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Does ICT Investment Matter for Growth and Labor Productivity in Transition Economies?

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Summary

Following up on a previous paper by the same author on the contribution of ICT capital to growth and labor productivity in Poland 1995-2000, this paper extends the study to eight transition economies: Bulgaria, Czech Republic, Hungary, Poland, Russia, Slovakia and Slovenia.

The paper shows that the contribution of investment in IT hardware, software and telecommunication equipment to output growth and labor productivity between 1995 and 2000 in most countries featured in the study was much higher than what might be expected on the basis of the level of their GDP per capita. This may suggest that the transition economies – through the use of ICT - are benefiting from the technological leapfrogging to increase the growth rates in output and labor productivity and hence accelerate the process of catching-up.

The relatively large contribution of ICT capital to output growth and labor productivity is due to an extraordinary acceleration in real ICT investments, which were growing between 1995 and 2000 at an average rate of more than 20% a year for almost all countries in the study. Large investments in ICT seem to have been induced by (i) falling prices of ICT products and services, which encouraged companies to substitute ICT for non-ICT capital and (ii) an opportunity for higher-than-normal returns on ICT investments due to a large pent-up demand for ICT infrastructure, a legacy of decapitalization and technological gap existing before 1989.

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1. Introduction

In spite of the 2001-02 worldwide economic gloom, the rapid pace of technological progress has not been arrested. The technological revolution in information and communication technologies (ICT), which has contributed to the extraordinary performance of the US economy in the late 1990's (Jorgenson and Stiroh 2001, Oliner and Sichel 2000, Stiroh 2002) and in 2000-03 (Economist 2003), has not slowed down. The computing power of microchips, which underlies the rapid progress in productivity of ICT, has kept on doubling every 18-24 months, as Moore's Law has rightly predicted since 1965. The pace of progress in capacity of microchips has accelerated after 1995 as the product cycle for semiconductors - due to increased market competition - shortened from three to two years, which led to a decline in prices of semiconductors of some 90 percent per year (Jorgenson 2001). The rapidly falling prices of ICT products and services along with their increasing efficiency and quality encouraged users to invest in ICT. After the slowdown in ICT investments recorded during the past two years, the growth in ICT spending is picking up speed again.

Aside from the USA, the use and/or production of ICT have contributed to an increase in the rate of productivity and economic growth in a number of developed and developing countries in the late 1990's. Among the former, Australia, Sweden, Finland, and Ireland seem to have tapped the 'new economy' to the largest extent (OECD 2001a, Jalava and Pohjola 2002, Daveri 2002). Among the developing countries, Malaysia, Philippines, Thailand, South Korea, and Taiwan benefited from the production of ICT (IMF 2001).

Yet, there is no evidence that other countries, both developed and developing, were able to take advantage of ICT in order to accelerate their rates of growth and productivity. There are also no studies that would estimate the impact of the ICT revolution on output growth and productivity in postsocialist, transition economies i.e. transforming from a command economy to a market economy.

Hence, this paper makes - following up on a previous paper by the same author on the contribution of ICT capital to growth and labor productivity in Poland 1995-2000 (Piatkowski 2003) - a first attempt at estimating the contribution of ICT investment to output growth and labor productivity in eight transition economies: Bulgaria, Czech Republic, Hungary, Poland, Russia, Slovakia and Slovenia. The study covers the period of 1995-2000. The paper utilizes the extended growth accounting methodology. Data for ICT spending between 1992 and 2001 is obtained from WITSA (2000, 2002), which in turn is provided by International Data Corporation (IDC). Other data is available from the World Development Indicators (2003), PWT 6.1 (Heston *et al.* 2002), and national statistical offices. Detailed description of data used for each country is in the Appendix.

The structure of the paper is as follows: Section 2 discusses the methodology of accounting for the overall economic impact of ICT based on the extended growth accounting methodology. Section 3 applies the methodology to measure the contribution of ICT investment to output and labor productivity growth. It also discusses challenges posed by the availability of data. Section 4 presents results of the study and international comparisons. Section 5 concludes the paper.

2. Accounting for the economic impact of ICT

The methodology of measuring the contribution of ICT to growth and productivity is based on original work by Solow (1957) and Jorgenson and Griliches (1968) and later extended by inter alia Oliner and Sichel (2000) and Jorgenson and Stiroh (2000). Since ICT products and services are both outputs from the ICT industries and inputs into ICT-using industries, ICT can impact economic growth through four major channels:

- production of ICT goods and services, which directly contributes to the aggregate value added generated in an economy;
- increase in productivity of production in ICT sector, which contributes to overall productivity in an economy (TFP);
- use of ICT capital as in input in the production of other goods and services;
- contribution to economy-wide TFP from increase in productivity in non-ICT producing sectors induced by the production and use of ICT (spillover effects);

To measure the overall impact of ICT on growth, it is best to express the aggregate production function in the following form:

$$Y_t = Y(Y_t^{ICT}, Y_t^0) = A_t F(C_t, K_t, L_t) \qquad (1)$$

where, at any given time *t*, aggregate value added *Y* is assumed to consist of ICT goods and services ICT – $Y^{ICT}_{t,}$ as well as of other production Y^0_t. These outputs are produced from aggregate inputs consisting of ICT capital $C_{t,}$, other (i.e. non-ICT) physical capital $K_{t,}$, and labor L_t. TFP (total factor productivity) is here represented in the Hicks neutral or output augmenting form by parameter A.

Assuming that constant returns to scale prevail in production and that all production factors are paid their marginal products, equation (1) can be expressed in the following form:

$$\hat{Y} = w_{ICT}\hat{Y}^{ICT} + w_0\hat{Y}^0 = v_{ICT}\hat{C}_t + v_0\hat{K}_0 + v_L\hat{L} + \hat{A} \qquad (2)$$

where symbol ^ indicates the rate of change and the time index t has been suppressed for the simplicity of exposition. The weights w_{ICT} and w_0 denote the nominal output shares of ICT and non-ICT production, respectively. The weights sum to one similarly as the weights v_{ICT}, $v_{0,}$ and v_L, which represent the nominal shares of ICT capital, non-ICT capital, and labor, respectively[2].

Denoting the total employment by *H(t)* and labor productivity by *Y(t)/H(t)*, the equation (2) can then be re-arranged to measure the contribution of ICT investment to growth in labour productivity

2 Please note that this study, due to a lack of data, does not correct TFP for changes in labor quality. Given the anecdotal evidence for the increase in quality of human capital in the transition countries in the sample (for instance, in Poland between 1990 and 2003 the percentage of population with tertiary education in the total doubled from roughly 7% to 14%), the results produced in this study are likely to overestimate the true increase in TFP.

$$\hat{Y} - \hat{H} = v_{ICT} (\hat{C}_t - \hat{H}) + v_0 (\hat{K}_0 - \hat{H}) + \hat{A} \qquad (3)$$

As shown in the above equation, there are three sources of growth in labor productivity: ICT capital deepening, i.e. increase in ICT capital services per employed person, non-ICT capital deepening, and total factor productivity. Due to the limited scope of the paper, the paper will focus on only one channel through which ICT impacts growth in output and labor productivity that is through the contribution of ICT capital.[3]

3. Accounting for contribution of ICT investment to output growth

As on the right hand-side of the equation (2) the contribution of ICT investment to output growth can be defined as a sum of contributions from ICT capital ($\hat{C}_t$), non-ICT capital ($\hat{K}_0$) and labor ($\hat{L}$), where weights v_{ICT}, v_0, and v_L represent the nominal shares of ICT capital, non-ICT capital, and labor, respectively, and sum to one. Total factor productivity (TFP) is represented in the Hicks neutral or output-augmenting form by parameter A. Symbol ^ indicates the rate of change.

$$\hat{Y} = v_{ICT} \hat{C}_t + v_0 \hat{K}_0 + v_L \hat{L} + \hat{A} \qquad (4)$$

So far the efforts to calculate the impact of ICT investment on growth in transition economies have failed due to the lack of data on:

- ICT investment and ICT capital stock,
- Total fixed capital stock,
- ICT capital services share in total income.

Yet these shortcomings in data can be overcome. The following subsections present the specific data problems together with methodologies used to arrive at the final estimates of ICT capital contribution to growth and labor productivity in eight transition economies between 1995 and 2000.

3.1 Accounting for ICT stock

Most statistical offices in postsocialist countries do not provide information about investment in ICT assets[4]. Neither do they provide hedonic (i.e. constant-quality) price indices for ICT investment and depreciation rates on ICT assets. Nonetheless, the lack of data from national statistics on ICT can be mitigated by a use of alternative sources of data and a number of assumptions.

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3 Due to poor availability of data it is quite challenging to estimate the impact of ICT on growth in post-communist countries through the remaining three channels – (i) direct contribution of ICT production to GDP (ii), increase in productivity of ICT production, and (iii) spillover effects of the ICT use. Piatkowski (2003) provides some rough estimates of the contribution of ICT production to output growth in three countries - Czech Republic, Hungary and Slovak Republic - for the period of 1995-2000. Van Ark (2003) provides first estimates of productivity growth in ICT-producing, ICT-using and non-ICT sectors in Czech Republic, Hungary, Poland and Slovakia between 1995 and 2000. The study shows that the productivity growth in ICT-intensive industries has been much larger than in low-ICT intensity industries ("non-ICT"). This may be the first evidence of spillover effects of ICT use in transition economies.

4 Slovenia is the only postsocialist country, which has so far published actual data for IT investment between 1996 and 2001, and total ICT investment for 2001 (Stare *et al*. 2003).

3.2 ICT investment

The data on ICT spending can be obtained from a private source - WITSA Digital Planet report (2002, 2000), which relies on data provided by International Data Corporation (IDC)[5]. WITSA provides consistent information on total spending on hardware, software and communication equipment between 1992 and 2001 in 51 countries representing 98% of the total global spending. The series include data on eight transition economies: Bulgaria, Czech Republic, Hungary, Poland, Romania, Russia, Slovakia, and Slovenia.

WITSA (2002) data shows that ICT spending as a share of GDP in eight transition countries has been steadily increasing during the 1990's (Table 1).

Table 1 around here

In 2001, relative spending on ICT was highest in Hungary, followed by Slovakia, Czech Republic and Poland. The first three countries also spent more than an average for the whole WITSA sample of 51 countries (which is biased towards developed countries).

Dataset from WITSA (2002) on ICT spending does not delineate the expenditure shares of enterprises, government and households. Neither does it divide the spending between investment and services. Since spending by households and spending on services should not be regarded as ICT investment, their share in total spending has to be estimated and deducted from the total.

Schreyer (2000) and Jalava and Pohjola (2002) estimate, based on a comparison between an actual investment data from the US Bureau of Economic Analysis (BEA) and WITSA data on the ICT spending in the US, that the share of telecommunication investment in total spending reported by WITSA equals 30%. Contrary to this approach, although based on the same BEA - WITSA comparison, Daveri (2002) breaks up the whole IDC data into investment shares and household expenditure, applying 59% share of investment in hardware expenditure, 33% for telecommunications spending and 205% for software (Daveri's investment shares are for business sector only – he excludes government spending).

For transition economies in the sample, the author estimates that the investment share in WITSA telecommunications spending amounted to 30% in the 1992-2001 period (based on a ratio of actual ICT investments in Slovenia – based on the data from the Slovenian Statistical Office - to WITSA data on ICT spending in Slovenia)[6]. Based on IDC (2001) breakdown for 2000, the investment share in IT hardware spending was assumed to equal 86.1% for Czech Republic, 89.6% for Hungary, 79.9% for Poland, 79.8% for Russia, and 87.0% for Slovakia. Due to lack of data, the IT hardware investment share in the other three countries – Bulgaria,

5 ICT spending by WITSA (2002) includes computer hardware, software, internal services, other office products, and telecommunications equipment and services. No data is provided on embedded ICT in non-ICT products and on ICT expenditure of non-incorporated entreprises. For exact definitions, refer to http://www.witsa.org/DP2000qa.htm. WITSA (2002) data definitions of ICT do not exactly conform to those of either OECD or national accounting. WITSA data is also subject to a few measurement biases, yet their combined effects are hard to measure (for more detailed discussion of other WITSA data caveats see Daveri 2002).

6 For definitions of WITSA spending and Slovenia investment data, see Table 2 in Appendix. Investment share in telecommunications is based on a 1996-2001 geometric average of a ratio of Slovenian actual data to WITSA data.

Romania, and Slovenia – was assumed to amount to 85%[7]. The investment share of software in WITSA data was assumed to equal 120% in the period for all countries based on a fact that WITSA spending on software does not take into account internally developed, custom made software.[8]

Based on the above assumptions, the value of investment in ICT in selected transition economies is much lower than ICT spending reported by WITSA (2002) (Table 3).

Table 3 about here

In all countries, the share of ICT investments in total GFCF between 1992 and 2000 has been gradually increasing (Table 4). In 2000, ICT investment had a largest share in total investment in Hungary, Czech Republic, and Bulgaria.

Table 4 about here

In spite of the increasing significance of ICT investment, the share of ICT in total GFCF in transition economies in 2001 was substantially lower than in the EU and the US, where it amounted to 17.1% and 29.6%, respectively (van Ark *et al*. 2002)[9].

3.3 ICT price indices

To arrive at ICT investments in the local currency, the data series were divided by an average annual exchange rate based on PWT 6.1 National Accounts (Heston *et al.* 2002).

Since a dollar today buys much more computing power than in the previous years, the data on ICT investments in current prices needs to be deflated to arrive at constant-quality prices. Otherwise, the use of traditional non-hedonic price indices would significantly understate the significance of investment in ICT as non-hedonic deflators do not take into account the rapid decrease in quality-adjusted prices of ICT (for example, the quality-adjusted price of a computer bought for $1,000 in 1995 amounts to $272 in 2001; the use of non-hedonic price deflator would however value the same computer at $1,068 in 2001 – based on Jorgenson *et al*. 2002 dataset for the US).

Since no quality-adjusted deflators are available from national statistics in transition countries,

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7 For IT hardware the geometric average of a ratio of actual Slovenian investment to WITSA spending on IT hardware (including IT office equipment) amounted to 109% in 1996-2001. This high ratio however seems unlikely as WITSA data includes business, government and household sector, while Slovenian data includes only the first two. Slovenian data then seems to be on a high side. This may be due to various exchange rates used (WITSA uses current exchange rates to USD, which are liable to significant swings) and the fact that the Slovenian Statistical Office values IT hadware investments by their total purchase value, which includes taxes, costs of delivery, and other direct costs, while WITSA seems to take into account only gross price of ICT spending (without costs of delivery and other associated costs). For definitions see Appendix, Table 2.

8 The geometric average for a ratio of actual Slovenian software investment to WITSA spending in 1996-2001 amounts to 71%. This however seems to be a very low estimates (in 2001 alone, the same ratio amounts to 113%). Although apparently the Slovenian data includes internally developed software, taking into account problems with its adequate measurement, the data is likely to understate the real investment. In addition, given still large investments in pirated software in transition economies, the 120% ratio seems to be the best estimate available.

9 Van Ark et al. (2002) reports total nonresidential GFCF only, excluding non-residential buildings. Since GFCF in this study includes residential investment, the gap in ICT investment as share of total GFCF between post-communist countries and the EU is even larger.

the paper uses "price index harmonization" methodology developed by Schreyer (2000) and then used by Colecchia and Schreyer (2001), van Ark *et al*. (2002) and others[10]. According to this methodology, the ratio of the US hedonic deflators 1990-2001 for ICT investment in computers, software, and telecommunication equipment relative to deflators for non-computers, non-software and non-telecommunication equipment (all data based on Jorgenson *et al*. 2002, who relies on the US Bureau of Economic Analysis[11]) was applied to the aggregate investment deflator for eight transition economies for the same period to obtain three separate ICT price harmonized deflators for each of the countries. This approach is based on an assumption that the ratio of prices of ICT to the overall investment prices in each of the countries follows the same ratio of prices for the US, which seems to be a plausible assumption given the high tradability of ICT products and a negligible size of the local ICT production. Hence, the US price level is directly converted into the local currency after being corrected for the general level of inflation. Although undoubtedly the above approach has a number of shortcomings, including the fact that it assumes that there are no differences in composition of ICT investment between transition countries and the US and that price indices of ICT products imported to each of the countries and those domestically produced in the US behave in the same way, the "price index harmonization" method seems to be the most appropriate for constructing the ICT deflators in the light of a lack of deflators from the national statistics. The most important thing here is to reflect - to the largest possible extent - the true decline in ICT prices.

Table 5 in the Appendix shows rate of inflation in prices of ICT investment (quality-adjusted) and non-ICT investment (based on 1996 fixed prices) for each of the countries for the period of 1990-2000. The nominal price of IT hardware between 1995 and 2000 declined in only Czech Republic, Hungary, Poland, Slovakia, and Slovenia. In all other countries, due to high inflation, the quality-adjusted prices of IT hardware, software, and telecommunications equipment were increasing, yet at a much lower rate than the inflation in non-ICT investment.

Table 5 about here

3.4 ICT capital stock

To arrive at a measure of the ICT stock, the real ICT investment series obtained above need to be depreciated using perpetual inventory method (PIM). In PIM method, capital stock is defined as a weighted sum of past investments with weights given by the relative efficiencies of capital goods at different ages:

$$K_{i,T} = \sum_{t=0}^{\infty} \partial_{i,t} I_{i,T-t} \qquad (5)$$

with $K_{i,T}$ the capital stock (for a particular asset type i) at time T, $\partial_{i,t}$ the efficiency of a capital good i of age t relative to the efficiency of a new capital good, and $I_{i,T-t}$ the investments in

10 Only US, France, Denmark, Sweden and Canada report quality-adjusted, hedonic prices for ICT equipment. National statistical offices in postsocialist countries do not report ICT separately; it is most often lumped together under "high-technology" products and services. Domestic hedonic price indexes have not been developed yet, either. For discussion of methodology of hedonic pricing, see OECD (2000) and Mulligen (2002).

11 Jorgenson *et al.* (2002) constant quality price index is based on BEA deflators for the private sector, government and households. Alternative approach is to use BEA deflators for the private sector only available from BEA (2002).

period *T-t*.[12] A geometric depreciation pattern is applied, which – as argued by Fraumeni (1997) - better reflects the pattern of stock aging (faster at the beginning of the utilization period, slower towards the end of efficient life) than a straight-line depreciation method. Hence, with a given constant rate of depreciation ∂_i different for each asset type, $\partial_{i,t}$ is given by $\partial_{i,t} = (1-\partial_i)^{t-1}$, so that:

$$K_{i,T} = \sum_{t=0}^{\infty} (1-\partial_i)^t I_{i,T-t} = K_{i,T-1}(1-\partial_i) + I_{i,T} \qquad (6)$$

Because of the lack of data on ICT investments before 1992 and in order to arrive at a sufficiently long series of ICT stock, the ICT investment series were extrapolated back to 1985 by applying a geometric average of growth rates in ICT real investment for the three types of assets in local currency between 1992 and 2001. ICT stock in 1985 was assumed to equal zero[13].

Alternative method of obtaining sufficiently long series of ICT investment, as reported by van Ark *et al.* (2002), is to derive the ICT investment for the period 1985-91 from a share of ICT investment in GFCF in a period for which the relevant data exists. Yet, since in 1985 the transition economies were operating under a totally different economic system of a command economy, any assumptions as to the share of ICT investment in the total GFCF in 1985 based on the data from the 1990's would not be justified. Van Ark *et al.* (ibid.) also apply a commodity flow method to arrive at long series of ICT investment, yet given the lack of detailed data on input-output tables from national statistical offices, its use in measuring ICT investment in postsocialist countries is not possible.

In this study, the geometric depreciation rate for IT hardware is based on van Ark *et al.* (ibid.) and is set at 0.295. Depreciation rates for telecommunications equipment and software, obtained from Jorgenson and Stiroh (2000) and Oulton (2001), were set at 0.115 and 0.315, respectively.

Real investments in ICT (1996 base year) in most transition countries between 1995 and 2000 have been growing at very high average annual rates of more than 20% (Table 6). Poland, Czech Republic, Romania, and Slovenia reported the highest real growth rates of 39%, 31%, 30% and 30%, respectively. Russia's ICT investment grew by only 17% annually in the period.

Table 6 about here

The growth rates in real ICT investment for the transition countries were much higher than in the EU and the US, which in the same period amounted to 18.5% and 19.3%, respectively (van Ark *et al.* 2002).

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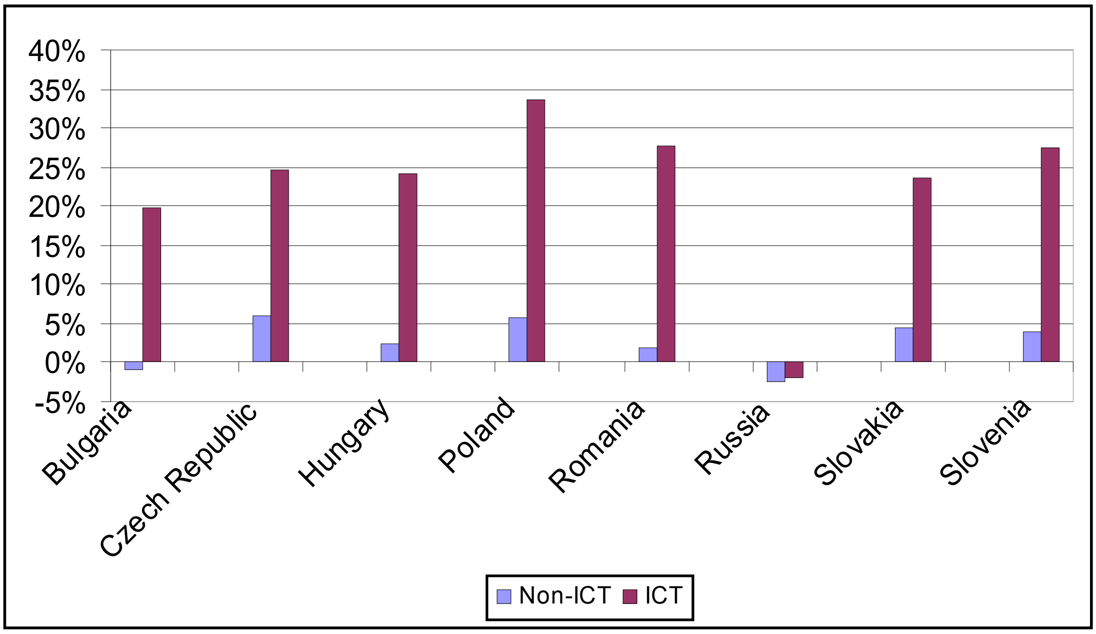
12 As remarked by van Ark *et al.* (2002), various equations of that kind make an implicit assumption that services of assets of various vintages are perfect substitutes for each other.

13 While this is surely an improbable assumption, given high depreciation rates for ICT, most of the early ICT stock from before 1992 depreciates to less than 10 per cent of the value of ICT stock in 1995 and to almost zero by 2000. Alternatively, one can assume the value of ICT capital stock to equal zero in 1992. Yet, since some ICT stock surely existed in 1992, it seems methodologically more appropriate to extrapolate the data back to 1985 as the starting point of ICT stock accumulation.

Finally, the author arrived at a measure of the end-year real ICT capital stock 1985-2001. These were adjusted from end-year to mid-year. Between 1995 and 2000, on the back of large ICT investments, the real stock of ICT was quickly growing (Figure 1).

Figure 1. Average annual growth rates in real mid-year ICT capital in selected transition economies, 1995-2000 (1996 base year)



Source: own estimates

As a consequence of the rapid growth in real ICT stock, its average share in the net total capital stock between 1995 and 2000 substantially increased in most countries (Table 7). Czech Republic, Hungary, and Slovenia reported the highest average ICT stock shares in total net capital of 3.78%, 3.73% and 2.86%, respectively.

Table 7 about here

3.5 Accounting for non-ICT capital stock

Only a few statistical offices in the countries featured in the study publish data on the value of total fixed capital stock (Poland, Hungary, Czech Republic, Russia, and Slovenia). Moreover, definitions and methods of estimation of the total capital stock differ from one country to another. Hence, in order to sustain consistency (where data is available) as well as to construct capital stock where data is not available, the non-ICT capital stock 1995-2000 will be constructed on the basis of the same methodology as applied to constructing the ICT capital stock. The 1960-2000 investment series (GFCF - gross fixed capital formation) will be depreciated by the PIM, as in equation 6 (this is the so-called vintage model approach).

Pula (2003) showed that for Hungary the vintage method yielded an estimate of the total capital stock in proportion to GDP much closer to expected levels based on international comparisons than a method used by the Hungarian Statistical Office based on a direct survey data (the so-called initial stock approach).[14] This finding corroborates the choice of the method

14 Pula (2003) shows that the two methods resulted in considerably different capital stock estimations: the stock based on the historical investment method is about 50% lower than stock based on a direct survey of enterprises data. He finds, based on a comparison of the expected levels of capital-to-GDP ratios for countries at a similar

in this study.

The historical GFCF series are depreciated at a geometric depreciation rate of 7.5%, which seems to most appropriately reflect the structure of investments in the selected transition countries (a lack of disaggregated data does not allow for applying separate depreciation rates for each type of investment).

There is a dearth of reliable, long-term data on GDP and GFCF in transition economies. This particularly applies to historical data series on GDP and GFCF in transition economies from before 1989, which were constructed based on methodologies not used elsewhere. The reliability was also often questionable[15]. In addition to that, statistical offices in transition countries have also used different definitions and methodology. Consequently, data available from national statistics can be hardly comparable on a cross-country basis. However, as argued by EBRD (1995), relative magnitudes (share of GFCF in GDP and GDP/NMP growth rates, both used in this study) tend to be more reliable than the absolute numbers.

Due to insufficient historical data, in this study the 1960-2000 investment series had to be build on the basis of a combination of data from a number of sources. The most recent and internationally comparable data on GFCF for years 1990-2000 is available form the World Bank's World Development Indicators 2003 database (WDI 2003)[16]. It is the most reliable source of consistent GFCF series for the countries in the study. Based on series on GFCF in current prices and real annual growth rates, GFCF 1990-2000 series in 1996 fixed prices were constructed.

For earlier years, where WDI data on GFCF was not available, the investment series can be built on the basis of either of the two approaches:

a) Where available, data on investment (GCF – gross capital formation) in 1996 fixed prices from PWT 6.1 (Heston et al. 2002) can be used. Where it is not available, the investment series can be constructed on the basis of data on the share of investment in GDP and GDP growth rates in the 1960-1989 period. Data on GDP growth rates 1960-1990 are available from Kolodko (2000), who used historical international statistics handbooks of the Polish

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stage of development as Hungary, that the investment method yields much more reasonable results (1.5 capita-to-output ratio) than the survey method (2.9 ratio). He argues that survey methods have three major shortcomings: (i) corporate accounts are strongly distorted by tax regulations, (ii) capital stock is booked at various historical prices so that the stock has no uniform price base, and (iii) book value of stock in the turbulent environment of transition countries hardly reflects their economic value. Pula also made a cross-check using the growth accounting method and found that the TFP estimated based on the generated capital stock is compatible with data from other sources.

15 Orłowski (2003) argues that if one believed official statistics in Poland, which reported average NMP (Net Material Product) growth per capita between 1950 and 1980 of 5% a year, in 1980 Poland should have achieved NMP per capita comparable to that of Spain and Ireland and only 30% lower than that of the West Germany. In reality, in 1980 Polish NMP per capita was two-and-a-half times lower than in Spain, and four times lower than in West Germany. If one was to believe Romanian statistics, its NMP per capita in 1980 exceeded that of France. Orłowski argues that socialist countries' growth statistics were exaggerated because of (i) methodology, which did not account for services, which were growing much slower than industrial production, (ii) data on growth provided by enterprises were jacked up in order to receive larger allocations within the command system, and (iii) statistics underreported inflation and quality change in production. Finally, (iv) there was a strong pressure from government to report increased growth rates.

16 For a number of countries, the WDI series stretch to 1985. In the case of Hungary, WDI publishes GFCF data, which goes all the way back to 1960. For description of all data sources and assumptions for each country in the study, refer to the Appendix 2, Table 18.

Statistical Office[17]. Based on the real growth rates, one can construct the 1960-1989 GDP series in 1996 fixed prices. For the share of investment in GDP, one can use PWT 5.5 (Summers and Heston 1993), published in EBRD (1995), which provides data on an average share of investment (GCF) in GDP for five transition economies between 1974 and 1989.

b) The long-term GFCF series can be built from data on GFCF share in GDP available from Glikman *et al.* (1997) for Bulgaria, Czechoslovakia, Hungary, Poland, Romania, and Russia for years 1960, 1970, 1975, 1980 and 1985 (based on historical international statistics handbooks of the Polish Statistical Office - *Roczniki Statystyki Międzynarodowej* 1970, 1973, 1981, 1987). For GDP growth rates, one can again use Kolodko (2000). For Slovenia, because of the lack of data from the above two sources, the GFCF share in GDP and GDP growth rates between 1960 and 1990 can be sourced from the national statistics for former socialist Yugoslavia based on the Statistical Yearbook of Slovenia 1990 and 1995.

The two approaches result in quite different estimates of the net capital stock. It is due to the fact that according to the data from Glikman *et al.* (1997), there was a substantial difference between the reported shares of GCF and GFCF in GDP in socialist countries in the 1960-1989 period (Table 8).

Table 8 about here

Glikman argues (ibid.) that due to market shortages under socialism (what Kornai 1980 called "economics of shortages"), enterprises had large incentives to hoard inventory in order to avoid constant interruptions in the state-controlled procurement. As a result, while GCF was on a level comparable to developed countries, a disproportionately large part of GCF was invested into inventory. GFCF as a share of GDP was then much lower than in developed countries.

Thus the use of GCF shares in GDP as reported by PWT 5.5 is likely to substantially overestimate the true GFCF, if one were to assume that the value of GCFC – as in the case of developed countries – would not be significantly different than GCF. This was clearly not the case in socialist economies. Hence, in this study in order to arrive at the 1960-1989 GFCF series, the author used the second approach based on data on GFCF shares in GDP from Glikman *et al.* (1997).

As a result, the author arrived at 1960-2000 investment series in 1996 fixed prices, which were subsequently depreciated according to the PIM. Thus, the 1960-2000 series of the total net capital stock were obtained. However, in order to appropriately reflect the true economic value of capital stock accumulated and operated under socialist system in the new market economy environment, the capital stock for 1990 for all countries was discounted by 25%.[18]

17 Kolodko (2000) data refers to "Net Material Product (NMP)" instead of GDP. NMP, which was used in statistics in socialist countries, did not take into account most part of value added created by the service sector (the so-called "non-material sphere"). While the two are not directly comparable on an absolute basis, EBRD (1995) estimates that that NMP would need to be multipled by 1.1 to 1.3 to arrive at a equivalent measure of GDP. Given relatively low share of the service sector in total GDP and service sector's low growth rates due to lack of investment (as it was mostly concentrated in the manufacturing sector), the NMP growth rate could be considered to largely approximate the GDP growth rate in the period. NMP growth rates, as reported in Kolodko (ibid.), are averaged over various periods: two, three, four, five or six years.

18 Similar approach was espoused by Pula (2003), who assumed a one-off 25% drop in the value of capital stock in Hungary in 1991 based on a Cobb-Douglas production function with a 0.6 labor share and zero TFP growth, where a 15% decrease in output corresponds to a 25% drop in the value of the capital stock. There are a number

The discounting of the value of the stock reflects the fact that a large part of the pre-1990 stock could not be effectively utilized in a market based economy. The turbulence of the transition period, which started in 1989, has also had a significant negative impact on the economic value of stock. The "transition shock" or "disorganization effect" (IMF 1999), which decreased the value of capital stock was due to:

- sudden exposure to technologically superior technologies, which rendered the existing stock technologically obsolete[19],
- almost immediate and deep change in structure of demand (plan-driven market changed into customer-driven market almost overnight),
- obsolescence of the existing equipment, which could not produce competitive products in the new market environment (Belka *et al.* 1994 shows that in Poland in 1993, a couple of years after the beginning of transition, 37% of the fixed capital of enterprises was aged 15 and more while the other 57% was 10 years and older).

The rationale for discounting the value of the stock may also be argued on the basis of a fact that (i) a large part of investments in the social period was concentrated in heavy industry, which largely proved to be non-competitive in the market environment, (ii) a number of companies was liquidated and capital stock, which could not be refitted, was scrapped, (iii) some significant part of investment was related to military applications, whose value after transition dramatically decreased, and – not less importantly – (iv) published data were often "improved" in response to pressure from state authorities.

The final estimates of the total net capital stock for eight economies in the study for the 1995-2000 period are displayed in Table 9[20].

Table 9 around here

To check robustness of these results, the author calculated the average net capital stock-to-GDP ratio (in 1996 fixed prices) for 1990-2000 and compared them with ratios (1980-90 average) for selected countries from World Bank dataset (Nehru and Dhareshwar 1993, based on Pula (2003)) (Figure 2).

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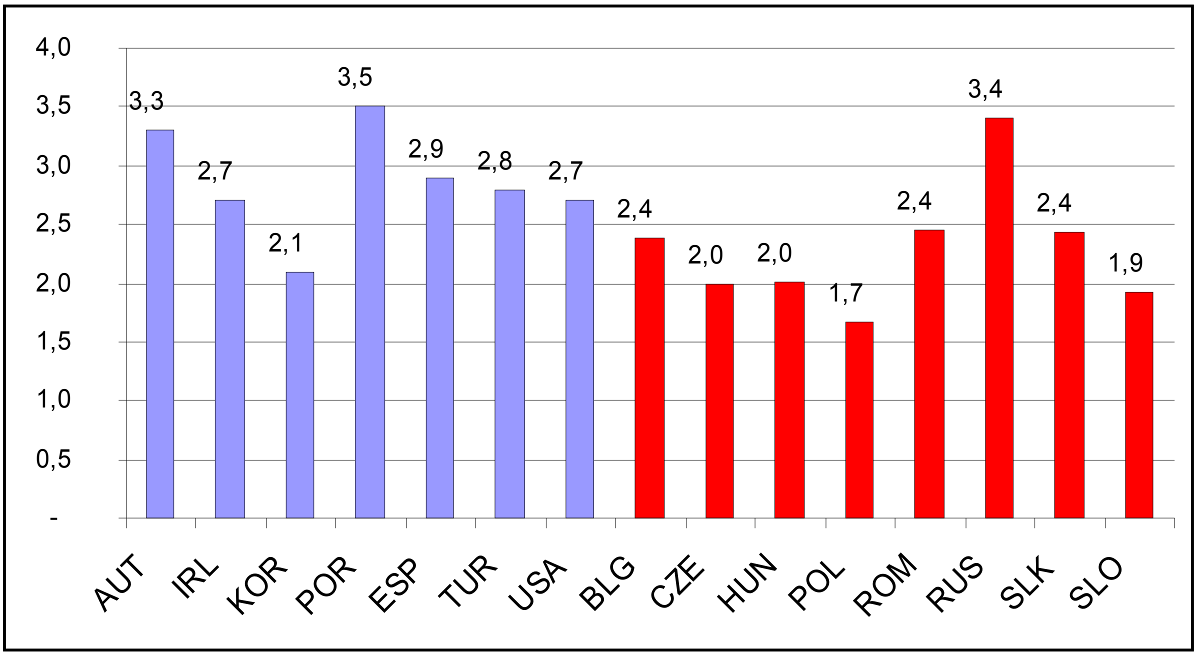
of other authors, who estimated a discount to the value of capital stock in socialist economies after the transition. Doyle et al. (2001) assumed a 35% drop in the value of capital stock in 1991 in Hungary, Poland, Slovakia, and Slovenia, and a 20% decrease in the Czech Republic. The same discount was applied to Hungary by IMF (1999). Darvas and Simon (2002) assumed a 21% discount for Hungary in 1991. Sinn and Sinn (1992) report the results of a study for East Germany according to which at reunification between 50% and 75% of stock were written-off under the West German accounting regulations (although book value do not necessarily reflect economic value). Borensztein and Montiel (1991) argued, based on their estimation of the value of stock that would generate the same ouput as in market–based economies at a similar level of development, that between 50% and 75% of capital stock in Czechoslovakia, Hungary and Poland should be written off. The last two estimates seem to be on a high side. In this study, we assume that a large part of existing capital was productively re-allocated either through privatization, sale of assets or liquidation. This assumption seems to be particularly pertinent to the leaders of transition – Poland, Hungary, Czech Republic, Slovakia, and Slovenia – where structural reforms facilitated the re-allocation process. The assumption may be less appropriate for Bulgaria, Romania and Russia, where reforms were much less pronounced, particularly in the early transition period.

19 Up until 1990-91 former socialist countries were not allowed to import from the US and Western Europe most kinds of high-technology equipment, which could have a military use. The restrictions applied to almost all ICT products.

20 Due to unavailability of data for all countries on the share of residential investment in total GFCF, our measure of total net capital stock includes residential capital. Available data for the Czech Republic (Czech Statistical Office 2002) shows that residential dwellings represented 5.7%, 7.7%, 8.5%, 9.3% and 9.2% of total annual GFCF between 1996 and 2000. Polish Statistical Office (2002) reports that in 2000 and 2001 residential dwellings represented 20% of the total value of gross capital stock. In 1995 the share amounted to 23.9%.

Figure 2. Net capital stock to GDP ratios for selected countries, averages for 1980-90 and 1990-2000



Source: Nehru and Dhareshwar (1993), based on Pula (2003), and author's calculations. Note: first seven countries based on World Bank dataset's average for 1980-90. Last seven post-socialist countries based on author's calculations of a 1990-2000 geometric average.

Total net capital stock-to-GDP ratios for the countries in this study are relatively high. Quite surprisingly, the lowest ratios are reported by Czech Republic, Hungary, Poland, and Slovenia, countries with highest GDP per capita among the socialist countries in the sample (except for Slovakia, which has higher GDP per capita than Poland). For Poland, the average ratio for 1990-2000 of 1.7 was lower - as should be expected - than the actual ratio of gross fixed capital stock to GDP (current prices) based on data from the Polish Statistical Office (2002), which amounted in 1995, 2000, and 2001 to 2.9, 2.1 and 2.1, respectively. This finding increases the reliability of the results.

It seems, however, that ratios for Bulgaria, Romania, Slovakia and Russia in particular, even in spite of discounting the 1990 capital stock by 25%, seem to be too high[21]. This may be due to overestimation of both NMP growth rates and GFCF shares in GDP in the 1960-1989 period. The 7.5% depreciation rate used in the study may also be too low.[22] The ratio is quite sensitive to changes in the depreciation rate: if the depreciation rate was increased to 10%, the ratio for Russia would decrease from 3.40 to 2.86. A one percentage point increase in depreciation rate translates in case of Russia into a decrease in net capital stock to GDP ratio of 0.24 and roughly 0.2 for other countries in the sample. Nonetheless, given that the capital stock in the study includes residential stock, which has low depreciation rates, the choice of the 7.5% seems appropriate.

21 Russian Statistical Office (2002) reports that in 2000 the ratio of gross fixed capital to GDP amounted to 2.61. The result of this study is then indeed on a high side.

22 Or there may be a large difference between GDP and investment price deflators, whereby fixed prices would overestimate the true value of GFCF. Yet, this seems not to be the case: for Bulgaria average share of GFCF in GDP in current and 1996 fixed prices, based on WDI 2003 data, for 1985-2001 was closely comparable, and amounted to 17.8% and 18.0%, respectively.

High net capital stock to GDP ratios may also point to the fact that productivity of existing capital stock is low. This in turn may be due to delays in market-oriented restructuring of the economy. This seems to be true for the post-socialist countries with the highest ratios – Bulgaria, Romania and Russia – where, as argued by the EBRD (2003), market reforms are the least advanced among the countries in the study.

For Poland, the author compared the net capital stock to GDP ratios based on data from PWT 6.1 and PWT 5.5 and data from Glikman et al. (1997) used in this study[23]. The first approach yielded an average 1990-2000 net capital-to-GDP ratio of 2.06, while the data used in this study returned a ratio of 1.68. The latter result seems to be closer to expected values based on international comparisons. Hence, the choice of the Glikman *et al.* (ibid.) data seems to justified.

Finally, having arrived at the estimates of 1995-2000 total net capital stock, in order to arrive at the non-ICT capital stock 1995-2000, the author deducted data on ICT stock (excluding software) for years 1985-2000 from the total net capital stock series in the same period.[24] With a view to limiting the impact of assumptions and unreliability of investment series from before 1989 (although mitigated by the 25% discount) on the results of the study, both relative to ICT and non-ICT stock, the study presents results for the 1995-2000 period only.

3.6 Accounting for ICT income share

Having obtained the estimates of the net ICT capital stock, the annual capital service flows from the stocks have to be estimated in order to measure the contribution of ICT capital to output growth. Capital service flows, representing the user costs for each type of asset, for ICT capital are much higher than for non-ICT capital due to high rates of depreciation for ICT assets and relatively large capital loss due to fast decrease in ICT prices. In other words, a dollar spent on new ICT equipment should provide higher services flows than alternative investment in non-ICT equipment. The difference between growth in capital services and capital stock represents the improvement in capital quality, which reflects the substitution towards assets from higher marginal products. Since ICT capital has relatively high marginal product, then a shift towards ICT increases the overall quality of capital. Any estimates based on capital stock only rather than on capital services do not take into account this increase in quality of capital and hence underestimate the contribution of ICT capital to output growth (Jorgenson 2001).

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23 According to PWT 5.5 (Summers and Heston 1993), investment (GCF) as a share of GDP between 1974 and 1989 amounted to on average 30% in Czechoslovakia, 27% in Hungary, 32% in Poland, 31% in Yugoslavia, and 38% in USSR. According to WDI 2003, the average share of GFCF in GDP in Hungary between 1960-89 amounted to 26.7%, while for Bulgaria between 1980-89 GFCF averaged 26.9% of GDP. In this study, the author assumed – as it would be the case for developed countries – that GCF share in GDP largely approximates the GFCF share. Under this assumption, the author extrapolated the 1974-89 PWT 5.5 averages to 1960 for Czech Republic, Poland, Russia, Slovak Republic (as part of Czechoslovakia). For Bulgaria the author extrapolated the WDI 1980-89 average to 1960. For Romania, for the lack of data, the author assumed that the share of GFCF in GDP in the whole period of 1960-1989 amounted to on average 30% (the only number available from any of the sources shows that GFCF share in GDP in Romania in 1981 amounted to 33.6% - WDI 2003).

24 Earlier data on ICT stock is not available. Yet, as mentioned earlier, due to fast depreciation of ICT stock, by 1990 most of the ICT depreciates down to almost zero. Software capital stock was not deducted since it was not part of the GFCF series.

The contribution of ICT capital to output growth in eight transition countries in the study is measured on the basis of the services flows from three separate ICT assets (IT hardware, software and telecommunication equipment) and non-ICT capital. Estimation of rental prices for each of ICT assets provides their weights in total income.

Based on an assumption that the flow of capital services from ICT capital (K^c) and non-ICT capital (K^n) is proportional to the mid-year capital stock (average of $K_{i,T}$ and $K_{i,T-1}$), the capital services for each type of asset will be obtained as:

$$CS_i = r_i K_{i,T} / p_y Y \qquad (7)$$

where r_i represents user costs of each specific asset, $K_{i,T}$ real capital stock of a specific asset at time T, and p_y the output price. User cost of each specific asset will be denoted as:

$$r_i = p_{i,T}(r_T + \partial_i - \pi_{i,T}) \qquad (8)$$

where $p_{i,T}$ represents the acquisition price of a new asset, r_T represents the nominal rate of return, ∂_i the depreciation rate of asset type *I*, and $\pi_{i,T}$, the rate of inflation in the price of asset type *I,* which can be calculated from the appropriate price deflators. The expression in the brackets represents the rental price, which measures the price of an asset good at which the investor is indifferent between buying or renting the capital good cost of capital. The rental price represents the cost of capital, which is an annualisation factor that transforms the acquisition price of investment goods into the price of capital input.

As shown in equations (2), (7) and (8) the size of the contribution of ICT capital to output growth will depend on the rate of capital accumulation, gross rate of return, and capital-output ratio.

Depreciation rates for each ICT asset type and rate of inflation in the price of each asset are already available. The nominal rate of return on the total stock in the economy has to be however estimated in order to calculate the user costs for each type of asset. The methodology for obtaining the nominal rate of return was developed by Jorgenson *et al.* (1987). The methodology applies an ex-post approach to measure the nominal rate of return based on the following assumptions:

a) there is perfect competition and zero profits in each market sector
b) the nominal rate of return is equal for all assets in a particular market sector
c) the sum of rental payments for all assets is equal to total capital compensation that is share of capital in total income.

Based on the above assumptions and given that the capital revenue (CR) is equal to:

$$CR^T = \sum_i p_{i,T} K_{i,T} \qquad (9)$$

where p_i represents the rental price of capital services from asset type *i* and that for each asset type

$$p_{i,T} = r_T + \partial_i - \pi_{i,T} \tag{10}$$

and where r_T represents the nominal internal rate of return, ∂_i the depreciation rate and $\pi_{i,T}$ the rate of inflation, the pre-tax nominal rate of return r_T can be obtained by combining (8) and (9)

$$CR^T = r_T \sum_i K_{i,T} + \sum_i (\partial_i - \pi_{i,T}) K_{i,T} \tag{11}$$

and finally solving for r_T[25]

$$r_T = \frac{CR^T - \sum_i (\partial_i - \pi_{i,T}) K_{i,T}}{\sum_i K_{i,T}} \tag{12}$$

In the eight countries in the study, the average nominal rates of return for 1995-2000 were quite high, mostly due to the high inflation in the period (Table 10).

Table 10 around here

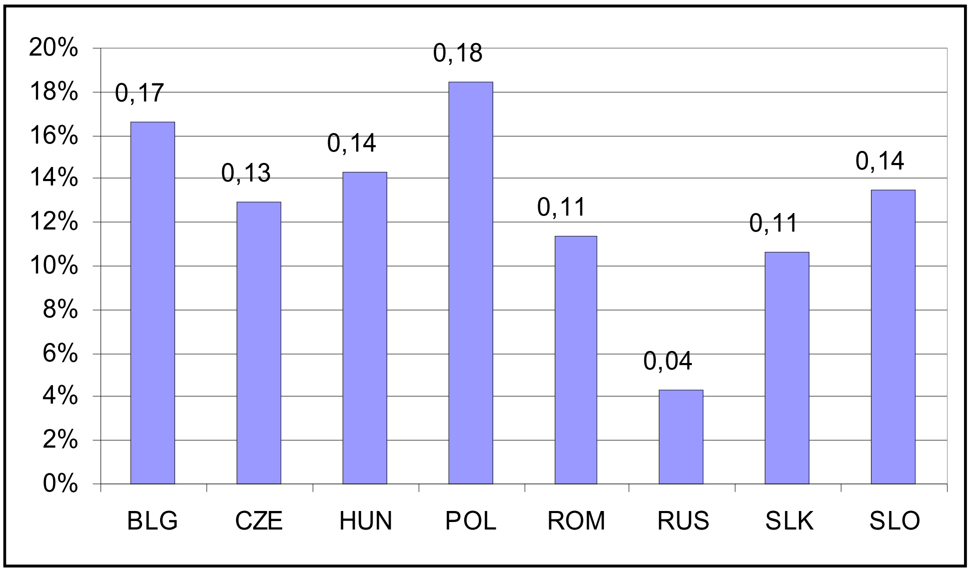
These high nominal rates compare with the EU and the US average of 0.14 and 0.15 for the same period (van Ark *et al.* ibid.). In the same study, Ireland had the highest rate of return at 0.38 followed by Portugal, the UK, and Italy, at 0.19, 0.18 and 0.17, respectively[26]. Oliner and Sichel (2000) came up with the estimated average rate of return on non-residential equipment and structures for the US between 1970 and 1992 of 0.12.

In order to eliminate the distorting impact of high inflation in cross-country comparisons, the real rates of return (IRR) can be calculated by subtracting the price change in the investment deflator for years 1995-2000 from the nominal rates of return for the same period. Between 1995 and 2000 Poland recorded the highest real rate of return on total net capital stock in the economy (0.18), followed by Bulgaria (0.17), Hungary (0.14) and Slovenia (0.14) (Figure 3). Poland's high IRR seems to reflect an advanced degree of structural reforms in the economy, which resulted in high productivity of the existing capital stock. Russia seems to represent the opposite case, where relatively slow structural reforms are likely to have resulted in low IRR.

25 Due to lack of data on tax expenditure, it was not possible to estimate the after tax rate of return. For a methodology of after-tax measurement of rate of return, refer to Jorgenson and Stiroh (2000). In this study, the capital revenu CR was estimated as a capital share in total income in current prices.

26 Van Ark *et al.* (ibid) study is for non-residential capital only, while this study – for the lack of detailed data on residential investment - computed the nominal rate of return for the capital stock including residential stock. Exclusion of the residential capital, if suitable data were available, would further increase the rate of return for all countries in the study. For Poland, where according to the Polish Statistical Office (2002) the gross stock residential dwellings represented 23.9%, 20.1% and 20.0% of the total gross fixed capital stock in 1995, 2000, and 2001, respectively, the nominal rate of return on non-residential capital would be some 20% higher.

Figure 3. Average real rates of return on total net capital stock in selected transition countries, 1995-2000



Source: own estimates

Combining the nominal rate of return on the total capital stock in the economy for 1995-2000 with a depreciation rate for each asset and the rate of inflation in the price of each asset type (total user costs for each type of assets) yields a total gross rate of return on each asset type, which – when multiplied by the nominal stock of each type of assets – returns the capital services of each type of capital (three types of ICT assets and non-ICT capital).

Finally, by dividing the capital services by GDP, one obtains income shares of each type of capital in the total income. However, before it is done, one needs to measure the share of labor and capital compensation in total income. Since there is no internationally comparable data on the share of labor compensation in total income for the eight transition countries in the study, one needs to resort to data from the national accounts of each of the countries. However, due to continued revisions of data related to changing methodologies and a relatively large size of the so-called "grey economy", which mostly escapes registration in the national statistics, the reliability of the national accounts data on the total labor compensation is not likely to be high[27].

Nonetheless, for the lack of an alternative, the study relies on the national statistics. The share of total labor compensation in GDP in the eight transition countries has been calculated as a sum of labor compensation and 60% of the net mixed income, which reflects the labor compensation received by the self-employed (the other 40% represents the capital share). Slovenia reports the highest average share of labor compensation in total income between 1995 and 2000, followed by Poland and the Czech Republic (Table 11). The labor compensation is particularly low in Bulgaria, Romania, Russia and Hungary. This seems to reflect the relatively largest size of the "grey economy" in the first three countries and methodological issues in the case of Hungary.

27 In principle, the labor compensation should include all costs related to employment: direct wages and salaries, social security payments, pension schemes, health insurance, any taxes paid and subsidies received related to employment, and other additional benefits (free housing, free education for children etc.). Anecdotal evidence suggests that most statistical offices in the region, due to a lack of sufficient technical expertise and funding for labor surveys, have failed to account for the full value of labor compensation. This particularly applies to the compensation of the self-employed, which quite often remains partly unregistered.

Table 11 around here

However, due to relatively low reliability of the data from the national accounts on total labor compensation, the next section of the paper will report the results of a sensitivity analysis on the impact of changes in the share labor compensation (assumed 0.6 and 0.65 share) on the contribution of ICT capital to GDP and labor productivity for all countries in the sample.

In the end, the author arrived at income shares of each type of capital in the total income (Table 12).

Table 12 around here

Among the transition economies in the study, Czech Republic, Hungary, and Russia reported the highest income shares of ICT of 2.93, 2.88 and 2.68, respectively. Romania and Poland had the lowest shares of 0.77 and 1.60, respectively. The ICT shares in total income in all transition economies in the study were lower than the average for the EU (3.0) and the US (5.4) in the same period (van Ark et al. 2002). The difference in ICT income shares is even higher than reported here since van Ark (ibid.) data applies to non-residential capital only. The low ICT shares seem to mostly reflect much lower value of accumulated ICT capital stock in transition economies relative to the developed countries.[28]

4. The contribution of ICT investment to output growth and labor productivity

Having arrived at the estimates of the ICT capital stock and income share of ICT capital in the 1995-2000 period and on the basis of the methodology presented in Section 3, it is now possible to measure the contribution of ICT investment to GDP growth and labor productivity in that period for the eight transition countries.

Between 1995 and 2000 ICT capital has most potently contributed to output growth in the Czech Republic, Hungary, Poland, and Slovenia. The lowest contributions were reported by Russia and Romania (Table 13).

Table 13 around here

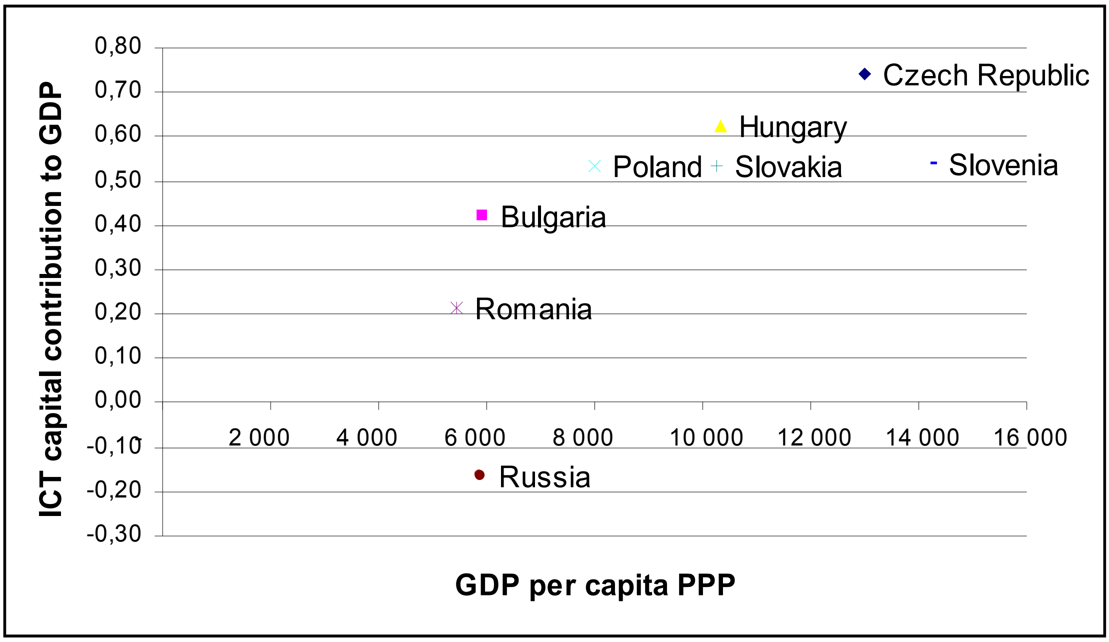
Except for the results for Poland, there are no studies on the contribution of ICT investment to output growth for the countries in this study, which could serve as a benchmark for a comparison of the results. The only option available is a comparison of the result of this study and previous estimates for Poland made by Piatkowski (2003a) (based on actual data from the national statistics), which shows that the contribution of ICT to output growth is closely comparable (0.54 in this study versus 0.47 in the other paper). However, the contribution of non-ICT capital to the output growth, and hence the TFP, is much different. In Piatkowski (ibid.), the non-ICT capital contribution to output amounts to 0.69 percentage points versus 2.55 in this study. Similarly, TFP contribution amounted to 3.93 versus 1.79 reported here. The difference seems to mostly stem from differences in the real growth rates of the net non-ICT capital stock. In this study, there are much higher than in Piatkowski (ibid.). This seems to be due to a different source of data for GFCF (values based on WDI 2003 are higher than those reported by the national statistics) and different approach to estimating the capital stock (vintage model, based on historical investment series, versus the initial stock model based on

28 Due to relatively low reliability of the data from the national accounts on total labor compensation, it seems appropriate to perform a sensitivity analysis. The impact of changes in the share labor compensation on the contribution of ICT capital to GDP and labor producitivity is reported in the next section.

data from the national statistics), which – in the case of the method used in this study - result in much lower estimate of the total non-ICT net capital stock.

GDP per capita (PPP) seems to be one of the strong determinants of the size of the ICT capital contribution to output growth for the countries in the study. There is a relatively strong correlation (0.70) between the GDP per capita in PPP terms and ICT capital contribution to GDP growth (Figure 4).

Figure 4. Correlation between GDP per capita (PPP) in USD and ICT capital contribution to output growth in selected transition economies



Source: WDI (2003) for GDP per capita (PPP) in USD, author's own for ICT capital. Note: GDP per capita (PPP) in USD and ICT capital contribution calculated as the 1995-2000 average.

There also seems to be a relatively strong correlation between the ICT capital contribution and the degree of advancement of structural reforms: in the least reformed countries in the group – Russia, Romania, and Bulgaria – the ICT capital has played the smallest role in growth.[29]

The ICT capital contributions to output growth in transition economies can be compared with the estimates for the OECD countries for the same period obtained by van Ark *et al.* (2002), whose study was largely based on actual data from national statistics, and Daveri (2002), who used the WITSA dataset for ICT spending, the same as in this study (Table 14).

Table 14 around here

The transition economies rank much higher than what would be their ranking based on their GDP per capita, which in 2002 hovered between 20% (Russia) and 70% (Slovenia) of the EU average.[30] The relatively high contribution of ICT capital to output growth for the countries in study, in spite of lower ICT income shares than in the EU countries, is mostly due to

29 More research on the determinants of investment in ICT is needed. Piatkowski (2002) provides a start with an analysis of the economic and institutional determinants of the absorption and diffusion of ICT in postsocialist countries. Also refer to Piatkowski (2003b), Kolodko, Piatkowski (2002) and Kolodko (2002).

extraordinarily high real growth rates in ICT investment in 1995-2000, which – as shown in Table 6 – averaged more than 20% a year for almost all countries.

The high growth rates in ICT investment were stimulated by (i) rapidly falling prices of ICT capital, which encouraged ICT users to massively substitute investment in ICT capital for non-ICT capital, and (ii) – a feature unique to the postsocialist countries - an opportunity to reap extraordinary rates of return on investments in ICT due to substantial pent-up demand for ICT products and services resulting from initial low level of penetration of IT and telecommunications infrastructure, a legacy of underinvestment and technological retardation under the socialist system.

The contribution of ICT capital to labor productivity growth was also quite high (Table 15). Czech Republic, Hungary, and Poland recorded the highest contributions in absolute terms. Russia and Romania reported the lowest contributions.

Table 15 around here

In relative terms (in per cent), ICT investment had a largest impact on labor productivity growth in Bulgaria (34.4%), Czech Republic (27.9%), and Hungary (22.4%), which was a higher average than in the EU and the US, which amounted to 17% and 20%, respectively (van Ark *et al*. 2002). Russia and Romania again reported the lowest contribution of -11.3% and 7.0%, respectively.

Slovakia, Poland, and Slovenia reported the highest average growth rates of labor productivity between 1995 and 2000. The increase in labor productivity in these countries was mostly driven by the growth in TFP. Quite surprisingly, however, Russia also reported a high growth rate in TFP of 1.81 %-points on average in the same period. This was higher than in Hungary, Czech Republic and the remaining countries. It seems then that the TFP growth is much less strongly correlated with the extent of the progress in market reforms than the ICT contribution to output growth. Capital deepening has had the largest impact on labor productivity in the Czech Republic, Romania, Poland, and Bulgaria.

If one assumed two different ratios of total labor compensation for all countries in the study (0.60 and 0.70), the average contribution of ICT capital to output and labor productivity growth in the countries in the sample would have changed by some 6% and 15% on average for the 60% and 70% labor share, respectively (Table 16 and 17). Bulgaria, Hungary, and Romania would have recorded the largest changes. However, even for the 70% labor compensation share, the contributions of ICT capital to output and labor productivity growth in most countries in the study are still higher than for Portugal and Spain, the EU two countries with the lowest ICT contributions to output growth.

30 As said earlier, due to unavailability of data on the share of residential dwellings in overall GFCF, the results of the study are not directly comparable with the van Ark et al. (2002) study, which is for the non-residential capital only. Given that in 1995, 2000, and 2001 in Poland the residential dwellings represented roughly 20% of the total gross fixed capital stock, and under the assumption that this ratio was valid for the whole 1960-2000 period, the contribution of ICT capital to growth in Poland for non-residential capital only between 1995 and 2000 would increase by 0.06 percentage points to 0.60, up from 0.54 reported in this study.

5. Conclusion

This paper makes the first attempt at estimating the contribution of ICT capital to output growth and labor productivity in eight postsocialist economies – Bulgaria, Czech Republic, Hungary, Poland, Romania, Russia, Slovakia and Slovenia – between 1995 and 2000. The methodology is based on an extended growth accounting framework and private-source data on ICT spending from WITSA (2000, 2002).

The paper shows that the contribution of investment in IT hardware, software and telecommunication equipment to output growth and labor productivity between 1995 and 2000 in most countries featured in the study was much higher than what might be expected on the basis of the level of their GDP per capita. This may suggest that the transition economies – through the use of ICT - are benefiting from the technological leapfrogging to increase the growth rates in output and labor productivity and thus accelerate the process of catching-up.

The relatively large contribution of ICT capital to output growth and labor productivity is based on an extraordinary increase in real ICT investments, which were growing between 1995 and 2000 at an average rate of more than 20% a year for almost all countries in the study. Large investments in ICT seem to have been induced by (i) falling prices of ICT products and services, which encouraged companies to substitute ICT for non-ICT capital and (ii) an opportunity for higher-than-normal returns on ICT investments due a large pent-up demand for ICT infrastructure, which was a legacy of decapitalization and technological gap existing before 1989 under the socialist economic system.

Given a relatively small size of ICT-producing sectors in most transition countries (with possible exceptions of Hungary and Czech Republic), the contribution of the ICT sector to output growth and productivity is not likely to be significant. Likewise, the contribution of TFP growth in ICT-producing industry to economy-wide TFP is likely to be marginal. As for the spillover effects of ICT use and production, given small size of the ICT producing sector and relatively low penetration of ICT networks, any potential economic effects are not likely to be significant. Hence, the overall impact of ICT on output growth and labor productivity in transition countries seems to be predominantly dependent on the use of ICT, whose aggregate impact is presented in this paper.

One can speculate that given a very likely continuation of growth in ICT investment above the growth rates for non-ICT capital, the contribution of ICT capital to growth is likely to gradually increase. Future research should focus on measuring the industry-level impact of the use of ICT in transition economies and on analyzing the determinants of absorption and diffusion of ICT.

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_______ (2000) “Digital Planet 2000: The Global Information Economy”. Vienna, World Information Technology and Services Alliance.

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Table 1. ICT spending in eight transition countries 1993-2001, as % of GDP

Country	1993	1994	1995	1996	1997	1998	1999	2000	2001
Bulgaria	2.23	2.88	2.32	2.71	2.97	3.11	3.60	4.12	4.17
Czech Republic	5.56	5.34	5.95	5.80	6.44	6.56	7.85	9.10	8.73
Hungary	4.17	4.32	3.88	4.28	4.46	7.50	8.23	8.93	10.02
Poland	2.06	2.08	2.16	2.28	2.57	4.59	5.43	6.06	5.95
Romania	1.07	1.09	0.93	1.03	1.28	1.39	2.09	2.32	2.41
Russia	4.01	3.18	1.83	1.71	1.97	2.66	4.11	3.52	3.20
Slovakia	4.23	4.18	4.04	4.02	3.89	5.55	6.78	8.12	8.78
Slovenia	3.02	3.03	2.92	3.08	3.39	3.72	4.42	5.26	4.72
Average*	**4.45**	**4.45**	**4.46**	**4.69**	**4.98**	**5.64**	**6.22**	**6.81**	**7.27**

Source: WITSA (2002). * Average for all 51 countries surveyed.

Table 2. Definitions of ICT investment: Slovenian Statistical Office and WITSA (2002)

	Slovenian Statistical Office	WITSA
IT hardware	Computers and other equipment for automatic data processing (computers, printers); other office equipment (typewriters, photocopiers, similar eq.); electronic cash registers, scales and scaners; ATM's and similar; CPA 30 - Classification of products by activity for EU.	servers, personal computers, workstations, data communication equipment and add-ons purchased by a corporation, household, school or government agency from an external agent or corporation. Office equipment: Typewriters, calculators, copiers, and other office equipment (duplicating equipment, cash registers, point-of-sale systems, etc.)
Software	Software: software bought and developed by firms themselves	IT software: includes the purchase of all software products and external customization of computer programs. Excludes expenses related to the internal (e.g. wages, rent) customization of computer programs. Includes systems software and utilities, application tools, and application solutions.
Telecommunications	Radio, TV and communication equipment (TV and radio receivers and transmitters; telephones and telephone switching centres, faxes and similar; CPA 32	Telecommunications: brings together expenditures by businesses, household, government, and education on private and public network equipment and telecommunications services.

* Slovenian Statistical Office data relates to business and government sector only, while WITSA data comprises all sectors. Slovenian data excludes individual private entrepreneurs.

Table 3a. Investments in ICT in Bulgaria, 1992-2001 (current prices, USD million)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
IT hardware	118	92	109	109	79	80	102	108	114	126
Software	8	9	11	10	14	15	20	25	32	35
Telecom. equipment	25	29	33	41	38	47	57	70	75	78
Total	**151**	**130**	**153**	**159**	**131**	**142**	**179**	**204**	**221**	**239**

Source: own estimates based on WITSA (2000, 2002)

Table 3b. Investments in ICT in the Czech Republic, 1992-2001 (current prices, USD million)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
IT hardware	373	422	482	694	729	707	653	680	721	761
Software	97	105	128	176	197	229	255	281	380	437
Telecom. Equipment	154	178	202	374	387	398	493	612	648	669
Total	**624**	**705**	**812**	**1 245**	**1 313**	**1 334**	**1 402**	**1 573**	**1 749**	**1 867**

Source: own estimates based on WITSA (2000, 2002)

Table 3c. Investments in ICT in Hungary, 1992-2001 (current prices, USD million)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
IT hardware	352	441	497	395	436	469	514	541	547	562
Software	115	139	149	139	173	193	216	238	348	390
Telecom. equipment	146	168	191	212	218	220	608	699	754	806
Total	**613**	**748**	**837**	**746**	**828**	**881**	**1 338**	**1 477**	**1 650**	**1 758**

Source: own estimates based on WITSA (2000, 2002)

Table 3d. Investments in ICT in Poland, 1992-2001 (current prices, USD million)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
IT hardware	468	489	555	704	842	962	1 143	1 227	1 322	1 418
Software	96	104	127	138	216	275	322	371	536	613
Telecom. equipment	155	176	200	324	360	395	1 315	1 609	1 781	1 937
Total	**719**	**769**	**883**	**1 166**	**1 418**	**1 632**	**2 780**	**3 207**	**3 639**	**3 969**

Source: own estimates based on WITSA (2000, 2002)

Table 3e. Investments in ICT in Romania, 1992-2001 (current prices, USD million)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
IT hardware	100	104	124	102	121	128	150	153	168	191
Software	7	8	10	9	15	21	28	36	45	55
Telecom. equipment	28	32	36	45	45	64	91	130	147	162
Total	**135**	**144**	**171**	**156**	**181**	**214**	**270**	**320**	**359**	**408**

Source: own estimates based on WITSA (2000, 2002)

Table 3f. Investments in ICT in Russia, 1992-2001 (current prices, USD million)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
IT hardware	2 172	2 268	2 754	1 686	1 947	2 500	1 644	1 617	1 856	2 027
Software	286	308	377	209	233	271	214	181	447	516
Telecom. equipment	730	844	958	741	890	983	1 085	1 199	1 313	1 395
Total	**3 187**	**3 420**	**4 090**	**2 636**	**3 069**	**3 754**	**2 943**	**2 997**	**3 616**	**3 938**

Source: own estimates based on WITSA (2000, 2002)

Table 3g. Investments in ICT in Slovakia, 1992-2001 (current prices, USD million)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
IT hardware	144	148	168	193	234	212	170	174	201	217
Software	32	35	42	49	55	66	79	88	107	122
Telecom. equipment	46	53	60	90	88	91	201	234	284	320
Total	**222**	**235**	**271**	**331**	**377**	**370**	**449**	**496**	**592**	**659**

Source: own estimates based on WITSA (2000, 2002)

Table 3h. Investments in ICT in Slovenia, 1992-2001 (current prices, USD million)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
IT hardware	125	128	146	167	177	176	186	212	208	213
Software	28	30	37	43	52	57	64	71	78	85
Telecom. equipment	35	40	45	71	74	81	101	131	147	152
Total	**187**	**198**	**228**	**282**	**303**	**315**	**351**	**414**	**433**	**450**

Source: own estimates based on WITSA (2000, 2002)

Table 4. ICT investment as a share of GFCF, 1992-2001, in current prices

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	AVG
Bulgaria	0,11	0,09	0,11	0,08	0,10	0,12	0,11	0,10	0,11	0,10	0,10
Czech Rep.	0,08	0,07	0,07	0,07	0,07	0,08	0,08	0,10	0,12	0,12	0,09
Hungary	0,08	0,10	0,10	0,08	0,09	0,09	0,12	0,13	0,15	0,14	0,11
Poland	0,05	0,06	0,05	0,05	0,05	0,05	0,07	0,08	0,09	0,10	0,06
Romania	0,04	0,03	0,03	0,02	0,02	0,03	0,04	0,05	0,05	0,05	0,03
Russia	0,14	0,10	0,07	0,04	0,03	0,05	0,06	0,10	0,08	0,07	0,07
Slovakia	0,06	0,06	0,07	0,07	0,06	0,05	0,06	0,08	0,10	0,10	0,07
Slovenia	0,08	0,08	0,08	0,07	0,07	0,07	0,07	0,08	0,09	n.a.	0,08

Source: own estimates based on WITSA (2000, 2002)

Table 5a. Inflation in prices of ICT (quality-adjusted) and non-ICT investment in Bulgaria, 1990-2000, based on 1996 fixed prices

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	AVG
IT hardware	19,8%	102,1%	16,0%	17,2%	45,3%	25,5%	49,8%	201,5%	-21,2%	-27,9%	-17,1%	35,1%
Software	29,9%	114,4%	27,7%	35,0%	55,7%	44,4%	75,5%	226,5%	8,8%	2,0%	0,9%	59,7%
Telecom. equipment	29,9%	112,7%	32,5%	33,6%	55,5%	41,0%	75,5%	227,6%	7,2%	-4,1%	-6,0%	56,9%
Non-ICT	34,1%	115,9%	35,5%	36,5%	61,4%	46,9%	81,3%	231,7%	12,1%	2,0%	1,2%	62,5%

Source: own estimates based on ICT deflators for the US available from Jorgenson et al. (2002) and national accounts data.

Table 5b. Inflation in prices of ICT (quality-adjusted) and non-ICT investment in Czech Republic, 1990-2000, based on 1996 fixed prices

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	AVG
IT hardware	2,6%	31,8%	-9,0%	-1,8%	-5,7%	-13,2%	-27,0%	-24,5%	-30,0%	-30,3%	-17,4%	-23,7%
Software	12,7%	44,0%	2,8%	16,0%	4,7%	5,7%	-1,2%	0,4%	0,0%	-0,4%	0,5%	0,8%
Telecom. equipment	12,7%	42,4%	7,6%	14,6%	4,6%	2,3%	-1,3%	1,6%	-1,6%	-6,4%	-6,3%	-2,0%
Non-ICT	16,9%	45,6%	10,6%	17,5%	10,4%	8,2%	4,5%	5,7%	3,3%	-0,3%	0,9%	3,7%

Source: own estimates based on ICT deflators for the US available from Jorgenson et al. (2002) and national accounts data.

Table 5c. Inflation in prices of ICT (quality-adjusted) and non-ICT investment in Hungary, 1990-2000, based on 1996 fixed prices

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	AVG
IT hardware	0,8%	23,4%	-5,7%	-7,7%	-0,8%	7,7%	-10,9%	-13,7%	-23,0%	-19,9%	-7,8%	-11,3%
Software	11,0%	35,7%	6,1%	10,1%	9,6%	26,6%	14,9%	11,2%	7,0%	10,0%	10,2%	13,3%
Telecom. equipment	10,9%	34,0%	10,8%	8,7%	9,5%	23,3%	14,8%	12,3%	5,4%	4,0%	3,4%	10,5%
Non-ICT	15,1%	37,2%	13,8%	11,6%	15,3%	29,2%	20,6%	16,4%	10,3%	10,1%	10,5%	16,2%

Source: own estimates based on ICT deflators for the US available from Jorgenson et al. (2002) and national accounts data.

Table 5d. Inflation in prices of ICT (quality-adjusted) and non-ICT investment in Poland, 1990-2000, based on 1996 fixed prices

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	AVG
IT hardware	175,4%	20,0%	-1,7%	2,7%	24,0%	-1,6%	-15,8%	-17,7%	-23,8%	-24,7%	-12,6%	-16,0%
Software	185,5%	32,3%	10,1%	20,5%	34,5%	17,3%	10,0%	7,2%	6,2%	5,2%	5,4%	8,6%
Telecom. equipment	185,5%	30,6%	14,9%	19,1%	34,3%	14,0%	9,9%	8,4%	4,6%	-0,8%	-1,4%	5,8%
Non-ICT	189,7%	33,9%	17,9%	22,0%	40,2%	19,9%	15,7%	12,5%	9,5%	5,3%	5,7%	11,4%

Source: own estimates based on ICT deflators for the US available from Jorgenson et al. (2002) and national accounts data.

Table 5e. Changes in real prices of ICT (quality-adjusted) and non-ICT investment in Romania, 1990-2000, based on 1996 fixed prices

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	AVG
IT hardware	86,6%	86,6%	99,5%	85,7%	68,6%	14,3%	11,2%	44,3%	-3,3%	10,3%	22,1%	16,5%
Software	98,9%	98,9%	111,2%	103,5%	79,0%	33,1%	37,0%	69,2%	26,6%	40,2%	40,1%	41,0%
Telecom. equipment	97,2%	97,2%	116,0%	102,2%	78,9%	29,8%	37,0%	70,3%	25,0%	34,1%	33,2%	38,2%
Non-ICT	100,4%	100,4%	119,0%	105,1%	84,8%	35,7%	42,8%	74,4%	29,9%	40,2%	40,4%	43,9%

Source: own estimates based on ICT deflators for the US available from Jorgenson et al. (2002) and national accounts data.

Table 5f. Changes in real prices of ICT (quality-adjusted) and non-ICT investment in Russia, 1990-2000, based on 1996 fixed prices

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	AVG
IT hardware	-12,8%	59,5%	297,8%	214,4%	147,7%	76,4%	22,5%	-18,3%	-20,8%	12,5%	18,3%	15,1%
Software	-2,7%	71,8%	309,6%	232,2%	158,2%	95,3%	48,3%	6,6%	9,2%	42,4%	36,3%	39,7%
Telecom. equipment	-2,7%	70,1%	314,4%	230,9%	158,0%	91,9%	48,2%	7,8%	7,6%	36,3%	29,4%	36,9%
Non-ICT	1,5%	73,4%	317,4%	233,8%	163,9%	97,9%	54,1%	11,9%	12,5%	42,4%	36,6%	42,6%

Source: own estimates based on ICT deflators for the US available from Jorgenson et al. (2002) and national accounts data.

Table 5g. Changes in real prices of ICT (quality-adjusted) and non-ICT investment in Slovakia, 1990-2000, based on 1996 fixed prices

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	AVG
IT hardware	-8,6%	19,1%	2,7%	-1,6%	-9,0%	-13,1%	-23,3%	-25,7%	-29,2%	-20,0%	-13,8%	-20,8%
Software	1,5%	31,4%	14,5%	16,2%	1,4%	5,8%	2,5%	-0,8%	0,8%	9,9%	4,2%	3,7%
Telecommunications equipment	1,5%	29,7%	19,3%	14,9%	1,2%	2,4%	2,4%	0,3%	-0,8%	3,8%	-2,6%	0,9%
Non-ICT	5,7%	33,0%	22,3%	17,8%	7,1%	8,4%	8,2%	4,4%	4,1%	9,9%	4,5%	6,6%

Source: own estimates based on ICT deflators for the US available from Jorgenson et al. (2002) and national accounts data.

Table 5h. Changes in real prices of ICT (quality-adjusted) and non-ICT investment in Slovenia, 1990-2000, based on 1996 fixed prices

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	AVG
IT hardware	57,3%	110,6%	89,9%	7,1%	2,4%	-11,2%	-20,6%	-24,1%	-28,4%	-25,1%	-9,3%	-19,8%
Software	67,4%	122,9%	101,7%	24,9%	12,8%	7,7%	5,2%	0,8%	1,6%	4,8%	8,7%	4,8%
Telecom. equipment	67,4%	121,2%	106,5%	23,5%	12,7%	4,3%	5,1%	2,0%	0,0%	-1,3%	1,8%	2,0%
Non-ICT	71,6%	124,4%	109,5%	26,4%	18,5%	10,3%	10,9%	6,1%	4,9%	4,8%	9,0%	7,7%

Source: own estimates based on ICT deflators for the US available from Jorgenson et al. (2002) and national accounts data.

Table 6. Real growth rates in ICT investment, 1992-2000

	1992	1993	1994	1995	1996	1997	1998	1999	2000	**AVG 95-00**
Bulgaria	11%	-17%	34%	-5%	19%	21%	39%	35%	35%	**24%**
Czech Republic	10%	8%	13%	40%	22%	31%	23%	36%	32%	**31%**
Hungary	17%	32%	20%	-8%	28%	29%	60%	27%	27%	**27%**
Poland	34%	25%	9%	27%	36%	42%	64%	39%	25%	**39%**
Romania	47%	6%	22%	-6%	35%	47%	37%	48%	19%	**30%**
Russia	68%	-54%	-56%	-53%	-6%	43%	36%	74%	8%	**17%**
Slovakia	-1%	9%	22%	19%	28%	23%	33%	32%	36%	**28%**
Slovenia	22%	25%	20%	17%	30%	34%	32%	41%	27%	**30%**

Source: own estimates based on WITSA (2000, 2002)

Table 7. Share of net ICT real capital stock in total net mid-year capital stock in selected transition countries, 1995-2000 (1996 base year), in %

	Bulgaria	Czech Rep.	Hungary	Poland	Romania	Russia	Slovakia	Slovenia
1995	1,64	2,29	2,12	1,11	0,48	2,65	1,55	1,51
1996	1,88	2,66	2,38	1,36	0,56	2,37	1,81	1,82
1997	2,24	3,15	2,80	1,72	0,71	2,22	2,11	2,28
1998	2,77	3,80	3,64	2,42	0,96	2,22	2,50	2,89
1999	3,59	4,72	4,94	3,51	1,38	2,53	3,13	3,76
2000	4,76	6,05	6,49	4,80	1,92	3,05	4,11	4,88
AVG	**2,81**	**3,78**	**3,73**	**2,49**	**1,00**	**2,50**	**2,53**	**2,86**

Source: own estimates

Table 8. Share of GCF (a), GFCF (f), and inventory and reserves (c) in GDP in selected socialist countries, 1960-1985, in %

Country	1960			1970			1975			1980			1985		
	a	b	c	A	B	c	a	b	c	a	b	c	a	b	c
Bulgaria	27,4	14,4	13,0	29,2	18,6	10,6	32,5	17,8	14,6	24,9	15,2	9,7	…	…	…
Czechoslovakia	17,7	11,7	6,0	27,0	16,7	10,3	29,2	20,1	9,1	26,2	16,1	10,1	20,2	17,5	2,7
Hungary	20,5	13,8	6,7	24,9	23,9	1,0	27,7	23,5	4,2	20,1	17,5	2,6	17,6	12,8	4,8
Poland	24,0	16,8	7,1	25,1	19,1	6,0	34,1	27,1	7,0	19,0	16,7	2,3	31,7	24,3	7,4
Romania	20,1	…	…	27,9	…	…	35,4	…	…	…	…	…	…	…	…
USSR	26,8	…	…	29,5	17,9	11,6	26,6	…	…	23,9	16,9	7,0	26,5	…	…
US	17,6	16,9	0,7	16,4	16,3	0,1	15,2	16,2	-0,1	18,8	17,0	0,7	19,2	18,6	0,6
West Germany	27,8	25,0	2,8	28,1	26,5	1,6	20,8	21,1	-0,3	24,8	22,7	2,1	19,9	19,5	0,4
Japan	33,6	29,9	3,7	39,5	39,6	4,9	32,3	30,8	1,5	33,0	32,0	1,0	28,2	27,5	0,7

Source: Glikman et al. (1997) based on international statistics handbooks of the Polish Statistical Office.

Table 9. Total net capital stock for selected transition economies, in 1996 fixed prices, mid-year, in million LCY

	1995	1996	1997	1998	1999	2000
Bulgaria	4 490	4 424	4 306	4 204	4 170	4 189
Czech Rep.	2 937 030	3 198 469	3 451 965	3 680 904	3 891 836	4 097 410
Hungary	13 978 564	14 359 324	14 825 788	15 432 211	16 130 488	16 854 249
Poland	581 061	611 256	654 525	710 217	772 477	835 477
Romania	237 997 824	244 475 787	251 356 712	257 181 534	261 233 079	264 931 931
Russia	9 028 338	8 859 915	8 636 841	8 393 553	8 149 084	7 961 996
Slovakia	1 474 970	1 543 748	1 645 864	1 767 634	1 869 248	1 940 708
Slovenia	4 874 645	5 062 162	5 292 627	5 575 617	5 942 151	6 350 455

Source: own estimates

Table 10. Average nominal rates of return on total net capital stock in selected transition countries, 1995-2000

	1995	1996	1997	1998	1999	2000	AVG
Bulgaria	0,77	1,44	9,31	0,34	0,25	0,31	0,81
Czech Rep.	0,22	0,18	0,19	0,17	0,13	0,14	0,17
Hungary	0,49	0,38	0,34	0,28	0,28	0,29	0,34
Poland	0,41	0,37	0,35	0,31	0,27	0,26	0,32
Romania	0,59	0,68	1,29	0,53	0,67	0,63	0,69
Russia	1,69	0,73	0,15	0,16	0,57	0,50	0,45
Slovakia	0,21	0,20	0,16	0,15	0,21	0,15	0,18
Slovenia	0,23	0,25	0,21	0,21	0,21	0,24	0,22

Source: own estimates

Table 11. Share of total labor compensation in GDP in selected transition countries, 1995-2000

	Bulgaria	Czech Rep.	Hungary	Poland	Romania	Russia	Slovakia	Slovenia
1995	0,53	0,56	0,53	0,56	0,50	0,51	0,51	0,63
1996	0,44	0,56	0,51	0,56	0,51	0,56	0,52	0,60
1997	0,46	0,55	0,51	0,54	0,45	0,56	0,53	0,59
1998	0,49	0,53	0,50	0,55	0,49	0,53	0,53	0,57
1999	0,47	0,53	0,49	0,53	0,50	0,47	0,52	0,57
2000	0,41	0,53	0,49	0,54	0,56	0,46	0,52	0,57
AVG	0,47	0,54	0,51	0,55	0,50	0,51	0,52	0,58

Source: own estimates

Table 12. Average shares of ICT capital, non-ICT capital and total capital compensation in GDP in selected transition countres, EU, and USA, 1995-2000, in per cent

	Total capital	Non-ICT	**ICT Total**	IT hardware	Software	Telecom equipment
Bulgaria	53,36	51,18	**2,19**	1,35	0,19	0,65
Czech Rep.	45,71	42,78	**2,93**	1,59	0,47	0,87
Hungary	49,42	46,54	**2,88**	1,44	0,54	0,91
Poland	45,34	43,74	**1,60**	0,87	0,22	0,52
Romania	49,88	49,10	**0,77**	0,49	0,06	0,22
Russia	48,55	45,87	**2,68**	1,40	0,20	1,08
Slovakia	47,86	45,61	**2,25**	1,26	0,36	0,63
Slovenia	41,19	39,22	**1,96**	1,17	0,33	0,47
EU	33,8	30,8	**3,0**	1,0	1,0	1,0
USA	31,3	25,9	**5,4**	1,8	1,8	1,8

Source: own estimates for all countries except the EU and the US, which is based on van Ark *et al*. (2002), for non-residential capital only.

Table 13: ICT capital contribution to output growth in selected transition economies, 1995-2000 average, in %-points

	GDP change	Total capital	Non-ICT	**ICT Total**	*IT Hardware*	*Software*	*Telecom. Equipment*	Labor	TFP
Bulgaria	-0,07	-0,01	-0,43	**0,42**	*0,29*	*0,03*	*0,10*	-0,61	0,55
Czech Rep.	2,11	3,23	2,49	**0,74**	*0,49*	*0,08*	*0,17*	-0,36	-0,76
Hungary	3,62	1,77	1,15	**0,63**	*0,39*	*0,06*	*0,17*	0,19	1,59
Poland	5,15	3,09	2,55	**0,54**	*0,32*	*0,05*	*0,17*	0,28	1,79
Romania	0,04	1,14	0,92	**0,22**	*0,15*	*0,02*	*0,05*	-1,81	0,71
Russia	0,48	-1,30	-1,14	**-0,16**	*-0,07*	*-0,04*	*-0,05*	-0,25	2,02
Slovakia	4,24	2,56	2,03	**0,53**	*0,33*	*0,05*	*0,15*	-0,44	2,12
Slovenia	4,33	2,11	1,57	**0,54**	*0,38*	*0,05*	*0,10*	0,18	2,04

Source: own estimates

Table 14. ICT capital contribution to output growth in the OECD and selected transition countries, 1995-2000 average, in %-points

	Van Ark et al. 2002 and this study	Ranking		Daveri 2002 and this study	Ranking
USA	0,86	1	USA	1,45	1
Ireland	0,8	2	UK	1,17	2
Czech Rep.	**0,74**	3	Ireland	0,96	3
UK	0,69	4	Sweden	0,85	4
Netherlands	0,68	5	**Czech Rep.**	**0,74**	5
Hungary	**0,63**	6	Finland	0,74	6
Denmark	0,61	7	Netherlands	0,72	7
Poland	**0,54**	8	Denmark	0,65	8
Slovenia	**0,54**	9	**Hungary**	**0,63**	9
Slovakia	**0,53**	10	**Poland**	**0,54**	10
Sweden	0,53	11	**Slovenia**	**0,54**	11
Bulgaria	**0,42**	12	**Slovakia**	**0,53**	12
Italy	0,41	13	Portugal	0,49	13
Finland	0,37	14	Germany	0,45	14
Germany	0,37	15	France	0,44	15
Austria	0,36	16	Austria	0,43	16
France	0,35	17	**Bulgaria**	**0,42**	17
Portugal	0,34	18	Italy	0,35	18
Spain	0,27	19	Spain	0,34	19
Romania	**0,22**	20	**Romania**	**0,22**	20
Russia	**-0,16**	21	**Russia**	**-0,16**	21

Source: van Ark *et al*. (2002), Daveri (2002) and own estimates for the transition economies (in bold). Note: Van Ark *et al.* (2002) for non-residential capital only.

Table 15. ICT investment contribution to labor productivity (LP) growth in selected transition countries, average for 1995-2000, in %-points

	Change in LP	Total capital	% in total	Non-ICT	**ICT Total**	**% in total change of LP**	IT Hardware	Software	Telecom. Equipment	TFP
	AVG 95-00									
Bulgaria	**1,34**	0,79	59,11%	0,33	**0,46**	**34,4%**	0,30	0,04	0,12	0,55
Czech Rep.	**2,80**	3,57	127,21%	2,78	**0,78**	**27,9%**	0,50	0,09	0,20	-0,76
Hungary	**3,24**	1,65	50,99%	0,93	**0,72**	**22,4%**	0,40	0,07	0,25	1,59
Poland	**4,74**	2,96	62,36%	2,36	**0,60**	**12,6%**	0,33	0,05	0,22	1,79
Romania	**3,66**	2,96	80,72%	2,70	**0,26**	**7,0%**	0,17	0,02	0,07	0,71
Russia	**0,95**	-1,08	-113,63%	-0,97	**-0,11**	**-11,3%**	-0,04	-0,03	-0,04	2,02
Slovakia	**5,08**	2,96	58,34%	2,40	**0,57**	**11,2%**	0,33	0,06	0,18	2,12
Slovenia	**4,04**	2,00	49,50%	1,45	**0,55**	**13,7%**	0,38	0,06	0,12	2,04

Source: own estimates. Note: labor productivity based on total employment (working hours not available).

Table 16. Sensitivity analysis: ICT capital contribution to output growth for various total labor compensation shares, in %-points

	Actual data	60% labor share	Change	in %	70% labor share	Change	in %
Bulgaria	0,42	0,37	-0,05	-12,0%	0,33	-0,09	-21,5%
Czech Rep.	0,74	0,71	-0,03	-4,5%	0,64	-0,10	-13,9%
Hungary	0,63	0,57	-0,06	-8,8%	0,51	-0,12	-18,4%
Poland	0,54	0,50	-0,04	-6,6%	0,44	-0,10	-17,8%
Romania	0,22	0,20	-0,02	-7,4%	0,18	-0,04	-16,7%
Russia	-0,16	-0,16	0,00	-2,8%	-0,15	0,01	-8,9%
Slovakia	0,53	0,50	-0,03	-6,5%	0,45	-0,08	-15,9%
Slovenia	0,54	0,53	-0,01	-1,4%	0,48	-0,06	-10,7%
AVG				**-6,3%**			**-15,5%**

Source: own estimates

Table 17. Sensitivity analysis: ICT capital contribution to labor productivity growth for various total labor compensation shares, in %-points

	Actual data	60% labor share	Change	in %	70% labor share	Change	in %
Bulgaria	0,46	0,40	-0,06	-12,8%	0,35	-0,11	-23,7%
Czech Rep.	0,78	0,74	-0,04	-5,5%	0,67	-0,11	-14,5%
Hungary	0,72	0,65	-0,07	-10,3%	0,58	-0,14	-20,0%
Poland	0,60	0,56	-0,04	-6,7%	0,49	-0,11	-18,3%
Romania	0,26	0,24	-0,02	-7,0%	0,21	-0,05	-18,7%
Russia	-0,11	-0,11	0,00	2,9%	-0,10	0,01	-6,5%
Slovakia	0,57	0,53	-0,04	-6,5%	0,48	-0,09	-15,3%
Slovenia	0,55	0,54	-0,01	-2,4%	0,49	-0,06	-11,4%
AVG				**-6,0%**			**-16,0%**

Source: own estimates

APPENDIX 2

Table 18. Explanation to sources of data and assumptions

Country	USD/LCY exchange rate	Investment shares in ICT spending 1992-2001	GFCF	Labor compensation
Bulgaria	1989-94 from EBRD (1995); 1995-2000 from EBRD (2002); 1985-1988 assumed to equal 1989.	IT hardware: 85.0% software: 120%, telecom. equipment – 30%.	1980-2001 from WDI (2003); 1960-1979 based on (Kolodko 2000) for GDP NMP growth rates and Glikman et al. 1997 for the share of GFCF in GDP 1960, 1970, 1975.	1994-2001: Bulgarian Statistical Office – various yearbooks.
Czech Rep.	1989-94 from EBRD (1995); 1995-2000 from EBRD (2002); 1985-1988 from PWT 6.1	IT hardware: 86.1% software: 120%, telecom. equipment – 30%.	1990-2001 from WDI (2003); 1960-1989 based on (Kolodko 2000) for GDP NMP growth rates and Glikman et al. 1997 for the share of GFCF in GDP 1960, 1970, 1975, 1980, 1985.	1996-2001: Czech Statistical Office – various yearbooks. 1994 and 1995 assumed to equal 1996
Hungary	1989-94 from EBRD (1995); 1995-2000 from EBRD (2002); 1985-1988 from PWT 6.1	IT hardware: 89.6% software: 120%, telecom. equipment – 30%.	1960-2001 from WDI (2003)	1994-2001: Hungarian Statistical Office – various yearbooks
Poland	1989-94 from EBRD (1995); 1995-2000 from EBRD (2002); 1985-1988 from PWT 6.1	IT hardware: 79.9% software: 120%, telecom. equipment – 30%.	1985-2001 from WDI (2003); 1960-1984 based on (Kolodko 2000) for GDP NMP growth rates and Glikman et al. 1997 for the share of GFCF in GDP in 1960, 1970, 1975, 1980, 1985.	1994-2001: Polish Statistical Office – various yearbooks
Romania	1989-94 from EBRD (1995); 1995-2000 from EBRD (2002); 1985-1988 from PWT 6.1	IT hardware: 85.0% software: 120%, telecom. equipment – 30%.	1990-2001 from WDI (2003); 1960-1984 based on (Kolodko 2000) for GDP NMP growth rates and Glikman et al. 1997 for the share of GFCF in GDP: for 1960, 1970, 1975 GCF minus 30%. 1980, 1985 assumed to equal GCF in 1975 minus 30%.	1994-2001: Romanian Statistical Office – various yearbooks. Net mixed income of self-employed in and outside of agriculture. 1995 and 1997: average of 1994-96 and 1996-98, respectively.

Russia	1994-2000 from EBRD (1995) and (2002); 1985-1990 assumed to equal 1991 from PWT 6.1.	IT hardware: 79.8% software: 120%, telecom. equipment – 30%.	1989-2001 from WDI (2003); 1960-1988 based on (Kolodko 2000) for GDP NMP growth rates and Glikman et al. 1997 for the share of GFCF in GDP 1970, 1980. For 1960, 1975, 1985: GCF minus 30%.	1994-2001: Russian Statistical Office - various yearbooks. For the lack of detailed data on the net mixed income, it is assumed – based on the average share of net mixed income in GDP in other countries in the sample – that in Russia between 1994-2000 the net mixed income represented 10% of GDP
Slovakia	1989-94 from EBRD (1995); 1995-2000 from EBRD (2002); 1987-1988 from PWT 6.1. 1986-1986 assumed to equal 1987.	IT hardware: 87.0% software: 120%, telecom. equipment – 30%.	1985-2001 from WDI (2003); 1960-1984 based on (Kolodko 2000) for GDP NMP growth rates and Glikman et al. 1997 for the share of GFCF in GDP in 1960, 1970, 1975, 1980, 1985.	1994-2001: Slovak Statistical Office for labor compensation – various yearbooks. Net mixed income not available. Labor share compensation for the self-employed assumed to amount to 50% of gross mixed income.
Slovenia	1989-94 from EBRD (1995); 1995-2000 from EBRD (2002); 1985-1988 assumed to equal 1989.	IT hardware: 85.0% software: 120%, telecom. equipment – 30%.	1991-2001 from WDI (2003); 1995-2000 revised according to new data from Slovenian Statistical Office; 1960-1990 based on NMP growth rates and share of GFCF in GDP for Yugoslavia, based on the Slovenian Statistical Office.	1994-2001: Slovenian Statistical Office – various yearbooks. 1994 assumed to equal 1990-1995 average. 2001 assumed to equal 2000.