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Improving competitiveness and productivity growth: the role of information and communication technology (with a nexus to Europe)

1. Information and communication technology (ICT) as a factor of production

Different factors of production might affect GDP growth of the particular economy. The rise and fall of those which do not make clear the growth in production match to the general TFP achievement which is largely associated with the technical progress. Thus, capital and labour to output growth could be estimated by means of a flexible trans-log production function, such as:

$$\Delta Y = \overline{v}_k \Delta K + \overline{v}_l \Delta L + \Delta A \qquad \textbf{(1)}$$

where, $\overline{v}_k$ and $\overline{v}_l$ represent the input share in gross value added, while ΔA stands for the rise in output over the growth in weighted factor inputs or TFP growth (Jorgansen, Gollop and Fraumeni, 1987). Nevertheless, if capital input *k* is tried to be decomposed into three different types of ICT capital *c*, as well as the non-ICT capital *n* the equation above might be revised as follows:

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$$\Delta Y = \sum_{i=o.m,s} \overline{v}_i^c \Delta k_i^c + \sum_{i=o,t,b} \overline{v}_i^n \Delta k_i^n + \overline{v}_i^l \Delta L + \Delta A \qquad \textbf{(2)}$$

where, variables *y* and *k* indicate the output (*Y*) per unit of labour input (*L*) and capital (*K*) per unit of labour input (*L*) respectively. Yet, TFP contribution to labor productivity could be additionally segregated into the possible gains from the ICT producing A^c and other non-ICT industries A^n. The first ones stand for the technological change that follows the ICT production itself, while the second comprises the effects of ICT dispersal on other industries, as well as the other sources to TFP growth (Jorgansen and Stiroh, 2000). At the outset, ICT contribution to labor productivity growth (ΔY^c) might be re-estimated if one includes input-share weighted contributions of service flows from ICT assets *i* within the total economy and the output-share weighted contributions of TFP in ICT producing industries *j,* or:

$$\Delta Y = \sum_i \overline{v}_i^c \Delta k_i^c + \sum_i \overline{u}_j^c \Delta A_j^c \qquad \textbf{(3)}$$

2. Estimates of ICT adoption for selected EU member states

Various methods are employed to replenish the breaks within the time series released on ICT investment in some EU countries[1]. The most preferred, however, is the so called "commodity flow method" which traces commodities from imports or home production to the final procurement. For this purpose, input and output tables are usually united with data on office, communication and computer equipment[2]. Input and output tables (I/O), notwithstanding, correspond to domestic output and imports share preordained to investment. If one melds office, computer and communication equipment to investment, the following estimation might be obtained:

$$I_{i,t} = (Q_{i,t} - E^{d}_{i,t})\left(\frac{I(Q)^{I/O}_{i,t}}{(Q-E^{d})^{I/O}_{i,t}}\right) + (M_{i,t} - E^{r}_{i,t})\left(\frac{I(M)^{I/O}_{i,t}}{(M-E^{r})^{I/O}_{i,t}}\right) \quad \textbf{(4)}$$

where, $I_{i,t}$ stands for investment in point *i,* within the year *t,* $Q_{i,t}$ represents the domestic output, $E^{d}_{i,t}$ symbolizes the exports from domestic production, $(Q-E^{d})^{I/O}_{i,t}$. signify the home production for domestic use as from I/O tables, $M_{i,t}$ are the imports in year *t*, $E^{r}_{i,t}$ stands for the re-exports in *t*, $(M-E^{r})^{I/O}_{i,t}$ corre-

[1] See P. Schreyer, *The Contribution of Information and Communication Technology to Output Growth: a Study of the G7 Countries*, STI Working Papers 2000/2, OECD, Paris, 2000; F. Daveri, *"Information Technology and Growth in Europe",* University of Parma and IGIER, 2001 (http://digilander.iol.it/crenos/cnr67701/Daveri.pdf); F. Daveri, *"The New Economy in Europe (1992-2001)"*, Working Paper No. 213, University of Parma and IGIER 2002.

[2] This method is not to be applied on software.

sponds to the imports excluding reexports as from I/O tables, while $I(M)_{i,t}^{I/O}$ denotes the investment originating from imports as from I/O tables.

Recent findings confirm that the three fundamental ICT categories (office and computer equipment, communication equipment and software), as well as the additional (non-ICT equipment, transport equipment and non-residential structure) accounted for 17.1% of EU Gross Fixed Capital Formation (GFCF) in 2000 (Figure 1). Nonetheless, the ICT share was 28.2% of GFCF, with the foremost part of distribution on computer and office machinery, particularly within Germany, Spain, Netherlands and United Kingdom, while Italy, Austria, Denmark and Sweden accounted for large shares in the software industry.

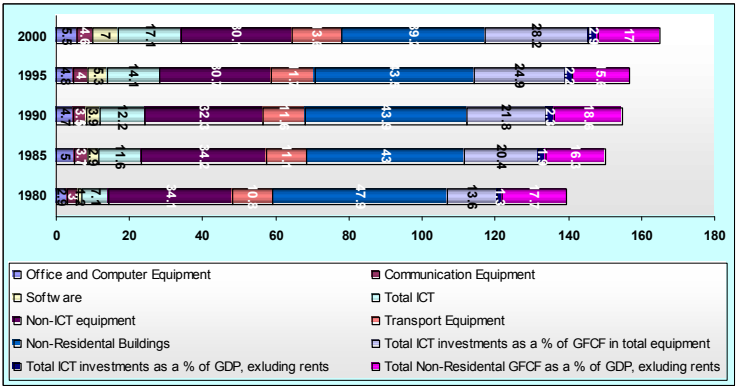
Noteworthy is to mention that growth rates of the real investment in communication and computer equipment has been even more rapid if one considers the deflators which reveal the EU price changes. In addition, ICT real investment growth was the most high-speeded in Ireland, which has started from relatively low level in the nineties, followed by the Nordic countries and Netherlands[3].

[3] B. van Ark, *The Renewal of the Old Economy: An International Comparative Perspective*, OECD STI Working Papers, No. 5, OECD, Paris, 2001.

3. The contribution of Information and Communication Technology to output and labor productivity growth

Although the ICT contribution to annual labor productivity growth within several EU member states has been relatively high, the labor productivity growth itself has essentially set back[4].

Figure 1: Gross Fixed Capital Formation by category as-% share of total Non-Residential GFCF and Total equipment



Source: Van Ark, Inklaar and McGuckin (2002, 2003a)

At the same time, TFP conduciveness to labor productivity growth has also slowed down starting from 1995.

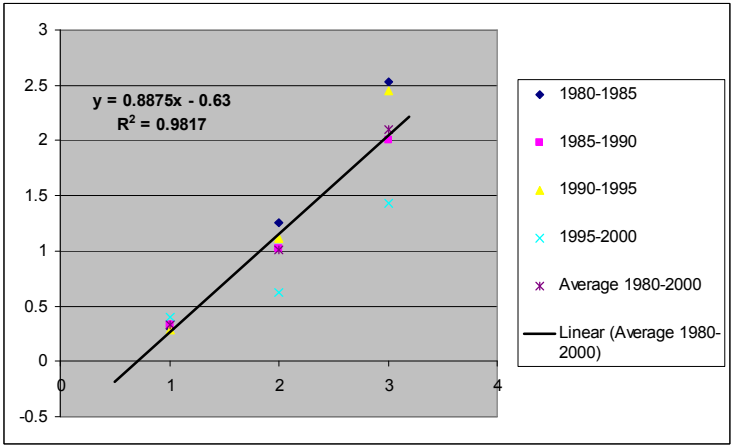
3.1. ICT and labor productivity growth

Within the mid nineties aggregate labor productivity growth has held up in some European countries, not only in relative, but also in absolute terms (Figure 2). Evidence suggests that ICT capital contri-

[4] Centre d' Etudes Prospectives et d 'Informations Internationales, *ICT and productivity: The situation in France",* La Lettre Du CEPII, No. 220, 2003.

bution to labor productivity has been increased during the period 1995-2000 in comparison with the one by mid nineties. To some extent, the particular improvement has been a result of the enlarged conduciveness of computer and office machinery[5]. Yet, large variations occur in absolute ICT contribution to labor productivity growth, in addition to its distribution among different ICT types of asset for a single country[6].

Figure 2: Contribution of Total ICT Capital and TFP to Annual Average Labor Productivity Growth, 1980-2000 in EU countries



Source: Van Ark, Inklaar and McGuckin (2002, 2003a)

Namely, United Kingdom, Ireland and Netherlands approach high contribution levels predominantly due to the elevated office and

[5] D. Jorgenson, K. Stiroh, *Raising the Speed Limit: US Economic Growth in the Information Age,* Brookings Papers on Economic Activity, vol. 2.
[6] R. McGuckin, B. van Ark, *Performance 2001, Productivity, Employment, and Income in the World's Economies*, New York, The Conference Board, 2001.

computer machinery, despite all the other countries which prove lower achievements in the particular asset type.

3.2. TFP and labor productivity growth

As mentioned above, ICT has a great contribution to output and labor productivity within some European economies. Besides the differentials in capital conduciveness, the major impact on labor productivity growth, however, has the total factor productivity growth. In consequence, labor productivity growth has been increased for the most part in Finland and Ireland since those are considered to be the major ICT producers, whereas United Kingdom and Netherlands suffered less augmentation although both are believed to be huge ICT investors. The equations proposed above indicate that TFP growth is dependant upon the differences in ICT producing industries which stand for the changes in technology, as well as the non-ICT industries which comprise the effects of ICT transmission to the other industries. The contributions of the both categories to aggregate TFP growth might be estimated by using the Domar final output weights. Thus, Evsey Domar[7] has proved that aggregate TFP may possibly be rewritten as a weighted average of the particular industry productivity growth, whereupon the industry gross output – GDP ratio will be considered as the required weight, given as follows:

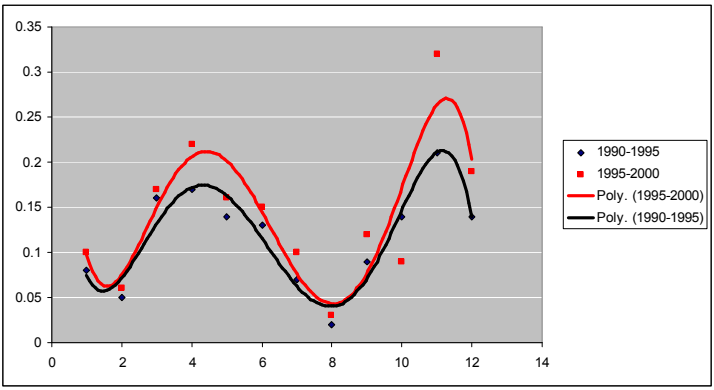
[7] E. Domar, *On the Measurement of Technological Change,* Economic Journal, 1961, vol. 71, No. 284, pp. 709-729.

$$A_{GDP} = \sum_i \overline{w}_i A_i \qquad \textbf{(5)}$$

$$\text{with } \overline{w}_i = \frac{1}{2}\left(\frac{GVO_{i,t}}{GDP_t} + \frac{GVO_{i,t-1}}{GDP_{t-1}} \right) \qquad \textbf{(6)}$$

where GVO stands for the value of gross final output of the industry i, A_i represents the productivity growth of the industry i, while A_{GDP} corresponds to the aggregate total factor productivity growth. The above estimations indicate that different concepts could be implemented at the industry and aggregate level (final output and value added, respectively). Additionally, the aggregate level comprises merely the primary inputs, while both primary and intermediary inputs are taken into the industry functions of production.

Figure 3: Contributions of ICT-producing industries to TFP



Source: Van Ark, Inklaar and McGuckin (2002, 2003a)

Evidence suggests that contributions of ICT-producing industries (office and computer machinery, communication equipment and semiconductors) to TFP growth have increased in about 40% within several EU member states (Figure 3). In other words, ICT manufacturers account for one third of TFP growth for the period of 1995-2000.

Office and computer machinery, nevertheless, are to be the major contributors to TFP growth in United Kingdom, while Ireland additionally includes the semiconductors, as well. Recent findings indicate that TFP growth has gained from the communication equipment industry in Sweden and Finland, but with no predominance as sometimes proposed[8]. Put forward differently, non-ICT producing industries account for the large share of TFP growth within the most of the EU countries, such as: Austria, Finland, Sweden and Ireland [9].

4. ICT and competitiveness of the Balkan countries

Taking into consideration the importance of information and communication technology for the competitiveness and economic growth of the countries, we are supposed to assess the progress of information society within the Balkans and the Republic of Macedonia, as well. We will therefore implement the methodology developed by the World Summit on the Information Society and thereby

[8] F. Daveri, *Information…*, op. cit.

[9] The estimates for Ireland need some prerequisites, since the production shares are noticeably high. Thus, the ICT contribution to aggregate TFP growth might be computed by weighting the TFP growth rates in each industry with the particular Domar weight.

make an analysis of the ICT and digital opportunity index within the Balkans.

The Digital opportunity index (DOI) stands for the methodology launched by the International Communication Union in cooperation with the Ministry on information and communications of Korea, the Korean agency on digital opportunities and promotion, as well as the United Nations Conference on trade and development. The assessment of DOI is to be separated in three groups heading for better analysis of the strong and weak points among the states. The clusters themselves comprise 11 indicators such as: opportunity, infrastructure and use. The Digital opportunity index runs form 0 to 1. Thus, the countries which may note a DOI values higher than 0,49 are sorted out as high digital opportunity ones, while those with DOI values from 0,30 to 0,49 and below 0,49 stand for average and low digital opportunity, respectively.

The ICT opportunity index is to be considered as a revision of the digital divisiveness index proposed by Orbicom. The particular index is dependant upon the level of infoconsistency and info usage of a country. The infoconsistency refers to a country's potential for production i.e. proper utilization of ICT capital and work force, while the info usage points to ICT consumption. Theoretically, the ICT opportunity index may receive unlimited values though some indicators are to contain various restrictions.

4.1. Analysis of Digital opportunity index within the Balkans

This index in particular does not point to huge disparity with special exceptions to Slovenia and Albania running toward the maximum and minimum, respectively (Table 1).

Table 1. Digital opportunity index (2006)

Country	DOI
Slovenia	0,62
Bulgaria	0,54
Greece	0,53
Croatia	0,53
Turkey	0,52
Romania	0,52
Montenegro	0,49
Bosnia and Herzegovina	0,48
Serbia	0,47
Macedonia	0,47
Albania	0,37

Taking into account the world's average value of the index which amounts to 0,40 in 2006 one may notice that all the Balkan countries apart from Albania are to be found beyond the world's average, whilst each of them except for Slovenia are set up below the European one (0,58 within the same timeframe). At the same time, the DOI analysis according to clusters may indicate the situation as in the Figure 4.

It is well expected that countries which record a higher Digital opportunity values to have an upper GDP level, as well. Nevertheless, the countries set up under the line (Figure 5) record a lower DOI value measured up to the GDP they achieve as the ones found

under the line which are supposed to have lower GDP values. Special emphasis should thus be placed on deviations from the predicted and observed values of Albania and Greece which obviously should have higher DOI records. That is to say the index for both the countries is to be found below their potentials.

Figure 4. Digital opportunity index according to clusters (2006)

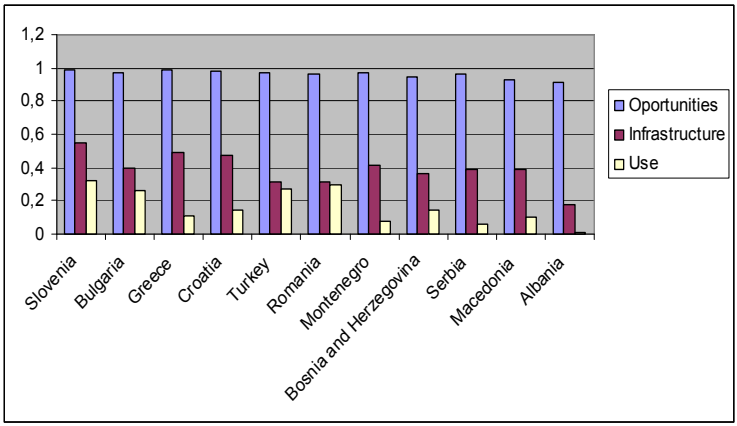
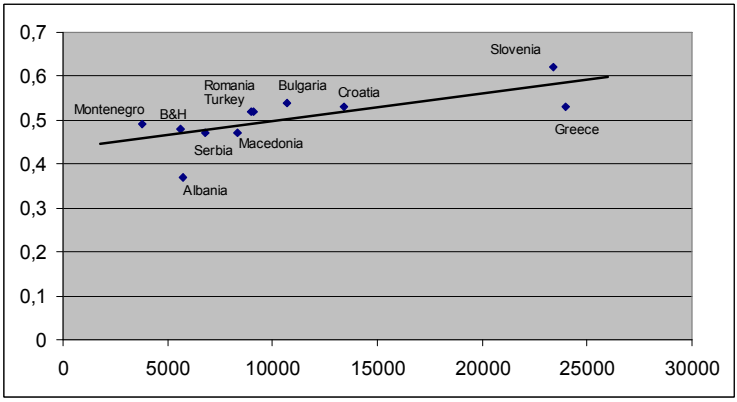


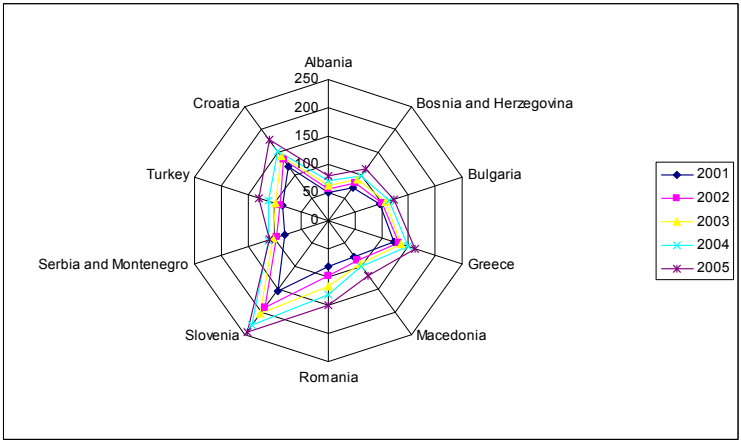
Figure 5. DOI and GDP/capita within the Balkans (2006)



4.2. ICT opportunity index in the Balkans

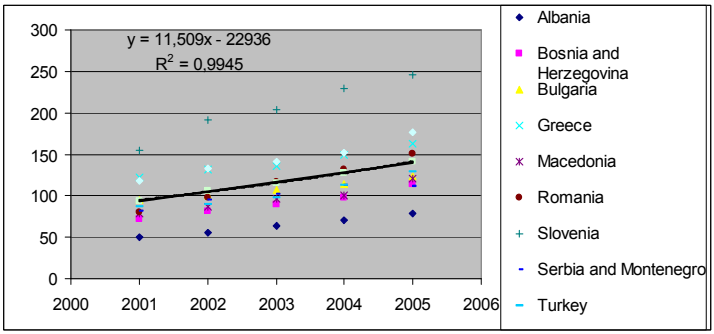
According to analyses made on the ICT opportunity index, the countries are to be divided in four groups: states with very high value of the index (larger than 249), countries with high levels (from 150-248), countries with average values (from 68 to 149) and those with low levels of ICT opportunity index (12-67). The particular classification is being completed for the estimates made in 2005 to which the Balkan countries are considered as those with average ICT opportunities. The evidence therefore suggests an upward tendency within all the Balkan states during the period 2001-2005 (Figure 6). Slovenia is the only one making a significant positive shift, whereas Albania records the lowest values of ICT opportunity index all through the indicated period of time.

Figure 6. ICT opportunity index within the Balkans (2001-2005)



On the other hand, the linear regression run from the results obtained for the Balkans indicates that ICT opportunity index on average increases for about 11,509 units each year after (Figure 7).

Figure 7. Regression, Balkan countries (2001-2005)



5. Conclusions

Within the early nineties European economies started with lower levels of ICT contributions to output and productivity growth, particularly because of the lesser production share in ICT. Many variations, however, emerge among different EU member states related to possible growth of ICT capital and the respective contributions to labor and TFP productivity growth. Thus, Netherlands, Ireland and United Kingdom are being characterized by a large ICT conduciveness to productivity growth, while Spain and Portugal are likely to be at lower positions. On the other hand, Nordic countries are distinguished by the relative share of software as the main contributor to any considerable diffusion, but with no ample hastening of the productivity growth. Recent findings suggest that many European economies suffered productivity setback within the non-ICT service

industry, despite those intensive ICT-using sectors. Nevertheless, ICT itself is not the only factor that has affected the particular productivity slowdown, but also the low levels of required skills, inflexible markets, the drop in capital/labor ratio etc. Many scholars[10] argue that number of additional restraints hinder the ICT investment within the European Union, such as: regulations and structural impediments, restrictive labor rules and procedures, barriers to entry etc.

On the other hand, the impact of information and communication technology on growth and competitiveness of the Balkans has been evaluated by employing the ICT and digital opportunity index. The outcomes obtained point towards a positive trend to both the indices, as the Balkan's average stands above the world's and below the European one.

[10] See e.g. R. McGuckin, B. van Ark, *Performance 2001…,* op. cit.

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Abstract

Information and Communication Technology (ICT) has a great effect on output and productivity growth. There is widespread evidence on total factor productivity (TFP) growth within some European member states caused by the rapid increase of ICT adoption. Such progress is being considered essential predominantly for the sectors which themselves produce new technology, but a large extension keeps going to the others, as well. Probable decline in ICT adoption, however, does not necessarily turn down the ICT contribution to output and productivity growth. That is to say, potential disparities may certainly appear due to the particular phenomenon improper assessment. Nevertheless, these variations are usually set off by the special requirements of different companies, in addition to necessary labour adjustments. Hence, this paper is to place a special emphasis on ICT and TFB contributions to labour productivity growth along with the related difference among some of the EU member and Balkan states, as well. Moreover, further assessments are supposed to be completed in order to get at the factors which may possibly stand behind the particular findings.

Key words: ICT, productivity, competitiveness