Chapter 1.

Productivity growth, technology and structural reforms in transition economies: a two-phase convergence process

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1.1. Introduction

In 2004, 15 years after the Wall came down, Central and Eastern Europe entered a new phase.[1] The accession to the European Union of ten post-communist economies, including Bulgaria and Romania in 2007, marked the formal end of their transition from a socialist centrally planned to a market economy. Interestingly, the economic data also showed an important turnaround in 2004. Table 1.1 shows that labour productivity growth in most New Member States (NMS) of the European Union accelerated in 2004, and continued to grow fast in 2005 and 2006, way above the growth rate of both the old EU-15 and the US (but slightly lower than in Russia).[2]

Strikingly, the strong productivity growth since 2004 has not gone any longer at the expense of further cuts in employment, as the NMS had been experiencing until 2000.

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[1] This productivity numbers reported in section 4 of this paper are based on the EU KLEMS Growth and Productivity Accounts, which is a database based on research by the EU KLEMS consortium supported by the European Commission, Research Directorate General as part of the 6th Framework Programme, Priority 8, "Policy Support and Anticipating Scientific and Technological Needs" and is part of the "EU KLEMS project on Growth and Productivity in the European Union". We are grateful to Marek Raczko and Edwin Stuivenwold for their excellent research assistance.

[2] New Member States (NMS) refers to Central and Eastern European countries only, excluding Cyprus and Malta.

Table 1.1. Labour productivity growth, GDP per person employed (annual average, percent)

	1995-2000	2000-06	2003	2004	2005	2006
NMS	**3.9**	**4.0**	**3.9**	**4.9**	**3.1**	**4.0**
Bulgaria	1.1	3.1	-1.7	3.2	3.8	4.6
Czech Rep.	2.3	3.4	4.5	4.0	4.3	4.6
Estonia	8.0	6.9	5.3	7.8	8.1	7.2
Hungary	2.7	3.8	2.1	5.5	4.1	3.6
Latvia	5.8	6.5	5.2	7.2	8.2	7.9
Lithuania	5.7	6.5	7.6	7.1	4.8	5.7
Poland	5.7	3.3	4.9	3.9	1.0	2.2
Romania	0.6	6.3	5.2	7.9	3.8	6.8
Slovakia	4.4	3.9	2.3	5.4	4.7	3.8
Slovenia	4.7	3.1	2.9	3.9	3.6	3.9
Russia	2.2	5.2	6.6	5.8	5.4	n.a.
EU-15	**1.4**	**0.8**	**0.5**	**1.6**	**0.6**	**1.3**
EU-10	4.5	3.6	4.1	4.5	2.8	3.3
EU-12	3.9	4.0	3.8	4.8	3.1	4.0
EU-25	1.8	1.1	0.9	1.8	0.8	1.6
EU-27	1.9	1.2	0.9	1.9	0.8	1.6
Unites States	2.4	1.7	2.0	2.5	1.4	1.4

Notes: NMS – New Member States. For Russia – 2000-05 average. EU-15 – EU until 30 April 2004. EU-10 – member states that entered the EU on 1 May 2004. EU-12 – EU-10 with Bulgaria and Romania.
Source: The Conference Board / Groningen Growth and Development Center (GGDC) Total Economy database, based on OECD National Accounts, Economic Outlook and Labour Force Statistics.

Table 1.2 shows that labour input growth has turned positive in most NMS since 2004. Hence, the region now seems to have entered a new phase of economic expansion driven by greater efficiency and employment growth.

However, the end of the restructuring phase does not imply that the NMS have fully converged in productivity and per capita income terms with the old member states of the European Union and the U.S., as was mistakenly assumed by some scholars when the process started a decade and a half ago.[3] After all, even within the old EU-15 there are still large differences in average per capita income between, for example, southern and northern member countries, and these gaps only narrow very slowly. The question therefore arises as to the future sources of convergence of the NMS with the EU-15 and the U.S. More specifically, we ask ourselves which role technology (in particular information and

[3] See Sachs (1993) and Aslund (1995) for the exposition of the optimistic view and Kołodko (2000) for critiques.

communication technology (ICT), which is the general-purpose technology of our days) and structural reforms are playing in the process.

Table 1.2. Growth in number of persons employed, annual average, percent

	1995-2000	2000-06	2003	2004	2005	2006
NMS	**-0.8**	**0.3**	**0.2**	**0.6**	**1.4**	**1.7**
Bulgaria	-1.9	1.8	6.1	2.2	1.5	1.2
Czech Rep.	-0.8	0.5	-1.4	0.1	1.6	1.4
Estonia	-2.1	1.4	1.5	0.0	1.8	3.2
Hungary	1.2	0.2	1.3	-0.7	0.0	0.3
Latvia	-0.5	1.8	1.7	1.1	1.6	2.6
Lithuania	-1.1	1.0	2.2	-0.1	2.5	1.9
Poland	-0.4	0.0	-1.2	1.2	2.3	2.8
Romania	-1.9	-0.5	-0.1	0.2	0.2	0.2
Slovakia	-0.8	1.2	1.8	-0.3	1.4	4.1
Slovenia	-0.4	0.5	-0.3	0.4	0.3	0.8
Russia	-0.6	0.8	0.5	1.1	0.8	n.a.
EU-15	**1.5**	**0.9**	**0.6**	**0.6**	**0.9**	**1.3**
EU-10	-0.3	0.3	-0.3	0.6	1.7	2.2
EU-12	-0.8	0.3	0.3	0.6	1.4	1.7
EU-25	1.2	0.8	0.5	0.6	1.0	1.5
EU-27	1.0	0.8	0.5	0.6	1.0	1.4
Unites States	1.7	0.9	0.5	1.3	1.7	1.8

Notes and source: as in table 1.1.

The purpose of this paper is to analyze the impact of ICT on labour productivity growth in the NMS and Russia in the framework of the catch-up and convergence hypotheses on productivity. In addition, we consider which type of reforms and regulations have been most effective during the first transition stage, and which reforms are key to continued convergence towards income levels in old EU members and in the US in the coming years. We especially look at the interaction between structural reforms and different productivity effects from ICT use and rapid restructuring in manufacturing vis-à-vis the reshaping of service activities. Hence, we focus explicitly on the linkages between the investment, diffusion, and productive use of ICT in the NMS with structural reforms, investment in human capital, and enterprise restructuring.[4]

[4] This paper builds on a previous publication by the same authors, which presented a detailed macro and industry-level analysis of the NMS relative to the EU-15 and the U.S (Van Ark and Piatkowski, 2004).

In the remainder of this paper, we will argue, based on a panel data analysis, that the convergence process can be divided into two phases:

1. in the first, "restructuring" phase, the convergence has been driven by rapid growth in ICT investment in many NMS countries which has facilitated the restructuring process in manufacturing, and a rise in ICT production mainly through foreign direct investment.[5] The completion of the first, restructuring phase is mostly dependent on basic fundamental reforms: macroeconomic stability, open markets allowing for inflows of FDI, basic quality of regulations and law enforcement, infrastructural improvements, and an increase in the financial system development. At the end of the first convergence phase, productivity growth may slow as the restructuring process in manufacturing nears completion.
2. During the next "expansionary" phase period, the convergence will have to rely mainly on an intensive and productive use of ICT in non-ICT producing sector of the economy, particularly in services. The successful move to the second phase, however, requires ICT to be complemented with a more sophisticated deregulation of product markets, increased labour flexibility, developed ICT infrastructure, organizational innovations in enterprises, improved management practices, access to financing, and investment in a broader palette of human capital and ICT skills. These reforms are much harder to achieve than those required during the restructuring phase. Compared to the EU-15, the NMS may or may not develop an advantage in achieving this.

The paper proceeds as follows. In section 1.2 we formalize the channels through which factor inputs affect labour productivity growth with an emphasis on the contributions of ICT capital, production and use. We first introduce a growth accounting model and a shift-share methodology, which are jointly used to observe the driving factors behind labour productivity growth at aggregate and industry level. We then provide a stylistic model that links the contributions of ICT to productivity growth making use of indicators of structural reform ("structural indicators"). In section 1.3 we use the growth accounting methodology to estimate the contributions of investment in ICT capital and TFP to labour productivity growth. We discuss the determinants of ICT investment and TFP during the restructuring phase and the type of structural reforms that were associated with it. In section 1.4, we focus on the impact of the ICT production channel on labour productivity growth, and we identify the most fundamental reforms that were required to make this possible. In section 1.5, we focus on the ICT use channel. We show the divergence in labour productivity growth rates

[5] As shown by Van Ark and Piatkowski (2004), labour shedding was also a major source of labour productivity growth in the NMS during 1993-2003. ICT contributed to restructuring mainly through increased investment in new equipment with embedded ICT and basic automatization of back-office operations (accounting, procurement, etc.).

between manufacturing and services in the NMS, EU-15, and the U.S. We then use panel data analysis to link productivity results to indicators that measure progress in structural reforms, management skills, and human capital which are crucial for a more productive use of ICT. Section 6 concludes by discussing the implications of our "two-phase" convergence hypothesis. We argue that further convergence of the NMS will depend on substantial changes in their economic environment, which would allow for productive implementation of ICT, particularly in services. The progress in convergence will also depend on whether the NMS adopt structural policies modeled on EU-15 or the U.S. If they adopt the former pattern, the pace of convergence may slow or even reverse, particularly vis-à-vis the U.S.

1.2. Technology, structural reforms and productivity growth

Output and labour productivity growth can be decomposed into contributions of inputs using a growth accounting framework based on the original work by Solow (1957) and Jorgenson and Griliches (1967). In recent years, this framework has been extended for measuring the separate contributions of ICT capital and productivity obtained from ICT production and use by inter alia Oliner and Sichel (2000) and Jorgenson and others (2002).[6] Since ICT products and services are both outputs from the ICT industries as well as inputs into ICT-using industries, ICT can impact labour productivity through the following three channels:

1. use of ICT capital as an input in the production of other goods and services;
2. increase in total factor productivity (TFP) of production in ICT sector, which contributes to aggregate TFP growth in an economy;
3. contribution to economy-wide TFP from increase in productivity in non-ICT producing sectors induced by production and use of ICT (spillover effects).

The growth accounting methodology can be summarized as follows. Gross domestic product (Y) is produced from aggregate factor inputs X, consisting of capital services (K), divided into ICT capital (K_{it}) and non-ICT capital (K_n) and labour services (L). Productivity is represented as Hicks-neutral augmentation of aggregate input (A). The aggregate production function takes the form:

$$Y = AX(L, K_n, K_{it}) \qquad (1)$$

[6] For the EU-15 countries, see for example, Daveri (2002), Jorgenson and Vu (2005), Timmer and Van Ark (2005) and Van Ark and Inklaar (2005). For the NMS, see Piatkowski (2004).

with subscript *n* indicating services from non-IT capital and subscript *it* indicating services from information technology capital (including office and computing equipment, communication equipment and software). Under the assumption of competitive factor markets and constant returns to scale, growth accounting expresses the growth of output as a share weighted growth of inputs and total factor productivity, denoted by *A*, which is derived as a residual:

$$\Delta \ln Y = v_L \Delta \ln L + v_{K_n} \Delta \ln K_n + v_{K_{it}} \Delta \ln K_{it} + \Delta \ln A \qquad (2)$$

where:

v's denote the average shares in total factor income and because of constant returns to scale: $v_L + v_{K_n} + v_{K_{it}} = 1$, and

Δ refers to first differences.

By rearranging equation (2) the results can be presented in terms of average labour productivity growth defined as $y = \frac{Y}{L}$, the ratio of output to employment, $k = \frac{K}{L}$, the ratio of capital services to persons employed and TFP:

$$\Delta \ln y = v_{K_n} \Delta \ln k_n + v_{K_{it}} \Delta \ln k_{it} + \Delta \ln A \qquad (3)$$

Section 1.3 measures the contribution of ICT capital deepening ($v_{K_{it}} \Delta \ln k_{it}$) to aggregate labour productivity growth.

Another useful distinction can be made between TFP growth originating in industries producing ICT goods (A_{prod}) which represents the second channel above, in industries which are heavy users of ICT (A_{use}) representing the third channel, and TFP in other industries (A_{other}):

$$\Delta \ln y = v_{K_n} \Delta \ln k_n + v_{K_{it}} \Delta \ln k_{it} + \Delta \ln A_{prod} + \Delta \ln A_{use} + \Delta \ln A_{other} \qquad (4)$$

However, without industry-specific data on investment we will not be able to separate TFP growth in ICT-producing industries ($\Delta \ln A_{prod}$), intensive ICT-using industries ($\Delta \ln A_{use}$) and other industries ($\Delta \ln A_{other}$).[7]

[7] Nonetheless, Timmer and Van Ark (2005), and Piatkowski (2004) provide rough estimates of the contribution of ICT-producing sector to TFP growth in the EU-15 and the NMS, respectively,

Some first clues on the distinction between productivity growth from ICT production, ICT use and other sources of productivity growth can be obtained by decomposing aggregate labour productivity growth into the contributions of ICT-producing industries ($\Delta y_{prod} S_{prod}$), other manufacturing industries and market services which may all be marked as intensive users of ICT ($\Delta y_{use} S_{use}$) and non-manufacturing industries and non-market services ($\Delta y_{other} S_{other}$) according to a shift-share methodology:

$$\Delta y = \frac{Y}{L} = \sum_{i=1}^{n} \left(\Delta \frac{Y_i}{L_i} \right) \left(\frac{L_i}{L} \right) = \sum_{prod} \left(\Delta y_{prod} S_{prod} \right) + \sum_{use} \left(\Delta y_{use} S_{use} \right) + \sum_{other} \left(\Delta y_{other} S_{other} \right) \quad (5)$$

with *S* denoting the share of each industry group in total employment.[8] In section 1.4, we focus on the contribution of ICT-producing industries to labour productivity growth, and in section 1.5 on the contribution from industries, which are typically classified as ICT-using industries.

The results of these two decomposition techniques may be used to analyze interactions between the contributors to average productivity growth and various indicators of structural reforms. These reforms reflect improvements in the quality of the economic and institutional environment in the NMS that contribute to faster productivity growth relative to the EU-15 and the U.S. Here we develop a "two-phase convergence" hypothesis, which is based on an interaction between investment, production, and use of new technology (notably ICT) with restructuring of the economy and structural reforms.[9]

Figure 1.1 provides a stylized representation of this process. In the early stage of transition, the primary reforms led to an immediate catch-up in productivity levels, in part supported by a strong – but temporary – negative effect on the labour market through labour shedding. This process has supported investment in new capital goods, such as ICT, and a surge in ICT production in some NMS

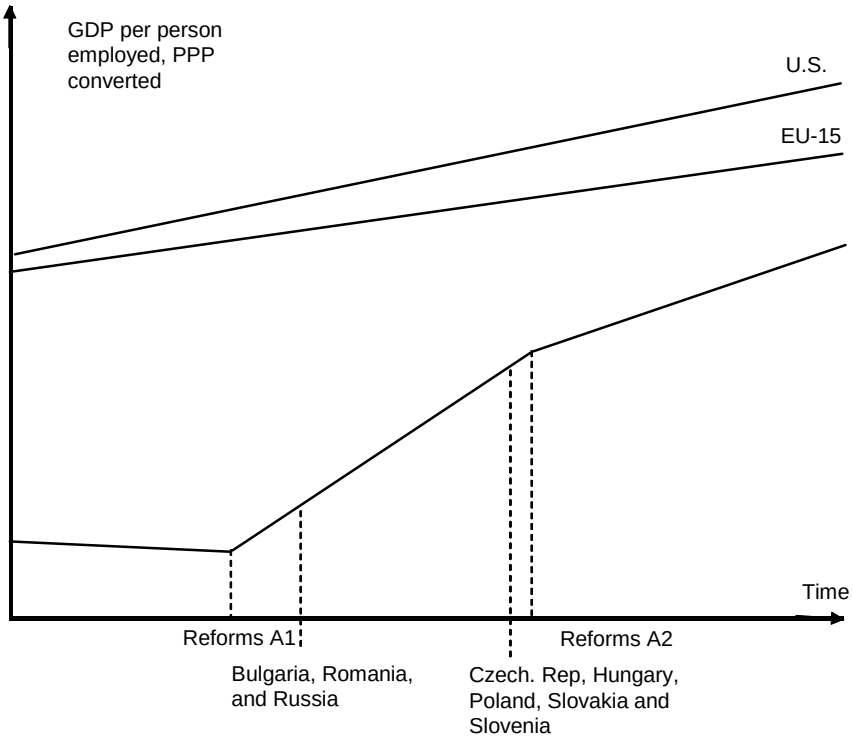
during 1995-2001. Their estimates are based on TFP growth rates in the U.S. ICT producing industry.

[8] This decomposition differs somewhat from what we used in earlier studies, including in van Ark and Piatkowski (2004) and Piatkowski (2005). There we made a distinction between intensive ICT-using industries and less intensive ICT users (non-ICT industries) on the basis of ICT investment intensity measures. However, it appears that this distinction is quite sensitive to cross-country differences and the phase in which the technology has been diffused. Van Ark and Inklaar (2005) show that the slightly cruder distinction used here is less sensitive to those factors.

[9] It should perhaps be stressed that ICT stands in general for the introduction of new technologies and modern equipment. As ICT emerged as the key general purpose technology driving accelerated growth in many countries during the 1990s, we use it as a symbol for the broader phenomenon of technological change that has also accompanied the growth process in the NMS.

with a more receptive climate for foreign direct investment. However, in particular the first effect is a transitional one, as ICT investment is characterized by diminishing returns. In addition, the impact of FDI on growth is not permanent, and FDI often leaves as easily as it comes. Hence, the productivity effects from the first convergence phase peter out after a certain period. During the second phase, convergence may continue but it will depend mainly on the productivity effects from the use of new technologies such as ICT. As services industries are the biggest users of ICT, reforms will mainly need to target these industries.

Figure 1.1. Stylized representation of Two-Phase Convergence Process in the NMS, EU-15 and the US since the beginning of transition in 1989



We can now build a simple stylistic model to test the dynamics of both convergence phases. Equation 6 show that changes in labour productivity growth ($\Delta Y / L$) in phase 1 are a function of the productivity contribution from ICT capital deepening ($v_{Kit}\ \Delta \ln k_{it,}$ see equation 4) and ICT production ($\Delta y_{prod} S_{prod}$). Labour productivity growth in phase 2 depends on ICT use ($\Delta y_{use} S_{use}$) (Equation

7). In addition, productivity growth in both periods is also dependent on specific structural reform indicators (*A*1 and *A*2), which are characteristic of the two phases of convergence, respectively.[10] The model can then be described as follows:

$$\frac{\Delta Y}{L}(phase\_1) = f(v_{K_{it}} \Delta \ln k_{it}, y_{prod} S_{prod}) \cdot A1 \quad (6)$$

$$\frac{\Delta Y}{L}(phase\_2) = f(y_{use} S_{use}) \cdot A2 \quad (7)$$

where:

*A*1 represent structural indicators relevant for phase one, with
*A*2 representing structural indicators relevant for phase two.

An important issue is to identify the structural determinants of adoption and diffusion of ICT at both aggregate and industry level. For advanced countries abundant research has shown that ICT use crucially depends on the level of competition in the product markets, flexibility of labour markets, quality of human capital, access to high-risk financing, spending on innovation, quality of law enforcement, trade openness, direct costs of ICT products, size of foreign direct investments and the level of liberalization of the telecom markets.[11]

Very few studies focus on the determinants of ICT adoption in developing and transition economies. Van Ark and Piatkowski (2004) provide a broad assessment of determinants of investment in ICT in the NMS. They provide updated results for a 'new economy' indicator, developed by Piatkowski (2002) that measures various components related to the quality of the economic and institutional environment in the NMS. The 'new economy' indicator includes, for example, trade openness, the development of financial markets, the quality of human capital, labour and product market flexibility, openness to macroeconomic stability and openness to foreign investment. These indicators show a positive relation with the ICT capital contribution to labour productivity growth.[12]

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[10] Following our previous paper (Van Ark and Piatkowski, 2004), the Composite Reform Indicator *A*1 is the aggregate of the quality of regulations and law enforcement, trade openness, macroeconomic stability, and financial system development, while the Composite Reform Indicator *A*2 is the aggregate of the level of development of ICT infrastructure, human capital, and labour market and product market flexibility. See Appendix 1 for details.

[11] OECD (2003, 2004) provides a very useful review. See also Jorgenson and Vu (2005) for their cross-country regression analysis of more than fifty developed and developing countries.

[12] Clarke (2003) provides evidence for the important role of FDI in ICT diffusion in the NMS. Muller and Salsas (2004) argue that the use of Internet is closely linked with GDP per capita, openness, liberalization of the telecom market, costs of access to the Internet and the quality of the telecommunication infrastructure.

A key question, however, is whether all of the determinants above are of equal importance in phases 1 and 2 of the convergence process. For instance, it seems unlikely that product market deregulation is equally important for realising productivity effects from ICT production during the first convergence phase as it is for the productive use of ICT in the service sector during the second, "expansionary" phase. Productivity from ICT production is mostly dependent on FDI, which--as argued by Piatkowski and Van Ark (2004) – is driven by open borders, existence of basic infrastructure, and the rule of law. Conversely, as argued by OECD (2003, 2004), productivity effects from ICT diffusion in the service sector seem to be strongly related to competition (while, paradoxically, enhanced competition could even deter FDI). Hence, some factors are more likely to interact directly with ICT investment, while others will mostly affect ICT production. In the following sections, we analyze the strength of interactions of productivity growth, manufacturing, and services with a number of structural factors that can be identified for the two convergence phases.

1.3. The contribution of ICT capital and TFP to growth

Much of the attention for the role of ICT in growth has focused on the contribution of ICT production to growth. However, as shown in a number of studies, ICT capital has been a more important source of growth in the U.S., G-7 countries, and EU-15 during the 1990s and early 2000s than production-related TFP growth contributions from ICT.[13]

This also appears to be the case for the NMS. Updated growth accounting results from Van Ark and Piatkowski (2004) compare the contribution of ICT capital to labour productivity growth in the NMS with EU-15 and the U.S. during 1995-2003. Table 1.3 shows that, in absolute terms, the contribution of ICT capital to labour productivity growth in most NMS (with the exception of Romania and Russia) was higher or comparable to that in the EU-15 (column 3).

However, there are substantial differences across countries, and in fact only the Czech Republic, Hungary, and Poland showed capital contributions which, in absolute terms, were above those of the EU-15.

A glance at Figure 1.2, which relates the comparative level of GDP per person employed to the *absolute* ICT contribution to labour productivity growth, reveals that ICT capital in itself has not been a direct source of convergence during the second half of the 1990s and in the early 2000s.

[13] See, for example, Jorgenson (2004) for the G7; Timmer and van Ark (2005) for the EU-15, Piatkowski (2004) for the NMS and Russia.

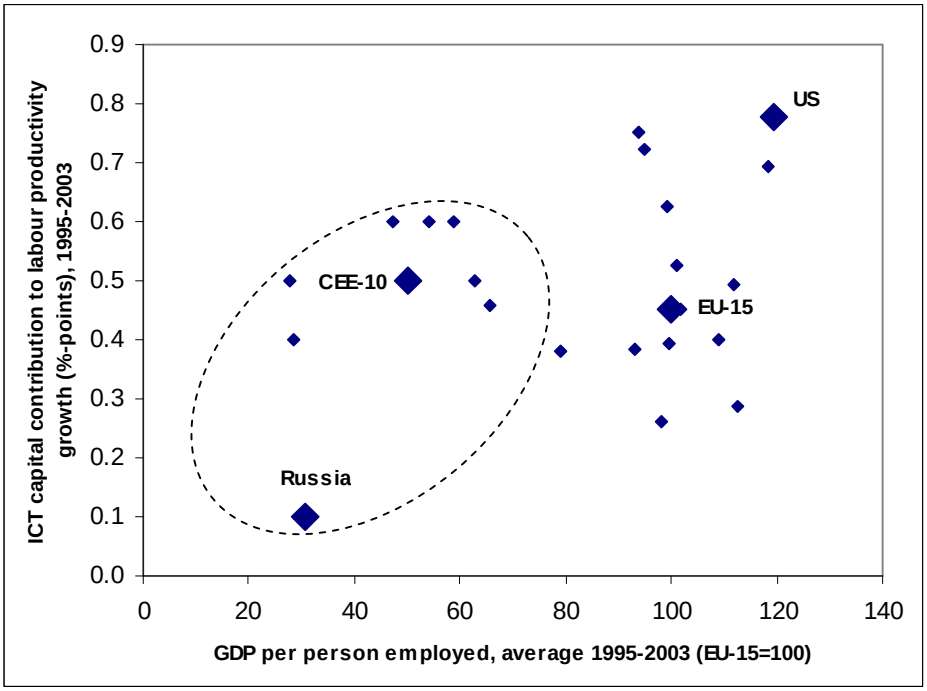
Table 1.3. ICT capital contribution to labour productivity growth (GDP per person employed) in the NMS, EU-15 and the U.S., 1995-2004, in %-points

	GDP per person employed (annual growth, %)	%-point contribution of			Relative ICT capital share in LP growth (%)
		Non-ICT capital intensity	ICT capital intensity	Total factor productivity growth	
NMS	**4.2**	**0.9**	**0.5**	**1.8**	**17**
Bulgaria	2.3	0.4	0.5	1.5	20
Czech Rep.	2.6	1.2	0.6	0.7	25
Estonia	7.6	…	…	…	…
Hungary	2.8	0.3	0.6	1.9	21
Latvia	5.9	…	…	…	…
Lithuania	6.5	…	…	…	…
Poland	4.7	1.9	0.6	2.2	12
Romania	2.6	0.8	0.4	1.5	14
Slovakia	3.8	0.8	0.5	2.5	13
Slovenia	3.4	0.8	0.5	2.1	15
Russia	3.5	-1.1	0.1	4.5	2
UE-15	**1.0**	**0.2**	**0.5**	**0.4**	**44**
Austria	1.8	0.6	0.5	0.8	25
Belgium	1.3	-0.1	0.7	0.7	53
Denmark	1.7	0.8	0.7	0.2	43
Finland	2.4	-0.4	0.5	2.3	21
France	1.0	0.4	0.3	0.3	29
Germany	1.2	0.2	0.4	0.6	13
Greece	3.0	0.7	0.4	2.0	13
Italy	0.2	0.4	0.4	-0.6	…
Ireland	3.8	0.7	0.5	2.5	13
Luxembourg	1.4	0.5	0.4	0.5	31
Netherlands	0.5	-0.1	0.4	0.2	73
Portugal	0.8	0.5	0.5	-0.2	56
Spain	-0.1	0.1	0.3	-0.5	…
Sweden	2.3	0.2	0.8	1.3	33
UK	1.8	0.2	0.6	1.0	34
United States	2.3	0.3	0.8	1.2	34

Note: Unweighted average for the NMS.
Source: EU-15 and U.S. data for labour productivity, capital intensities, and TFP growth are based on Timmer *et al*. (2003), updated June 2005. Data for the NMS, except Estonia, Latvia, and Lithuania are for 1995-2003 only based on Van Ark and Piatkowski (2004) updated to 2003.
Labour productivity growth rates for Estonia, Latvia, and Lithuania are based on The Conference Board / Groningen Growth and Development Center Total Economy database.

However, lower labour productivity levels of the NMS also did not prevent these countries from benefiting from ICT capital to the same degree as in the EU-15, and it has therefore not been a cause for divergence either.[14]

Figure 1.2. Contribution of ICT capital to labour productivity growth versus average GDP per person employed (EU-15=100), 1995-2003



Note: ICT capital contribution for the EU-15 and the US for 1995-2004.
Source: table 1.3 for ICT capital contribution and www.ggdc.net for GDP per person employed.

Figure 1.2 also shows that, within the NMS group, countries with higher labour productivity levels are characterized by a somewhat larger contribution of ICT capital. This suggests that ICT investment in the NMS may have been dependent on "network effects": higher levels of development, particularly as regards the ICT infrastructure, may have stimulated faster growth in ICT use through feedback effects.[15]

[14] The final column of Table 3 shows that the *relative* contributions of ICT capital to labour productivity growth were much lower for the NMS than for the EU-15 (17% and 44%, respectively) because of the higher growth rates of labour productivity itself in the NMS.
[15] See also, for instance, Roller and Waverman (2003) who argue that improvements in telecom infrastructure provide for non-linear network effects.

Rapid total factor productivity growth in the NMS was the most important source of convergence with the EU-15 during the first convergence phase (column 4 of table 1.3). These relatively high TFP growth rates are likely to be strongly related to the effects of restructuring driven by large-scale privatization and liquidation of inefficient state-owned companies, a phenomenon mostly unique to countries transitioning from a centrally planned to a market economy.[16] However, the high TFP growth in the NMS may have also to some extent arisen from "productivity effects" due to the production or use of ICT goods and services, which is the topic of the next two sections.

1.4. The contribution of ICT production

Although ICT capital has been an important source of growth in the NMS, there are reasons to assume that at least some countries in the region may have also greatly benefited from attracting production of ICT goods and services. Table 1.4 shows that ICT production had the largest absolute contribution to labour productivity growth in Latvia, Hungary, and Estonia.[17] The (unweighted) average for the ICT contribution to productivity for all NMS was higher than in the US and the EU-15.[18] Thus, the growth in the ICT producing sector accelerated the convergence between most NMS and industrialized countries.[19]

What explains the difference between the fast growth of the ICT sector in some NMS countries (Hungary, Latvia, Estonia) and much slower growth in other NMS countries, particularly in Slovakia and Slovenia? Piatkowski (2006) and Van Ark and Piatkowski (2004) argue that the rise of the ICT sector in the NMS can be largely explained by inflows of FDI as at the beginning of transition domestic industries were not competitive enough to develop owing to technological retardation, lack of access to high-risk financing and low level of innovation. FDI, in turn, was dependent on first-stage reforms (trade openness, development of infrastructure, rule of law, macroeconomic stability) and privatization policies.

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[16] Between 1990 and 2004, the share of the private sector in GDP in the NMS increased from less than 10% to more than 60% of the total (WDI 2005).

[17] ICT production consists of the following industries: Office machinery (30), Insulated wire (313), Electronic valves and tubes (321), Telecommunication equipment (322), Radio and television receivers (323), Scientific instruments (331), Communications (64), and Computer and related activities (72).

[18] It has to be remembered that most of the ICT production in these three NMS countries does not represent ICT-products at the high-tech end, but rather household electronic equipment and assembly items, for example, television screens, computer monitors, other electronic equipment, etc.

[19] Perminov and Egorova (2005) provide productivity growth estimates for the ICT sector in Russia, yet their results are not directly comparable with this study.

Table 1.4. Contributions to labour productivity growth (real GDP per person employed) of ICT-producing industry in the NMS, EU-15 and the US, 1995-2004

	Labour productivity (LP) growth, market economy	Contribution of ICT producing industries to LP growth		Share of ICT sector in GDP (in %)
		in %-points	in %	
EU-15	1.3	0.4	30.3	7.7
United States	2.8	0.6	19.3	9.5
NMS	**4.9**	**0.6**	**13.9**	**6.6**
Czech Rep.	2.9	0.4	14.7	6.6
Hungary	3.5	0.9	26.9	9.1
Poland	4.9	0.5	11.1	5.0
Slovakia	4.0	0.4	10.0	6.1
Slovenia	4.8	0.4	7.9	6.1
Estonia	7.6	0.8	10.2	6.7
Latvia	4.5	1.0	22.2	7.9
Lithuania	6.7	0.5	8.0	5.7

Note: Real estate has been excluded from market services. For all countries, deflators have been used. Non-market services have been excluded. NMS unweighted average.
Source: EU KLEMS Database, March 2007, www.euklems.net

Despite its positive contribution, the ICT sector in the NMS is simply too small (ICT sector's share in GDP of most NMS oscillates around only 5-6%, see table 1.4) and the ICT-related spillover effects are too scant to drive the sustained convergence towards the EU-15 income levels. Hence, convergence will have to rely on productivity growth outside ICT producing industries. This is the topic of the next section.

1.5. The contribution of ICT use and interplay with structural reforms

Given the overwhelming share of industries that may be characterized as "ICT-using" in market GDP, and given their much greater share compared to the ICT-producing sector, productive use of ICT in manufacturing and services will be key to faster growth and convergence.

Table 1.5 shows productivity growth rates in manufacturing, non-manufacturing, and market services industries in the NMS, EU-15, and the U.S. during 1995-2004.[20]

[20] For a detailed classification of industries, please refer to Van Ark and Inklaar (2005).

Table 1.5. Labour productivity growth (real GDP per person employed), 1995-2004

	Labour productivity (LP) growth, market economy	ICT production	Other production: manufacturing	Other production: non-manufacturing	Market services
EU-15	1.3	5.6	1.9	1.6	0.5
United States	2.8	6.1	3.4	0.0	3.1
NMS	**4.9**	**9.0**	**6.3**	**4.1**	**3.5**
Czech Rep.	2.9	6.5	3.7	1.7	2.4
Hungary	3.5	12.0	3.9	3.7	1.7
Poland	4.9	10.1	8.5	1.3	3.7
Slovakia	4.0	6.6	6.6	7.3	0.4
Slovenia	4.8	5.9	6.4	4.2	3.1
Estonia	7.6	11.5	9.0	5.1	7.5
Latvia	4.5	12.3	2.6	4.4	3.8
Lithuania	6.7	9.1	9.5	5.0	5.6

Notes and source: as in table 4.

It turns out that productivity growth rates in manufacturing in the NMS were substantially higher than in the EU-15 and the US.[21] It provides evidence for the success of the "first phase" restructuring of manufacturing industries in the NMS. Because of the high productivity growth rates, manufacturing industries in the NMS contributed between 0.4 and 1.9 percentage points to the aggregate labour productivity growth between 1995 and 2004, substantially more than in the EU-15 and the US (table 1.6).

In contrast, productivity growth in market services in the NMS was much lower than in manufacturing. The growth rates were also much lower than in the U.S. (table 1.5). As a result, and despite having a two-thirds share in total GDP, in most NMS the contribution of market services to productivity growth did not exceed that of manufacturing.

The question is then as to what explains such large differences in the productivity growth between manufacturing and market services. To answer this question, we set out to investigate which type of structural reforms have been most effective in driving productivity growth in manufacturing in the first transition stage, and which reforms are key to continued convergence through faster productivity growth in market services.

[21] Gven the scope of the paper, we will not analyze non-manufacturing industries, which comprise agriculture, forestry, mining and quarrying and fishing, and non-market services, which mostly relate to the public sector.

Table 1.6. Contributions to total labour productivity growth (real GDP per person engaged growth), 1995-2004

	Labour productivity (LP) growth, market economy	Contribution of: ICT production	other production: manufacturing	other production: non-manufacturing	market services	Reallocation
EU-15	1.3	0.4	0.5	0.3	0.2	-0.1
United States	2.8	0.6	0.8	0.0	1.6	-0.2
NMS	**4.9**	**0.6**	**1.6**	**0.9**	**1.7**	**0.1**
Czech Rep.	2.9	0.4	1.1	0.3	1.0	-0.2
Hungary	3.5	0.9	1.1	0.7	0.7	0.1
Poland	4.9	0.5	1.9	0.3	1.8	0.3
Slovakia	4.0	0.4	1.9	1.5	0.2	0.0
Slovenia	4.8	0.4	2.1	0.7	1.3	0.3
Estonia	7.6	0.8	2.0	1.1	3.7	0.1
Latvia	4.5	1.0	0.5	0.8	2.0	0.1
Lithuania	6.7	0.5	2.2	1.3	2.5	0.1

Notes and source: as in table 1.4.

The differences in the productivity growth rates in market services in favor of the U.S. seem to suggest that at least that country has succeeded in moving to the "second phase" of the productive use of ICT in the service sector, although recent work for Europe shows that a few European countries (e.g. the Netherlands and the United Kingdom) also show signs of improved productivity in services (Van Ark *et al.*, 2007). As argued by Piatkowski and Van Ark (2005), the ability to increase productivity in the service sector seems to be dependant on competitive products markets, flexible labour markets, organizational innovations, large investments in R&D, and availability of high-risk financing.

We use a panel data analysis for four NMS (Hungary, Czech Republic, Slovakia, and Poland), the EU-15, and the U.S. to find structural and institutional determinants of labour productivity growth in manufacturing and market services during 1995-2003 (see Appendix for details on the methodology and data). Despite a low statistical fit due to a small dataset and high volatility of productivity growth rates, the regression results show that labour productivity growth in manufacturing is more closely correlated with basic fundamental reforms represented by the Composite Reform Indicator A1 than productivity growth in market services (tables 1.7 and 1.8).[22]

[22] The explanatory variable A1 is statistically significant at 1% level. A2 variable is statistically significant only at 10% level. The A1 coefficient is higher than in A2 and has the expected sign. The lagged log of GDP per capita is statistically significant and has the expected negative sign.

Table 1.7. Labour productivity growth in manufacturing – Reform Indicator A1

Variable	Coefficient	Std. error	t-Statistic	Prob.
Constant	49.44486	13.48175	3.667539	0.0003
*A*1	1.246516	0.362711	3.436664	0.0008
LOG(GDPPC(-1))	-4.695648	1.337200	-3.511552	0.0006

Note: all values significant at 1%. Total panel (balanced) observations: 152.
R^2 = 0.025951, adj. R^2 = 0.012876.
Source: authors' own.

Table 1.8. Labour productivity growth in manufacturing - Reform Indicator A2

Variable	Coefficient	Std. error	t-Statistic	Prob.
Constant ***	28.66235	11.33914	2.527736	0.0125
*A*1 *	0.596429	0.342849	1.739625	0.0840
LOG(GDPPC(-1)) ***	-2.609090	1.121560	-2.326304	0.0214

Note: *** significant at 1%, * significant at 10%. Total panel (balanced) observations: 152.
R^2 = 0.035524, adj. R^2 = 0.022578.
Source: authors' own.

At the same time, we find that more sophisticated reforms (Composite Reform Indicator A2) seem to be more important for productivity growth in market services than in manufacturing (tables 1.9 and 1.10).[23] These findings are consistent with our hypothesis of a "two-phase" convergence.

These results suggest that the successful move to the second phase of convergence is likely to require a more sophisticated deregulation of product markets, increased labour flexibility, better ICT infrastructure, organizational innovations in enterprises, and improved management practices, access to financing and investment in a broader palette of human capital and ICT skills.[24] These structural reforms are especially important for the NMS as the productivity effects from the "restructuring" phase and simple post-transition growth reserves have been mostly exhausted, in particular in the most developed NMS (Piatkowski and Van Ark 2005, Schadler and others 2006). These reforms are, however, much harder to achieve than those required during the restructuring phase.

[23] Explanatory variable A1 and lagged log of GDP per capita is statistically insignificant (although it has the expected negative sign). In turn, A2 variable is statistically significant at 1 percent level. It also has the expected sign.

[24] For a discussion of the importance of organizational changes in entreprises and improved management, refer to Brynjolfsson and Hitt (2000) and Dorgan and Dowdy (2005).

Table 1.9. Labour productivity growth in market services - Reform Indicator (A1)

Variable	Coefficient	Std. error	t-Statistic	Prob.
Constant	7.931392	9.437073	0.840450	0.4020
*A*1	0.316686	0.272063	1.164018	0.2463
LOG(GDPPC(-1))	-0.734389	0.938249	-0.782723	0.4350

Note: Total panel (balanced) observations: 152.
R^2 = 0.025095, adj. R^2 = 0.038855.
Source: authors' own.

Table 1.10. Labour productivity growth in market services - Reform Indicator A2

Variable	Coefficient	Std. error	t-Statistic	Prob.
Constant	19.24258	7.686606	2.503391	0.0134
*A*1	1.045741	0.187810	5.568081	0.0000
LOG(GDPPC(-1))	-1.858368	0.759111	-2.448085	0.0155

Note: all values significant at 1%. Total panel (balanced) observations: 152.
R^2 = 0.124791, adj. R^2 = 0.113043.
Source: authors' own.

Compared to the EU-15, the NMS may or may not develop an advantage in achieving these more advanced structural reforms. Depending on whether the NMS will improve their institutional environment to the level of the EU-15 or the U.S., they may follow either the low-productivity path of the EU-15 or the high-productivity path of the US. Given the substantial differences in productivity growth rates between Western Europe and the US, particularly in services (table 1.5), the chosen institutional path will have a significant impact on the pace of convergence of the NMS with industrialized countries. That said, the recent evidence of a modest improvement in services productivity in some EU-15 countries might be a sign that reforms as included in the Composite Reform Indicator A2 are showing some effect.

1.6. Conclusions

This paper investigated how the productivity performance of the New EU Member States (NMS) and Russia evolved during 1995-2006 vis-à-Vis the EU-15 and the US. We showed that the NMS, with the exception of Romania, seem to have exploited the direct productivity gain from ICT to accelerate its convergence with the EU-15, partly through ICT investment and productivity growth in ICT-

using manufacturing, and partly through productivity growth in ICT production. However, in the case of Romania and Russia, ICT led to a divergence rather than convergence of productivity to the other countries. The difference between the economic impact of ICT in Romania and Russia relative to the other NMS provides substance to a hypothesis that there is a close link between diffusion of ICT and advancement of fundamental reforms.

We have also showed that the ICT-led convergence process in the NMS can be divided into two phases: in the first "restructuring" phase, convergence is driven by growth in ICT production and ICT-aided restructuring in manufacturing industries. At the end of the first phase, however, productivity growth slows as the restructuring process in manufacturing nears completion. Hence, in the second, "expansionary" phase, the convergence needs to rely mainly on an intensive use of ICT in non-ICT producing sector of the economy, particularly in services.

The results of the panel data analysis show that the completion of the first, restructuring phase seems to be mostly dependant on some basic fundamental reforms: open markets, which allow for inflows of FDI, basic rule of law, sufficiently developed financial markets and some measure of macroeconomic stability. A successful transition to the "expansionary" phase, however, seems to require more sophisticated reform measures:

- deregulation of product markets,
- more flexible labour markets,
- business re-organization based on improved management practices, and
- larger investment in human capital and ICT skills.

These are in practice much harder to achieve.

Based on the available evidence, it appears that most NMS have more or less realized the first convergence phase (although less so in Bulgaria and Romania). Further income and productivity convergence of the NMS with EU-15 will now be dependent on faster growth in the services sector, which already represents two-thirds of GDP in these countries. In spite of the potential for technological leapfrogging, the service sector in the NMS reported much lower labour productivity growth than in manufacturing. Further growth in the NMS and Russia (as well as in many EU-15 countries) will depend on continued progress in the creation of modern institutions, implementation of market-oriented policy reforms aimed at strengthening competition, increased innovation, improvements in the quality of the human capital and an enhancement of the comprehensiveness and effectiveness of regulations. Should these reforms not be fully implemented, the convergence process in the NMS may slow or even reverse, particularly relative to the U.S.

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Appendix: The Panel Analysis

1. The model

The following panel equations are estimated by Pooled Generalized (Weighted) Least Squares (GLS) model with common intercept for all countries and periods:

$$\frac{\Delta Y}{L_{manufacturing(it)}} = \mu + \alpha \ln(Y_{per\_capita(it)}) + \delta A1(A2)_{it} + \varepsilon_{it}$$

$$\frac{\Delta Y}{L_{market\_services(it)}} = \lambda + \alpha \ln(Y_{per\_capita(it)}) + \delta A2(A1)_{it} + \varepsilon_{it}$$

where:

*A*1 and *A*2 denote composite structural indicators for the first and second stage of structural reforms, respectively,

i and *t* denote an economy and time,

μ_i and μ_y are constants and ε_{it} an error term.

Dependant variables, $\Delta Y / L_{manufacturing(it)}$ and $\Delta Y / L_{market\_services(it)}$, are the labour productivity growth rates for manufacturing and market services, respectively. The sample includes nineteen countries (EU-15 without Luxembourg, the U.S. and four NMS countries). Frequency of data is annual for the period 1996-2003.

There are three explanatory variables:

1. Composite Reform Indicator *A*1, represented by an aggregate of the quality of regulations and law enforcement, trade openness, macroeconomic stability, and financial system development (see Data Used below for details).[25]
2. Composite Reform Indicator *A*2, represented by an aggregate of the level or development of ICT infrastructure, human capital, labour market flexibility and product market flexibility
3. Lagged natural log of GDP per capita, included to capture catching-up effects.

The point of the regression is not to test the *strength per se* of the relationship between labour productivity and specific composite structural reforms, which would create a need for a much larger data sample to obtain robust results, but rather the *existence* of the relationship as such. This approach also lessens the importance of the omitted variables problem.

[25] In the aggregation method, the sample mean of values of all variables is subtracted from each number and then the result is divided by sample standard deviation. This implies a mean of zero and a standard deviation of one across countries in the sample. Hence, all results are comparable and can be aggregated. The aggregated results are submitted to the same procedure.

To mitigate the effect of heteroskedaticity typical for panel data, we use a Generalized (Weighted) Least Squares estimator. Nonetheless, and as discussed in other studies, we are aware that economic policy and institution variables can be often considered endogenous. However, as argued by Bosworth and Collins (2003), it is difficult to find effective instruments for each endogenous variable. Hence, the presented results, which do not control for the endogeneity problem, should be interpreted as merely showing correlation, not causality.

The weak fit of the regressions below is due to the short sample period and high volatility of labour productivity growth rates. The fit could be improved by introducing country dummies. Yet, country dummies would significantly increase the number of estimated parameters and reduce the number of degrees of freedom. It would thus reduce the explanatory power of *A*1 and *A*2 variables.

We have also run separate regressions for developed countries (EU-15 and the US) and the NMS. While the regressions for the developed countries showed generally the same results as for the full sample, the regressions for the NMS showed both very weak fit and statistically insignificant variables. This is not surprising given the small number of observations.

2. Data Used

Factor	Variable	Source
1. Quality of regulations and contract enforcement	Sum of World Bank Regulatory Quality and Rule of Law Indicator	Kaufmann *et al.* (2005)
2. ICT Infrastructure	Sum of total number of telephone lines (main and cellular) and PCs per 1000 persons	WDI 2005
3. Trade openness	Share of trade in GDP (in %)	WDI 2005
4. Development of financial markets	Domestic credit to private sector (% of GDP)	WDI 2005
5. Quality of human capital	Tertiary school enrollment (% gross)	WDI 2005
6. Labour market flexibility	Rigidity of Employment Index	World Bank (2005)
7. Product market flexibility	Product market regulation indicator	Conway et al. (2005)
8. Macroeconomic stability	Inflation (CPI) (in %)	WDI 2005
GDP per capita	GDP per capita in EKS$ 2002	OECD

Note: Human capital for all countries for 1995-97 is equal to 1998, while 2002-03 is equal to 2001. Labour market flexibility for all countries for 1995-2003 is equal to 2004. Product market flexibility: 1995-97 is assumed to equal 1998, while 1999-2002 is based on the average of 1998-2003.