectively, while Germany and France scored 98.55 and 99.56 respectively. On the other hand, TFP shows an increase in cross-country dispersion during the considered period, reaching a maximum value of 0.58 in 1998.

Fig. 7. Standard Deviation of Log(LP) and Log(TFP)



These results suggest that productivity differences in the TFP of the telecommunications industry might be permanent rather than transitory. The second test performed, the β-convergence test, was conducted in order to analyse whether less developed industries exert such a growth rate as to enable them to overtake initial high performers (leap-frogging). The existence of β-convergence can imply a catch-up process, when the growth of less productive industries is so fast with respect to the initial leader as to increase the dispersion in the performance measure. Therefore, pursuing the paper by Bernard and Jones (1996), it can be assumed that regardless of the measure of productivity, *P*, considered at time *t* in country *i*, the rate of productivity evolves according to:

$$lnP_{i,t} = \gamma_i - \lambda\ lnln\left(P_{i,t}/P_{1,t}\right) + lnP_{i,t-1} + ln\varepsilon_{i,t} \qquad i = 1, 2, \ldots, I \qquad (6)$$

where γ_i is the asymptotic rate of productivity growth in country *i*, λ is the speed of catch–up, $P_{i,t}/P_{1,t}$ is the ratio between the level of productivity of country *i* and country 1 (the most productive country), and $\varepsilon_{i,t}$ represents an industry productivity shock. By solving the difference equation (6) [see Bernard and Jones (1996)], it is possible to obtain the following function:

$$p^*_{i,t} = \alpha + \beta\ lnP^*_{i,0} + \varepsilon \qquad i = 1, 2, \ldots, I \qquad (7)$$

with $p^*_{i,t}$ the average growth rate of country *i* relative to country 1 between time 0 and time *t*, $P^*_{i,0}$ the ratio of productivity level in country *i* to the level in country 1 at time 0, and ε a stochastic normally distributed error term. In this framework, a negative and significant coefficient β confirms the existence of productivity convergence among countries. Although simple, this way of analyzing the productivity evolution among countries is extremely powerful as it overcomes specification problems of the production function. Looking at the values of the LP and TFP logarithms of 1979 (see Figures 6 and 7), it is easy to see that Denmark and the Netherlands have the highest values in the two productivity performance measures. Thus, by regressing the relative level of the LP (TFP) logarithm for the 13 telecommunications industries on the relative average LP (TFP) growth rates obtained in Table 1, it is possible to test the existence of β-convergence. The results are reported in Table 2.

Table 2. Regression of LP (TFP) Relative Productivity Level in 1979 on Relative Average LP (TFP) Growth Rates

	Labor Productivity	Total Factor Productivity
Constant	0.967° (8.953)	0.924° (5.202)
β	−0.376°° (−1.94)	0.133 (0.815)
R^2	0.23	0.04
Sample size	12	12

Note: ° and °° indicate significance at the 5- and 10-percent levels respectively.

Both regressions have poor capacity to explain cross-country growth rates. In fact, simple regression explains 23% of cross-country variation in LP and only 4% of cross-country variation in TFP. Furthermore, the results of the β-convergence test are only moderately supportive for the LP. Indeed, for LP we obtained a significant negative estimate of $\beta = -0.376$, at the 10% level. Thus, between 1979 and 1998, the telecommunications industries of the 13 OECD countries were characterized by a weak leap-frogging process in labor productivity. In other words, countries that were relatively less efficient in the telecommunications labor productivity in 1979 improved their performance position compared to those which were more efficient in 1979. This implies that the less productive telecommunications industries have caught up with the previously efficient telecommunications industries. However, this catch-up process was not followed by a reduction in the dispersion of LP levels, as indicate by σ-convergence. For the TFP, the negative evidence of the two convergence tests implies that no leap-frogging or catching-up occurred during the period 1979-98. Thus telecommunications industries which lag furthest behind the leading countries in terms of technology level did not exhibit the most rapid rate of growth in technology. However, the moderate convergence in the levels of the labor productivity as well the lack of convergence in the levels of the total factor productivity could be explained by the "new growth theory," whereby the long-run average productivity growth rate of countries or industries that are not converging will be different.

4. Concluding Remarks

This paper analyzes the evolution of labor and total factor productivity in the telecommunications industries of 13 OECD countries over the period 1979-1998. The analysis was conducted using a non-parametric technique based on linear programming known as Data Envelopment Analysis (DEA), which allows the measurement of the Malmquist TFP index. In this framework, countries are characterized by different average growth rates both in labor and total factor productivity. Comparison between average labor and total factor productivity sheds light on some important characteristics of the telecommunications industries of these countries. In particular, the contribution of capital accumulation to the labor productivity growth has been 33% on average, with the remaining portion attributed to the contribution by technical change. However, there are great differences among the 13 countries in the sample. In particular, capital deepening varies from a minimum of 2% in Denmark to a maximum of 68% in Norway. Therefore, the results show that even if countries experience similar TFP, the difference in LP growths is due to a different pattern in capital accumulation.

Looking at the breakdown of the TFP into Overall Technological Efficiency Change and Technical Change, it can be seen as that technological change has been the most important cause of TFP growth. In particular, Technical Change has caused an improvement of 4.83% compared with 0.04% caused by the Overall Technological Efficiency.

The second objective of this paper was to explore the existence of convergence in both labor and total factor productivity among the 13 telecommunications industries. Our analysis was based on the cross-section technique developed by neoclassical growth literature. In this framework, we first tested the existence of σ-convergence. The aim of this test was to evaluate whether telecommunications industries characterized by initial poor performance perform better, on average, when compared to initially high performance (catch-up). Pursuing the paper by Bernard and Jones (1996), we tested the hypothesis of β-convergence, according to which less developed telecommunications industries exert such a growth rate as to allow them to overtake the initial high performers (leap-frogging).

The telecommunications industries of the 13 OECD countries were characterized by a weak process of catch-up in labor productivity. Yet the above process, boosted by leap-frogging, has not been followed by a reduction in the dispersion of LP levels, as indicated by the σ-convergence. As far as the TFP is concerned, the negative evidence of the two convergence tests implies that no leap-frogging or catch-up occurred during the period 1979-98. Thus, less developed telecommunications industries did not exhibit the most rapid rate of growth in order to reduce the technological gap with the respect to the leading telecommunications industries.

Since we have employed traditional DEA models, which assume diminishing returns technology, our measures could underestimate efficiency for some countries in periods close to major technological change. However the existence of increasing return to scale technology could be, in its turn, offset by the presence of the market liberalization process.

The above issue can be solved by applying the methodology proposed by Chang (1999), but this represents one future area of research. Moreover, the existence of convergence both in levels of the labor and total factor productivity will be analyzed in the framework of the "new growth theory," whereby the long-run average productivity growth rates of countries or industries that are not converging will be different.

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