EUROPEAN CENTRAL BANK

WORKING PAPER SERIES

NO. 486 / MAY 2005

WHAT DRIVES PRODUCTIVITY GROWTH IN THE NEW EU MEMBER STATES?

THE CASE OF POLAND

by Marcin Kolasa

EUROPEAN CENTRAL BANK

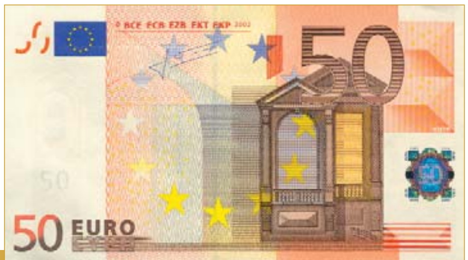
WORKING PAPER SERIES

NO. 486 / MAY 2005

WHAT DRIVES PRODUCTIVITY GROWTH IN THE NEW EU MEMBER STATES?

THE CASE OF POLAND [1]

by Marcin Kolasa [2]



In 2005 all ECB publications will feature a motif taken from the €50 banknote.

1 This paper was completed while the author was working in DG Research of the European Central Bank. The author would like to thank the participants to an internal ECB seminar for valuable comments and Frank Smets for support and discussion. Special thanks are owed to Zbigniew Zolkiewski (NBP) who contributed to an earlier version of this paper. This paper also benefited from the comments of the participants of NBP Conference "Potential Output and Barriers to Growth" and TIGER Conference "ICT as Drivers of Development in Transition Economies". Last, but not least, the author would like to thank an anonymous referee for valuable comments to the draft version of this paper. The views expressed herein are those of the author and not necessarily those of the National Bank of Poland or the European Central Bank.

2 National Bank of Poland, e-mail: Marcin.Kolasa@mail.nbp.pl

Address
Kaiserstrasse 29
60311 Frankfurt am Main, Germany

Postal address
Postfach 16 03 19
60066 Frankfurt am Main, Germany

Telephone
+49 69 1344 0

Internet
http://www.ecb.int

Fax
+49 69 1344 6000

Telex
411 144 ecb d

ISSN 1561-0810 (print)
ISSN 1725-2806 (online)

CONTENTS

Abstract

This paper considers productivity developments in the new EU member states and provides evidence on factors driving productivity growth in these countries, focusing on a panel of Polish manufacturing industries. Companies in Poland seem to benefit significantly from transfer of technologies that have been accumulated in more developed economies. By contrast, no strong evidence is found on immediate technology transfer. Another result is a significant effect of domestic innovation activity. There are signs that market reforms also boosted efficiency, whereas the role of reallocation of production factors towards more productive activities was marginal. Bearing in mind all methodological and data-related caveats, as well as cross-country diversity, caution is required while interpreting the findings and extrapolating them to other new member states. However, the results obtained provide some policy implications and make the case for taking into account domestic innovation activity while constructing endogenous growth models for the EU catching-up economies.

Keywords: multi-factor productivity, innovation, convergence, new member states, manufacturing

JEL Classification: C23, O31, O47

Non-technical summary

This paper considers productivity developments in the new EU member states and provides evidence on factors driving productivity growth in these countries over the last decade. The analysis starts with a short overview of labour productivity levels and growth in the new member countries. Despite the relatively rapid catching-up process observed in recent years, labour productivity levels in the new member states are still well below those observed in EU-15 countries. The largest distance can be found in manufacturing, whereas construction and market services seem to be less behind.

The main part of the analysis concentrates on the case of Poland, using panel data from 21 manufacturing industries covering the period 1994-2002. One of the reasons why an average worker in the new EU member states still produces only about half the amount of goods and services that are produced in the pre-enlargement EU are differences in capital intensity. However, it is rapid growth in multi-factor productivity that seems to be crucial for the pace of convergence over the medium to long term perspective. Given the above, the productivity measure used for a more in-depth analysis is multi-factor productivity, derived from a gross output based production function.

The estimated productivity growth rates and levels are then used for an econometric analysis, aimed at extracting relevant factors driving productivity growth in Poland. The theoretical derivations rely on the theory of endogenous growth, according to which the productivity level is a function of the stock of knowledge. Since Poland, similarly to other new member states, is surely behind a technology frontier, variables serving as proxies for technology transfer from technologically developed economies were also included. Finally, dealing with a transition economy justifies considering other variables as well, controlling for the effect of market reforms, increased competition and other transition-specific factors.

The main findings of the paper are as follows. First, companies in Poland seem to benefit significantly from transfer of technologies that have been accumulated in more developed economies some time ago. By contrast, we find no strong evidence on significant contribution of immediate technology transfer. Second, there is a statistically and quantitatively significant effect of domestic innovation activity on productivity growth in Poland. Finally, there are signs that market reforms, including privatisation and liberalisation, also boosted efficiency, whereas the effect of reallocation of production factors towards more productive activities was marginal.

In view of possible methodological and data-related caveats, caution is required while interpreting the results. Moreover, since the econometric analysis focuses on the case of Poland, the findings may not necessarily be relevant for all other new EU member states. However, bearing in mind all these limitations, several policy implications could be ventured.

An important condition for fast convergence towards EU-15 countries is to support innovation in the new member states. This is in contrast to some of opinions claiming that, following the EU-entry, an increased foreign direct investment inflow will suffice to ensure fast technological progress in the medium term and that domestic innovation gain much importance only when the technology gap becomes relatively small. This paper suggests that it might be as well possible that a sizeable part of the potential technology transfer has already taken place and foreign companies might tend to use brand-new technologies rather domestically, transferring them abroad with a significant lag. Moreover, if the level of innovativeness in a country is low, possible spillovers from foreign direct investment might be very limited. Adding to it stalled reforms in some sectors, inhibiting reallocation of resources to more productive industries, could then result in a sizeable deceleration in productivity growth in the new member countries over the medium term. This issue is even more important, given that most of “easy” gains in productivity achieved by removing inefficiencies accrued over the command-economy period have already dried up.

This paper shows that all these aspects should be taken into account while assessing growth perspectives in the new EU members over the medium to long term perspective. In particular, domestic innovation activity should not be neglected while building endogenous growth models for catching-up economies, which makes the case for models based on the concept of conditional rather than unconditional convergence.

1. Introduction

Productivity growth, being the basis for gains in income and ultimately in welfare of economies, has always been an important subject of economic studies. The interest in factors determining productivity across time, countries and industries increased with the development of models of endogenous growth, particularly those focusing on research and development activities.[1] However, productivity issues are not an exclusive domain of long-term growth analysis and they also attract interest of monetary policy authorities.

A good example of the importance that monetary policy and academic circles dealing with monetary policy attach to productivity growth is the discussion in the United States that was initiated in the late 1990s. The heavily discussed issue was whether acceleration in productivity in the US economy, probably driven by 'new economy', raised 'the speed limit', i.e. the rate of economic growth consistent with stable inflation.[2] Recently, productivity issues gained also importance among European central bankers, one of the examples could be recent research carried out at the Bank of England.[3]

Describing the relationship between output and inputs necessary to generate that output, productivity seems to be a straightforward indicator. There are, however, many different measures of productivity widely used, depending on the choice of input (or a bundle of inputs) and output.[4] The focus of this paper is to analyse cross-country differences in output that cannot be accounted for the differences in the use of inputs, which makes so-called multi-factor productivity (MFP) a preferable measure. Unfortunately, as it will be seen later in the text, well-defined MFP indicators are relatively data-intensive. This limitation is particularly important in the case of transition economies, for which the consistent capital stock series are rarely available.

Given the above considerations, we start the overview with the simplest indicator, i.e. labour productivity, whereas the empirical part of the paper, concentrating on Poland's manufacturing, will rely on a more sophisticated MFP indicator.

The labour productivity index is defined as a relation between output and labour input. The first is usually expressed in terms of GDP, value-added or gross output, whereas the latter is preferably calculated as the number of hours worked, but the number of people employed is also frequently used due to data limitations. Labour productivity can be classified as a single-factor productivity measure, which implies that it is affected

[1] See e.g. Romer (1990), Grossman and Helpman (1991).

[2] See e.g. Sahlman (1999), Jorgenson and Stiroh (2000)).

[3] See Groth, Gutierrez-Domenech, Srinivasan (2004) for an outline of a recent project aimed at productivity measurement and analysis.

[4] See e.g. OECD (2001).

not only by purely technological or organisational developments, but also reflects intensity of the use of other inputs.[5] Nevertheless, it is widely used for cross-country comparisons and provides a useful departure point for further analysis.

Half a century of central planning left the eight Central-European (CE-8) economies with outdated technologies and inefficient allocation of resources. Following market reforms and structural changes during the 1990s, the situation in the region started to improve and in most countries significant productivity gains could be observed. However, nearly a decade after the transition began, an average worker in CE-8 countries still produces only about half the amount of goods and services that is produced in the pre-enlargement EU (see Table 1). Since people in CE-8 economies work longer hours than in the EU-15, the actual discrepancy in labour productivity is even larger.

Table 1. Labour productivity levels and growth in ten EU new member countries

	Labour productivity[a]		Labour productivity growth[b]	
	GDP per person employed	GDP per hour worked	GDP per person employed	GDP per hour worked
Poland	48.9	38.7	5.1	5.5
Czech Republic	57.7	46.0	2.2	2.7
Slovakia	56.3	44.9	4.4	4.0
Hungary	62.7	56.0	3.0	3.1
Lithuania	43.6	-	-	-
Latvia	38.6	-	5.7	-
Estonia	42.8	-	7.1	-
Slovenia	69.4	-	-	-
EU-15	100.0	100.0	1.1	1.5
Germany	94.9	104.2	0.9	1.7

[a] 2002, EU-15=100, at current prices and PPPs.

[b] annual average growth rate for 1995-2002.

Source: OECD, Eurostat, own calculations.

Labour productivity gap between CE-8 and EU-15 countries is not evenly spread across sectors. As can be seen from Table 2 covering the four largest CE-8 economies,

[5] It can be clearly seen in a standard growth accounting framework (constant returns to scale, perfect competition, Hicks-neutral technological progress, two primary inputs: labour and capital), in which the growth rate of labour productivity can be expressed as a weighted average of MFP growth (genuine productivity advance) and change in capital-labour ratio (see Solow (1957)).

new member states are particularly behind in manufacturing, whereas the gap in construction and market services is considerably smaller. One of the possible explanations is low capital intensity in the region, which may be particularly important for manufacturing industry, relying to large extent on heavy machinery and equipment.

Table 2. Sectoral labour productivity in ten EU new member countries

	Labour productivity[a]		
	Manufacturing	Construction	Market services[b]
Poland	42.0	71.7	55.6
Czech Republic[c]	49.8	56.9	58.8
Slovakia[c]	45.1	63.7	62.6
Hungary	51.5	60.6	65.0
Germany	100.0	100.0	100.0

[a] 2001, Germany=100, value-added at current prices and PPPs per person employed.

[b] Trade and Repairs, Hotels and Restaurants, Transport, Storage and Communication, Financial Intermediation, Real Estate, Renting and Business Activities.

[c] 2000.

Source: OECD, Statistical Yearbooks of respective countries, own calculations.

This paper aims to enhance the understanding of factors driving productivity growth in the new EU member states and thereby to provide insight on their growth potential over the medium to long term perspective. It also conveys some policy implications on what should be done to accelerate convergence within the EU after recent enlargement. Finally, it provides empirical support for building endogenous growth models for the new EU member countries. This issue gained importance in the context of national development plans that each new member has to prepare in line with EU regulations.[6]

The rest of the paper is organised as follows. Section 2 provides theoretical foundations for measuring MFP and explaining its growth in the context of catching-up economies. Section 3 addresses data issues and describes the variables used in the econometric analysis. Section 4 deals with estimation issues, presents regression results and discusses their robustness. Section 5 concludes, summarising the main results and policy implications.

[6] See e.g. EC regulation no. 1260 of 21st June 1999 (1260/99/EU).

2. Theoretical foundations

2.1. Measuring MFP growth and levels

A more detailed analysis carried out henceforth concentrates on MFP developments in manufacturing industries. One of the reasons for turning to manufacturing is data availability and comparability. Also, as it will be seen further in the text, concentrating on this sector justifies some useful technical assumptions made while deriving MFP measures. Although manufacturing in most CE-8 countries accounts for less than a quarter of total output, most of technical change can be attributed to this very sector, which makes it attractive for analysing productivity developments in the region.[7]

The departure point in most of literature on multi-factor productivity is the value-added based production function, relating the real value-added to the input of two primary factors, i.e. capital and labour. One of the problems with this approach to calculating productivity change is that a stable value-added function exists only under separability conditions (see e.g. Bruno (1978)). A more practical argument against using value-added at a disaggregate level is that there is no physical quantity that corresponds to a volume measure of value-added. From the point of view of the subsequent analysis, what also makes the case for relying rather on a gross-output-based measure of productivity is that it enables to handle time-varying capital utilisation in an explicit way. Finally, an additional dimension to this problem emerges when firms operate under imperfect competition (see Basu and Fernald (2000)).

It should be noted that the gross-output-based productivity measure has some shortcomings as well. One important issue is the problem with comparing gross-output-based MFP growth across different levels of aggregation, due to complications related to intra-industry deliveries. However, these problems disappear while operating on a firm level and are probably negligible on the level of aggregation considered in this paper.[8]

In view of the above considerations, let us assume that the firm-level production function can be written in the following general form:

---

[7] As can be seen from Table 2, the productivity gap in the service sector between Germany and the larger new member states, though smaller than in the case of manufacturing, is also fairly large. Moreover, recent studies suggest that the difference in overall productivity growth performance between the United States and the euro area can be traced to a productivity surge in US market services (mainly trade and financial intermediation), which was probably driven by faster diffusion of new technologies (see Estevão (2004)). Therefore, although a careful analysis of the service sector in the new member states is beyond the focus of this paper, it should not be ignored while assessing their prospects for catching up with EU-15 countries.

[8] For a more extensive coverage of advantages and disadvantages of using both productivity measures, see OECD Manual (2001) or Schreyer and Pilat (2001).

$$Q = F(\tilde{K}, \tilde{L}, M, E, A), \quad (1)$$

where Q denotes gross output, $\tilde{K}$ and $\tilde{L}$ are capital and labour services respectively, M is intermediate input less electricity, E is the use of electricity and A indexes productivity, given exogenously at this stage.[9]

A time-varying level of capacity utilisation is taken into account by stating that the services of capital and labour depend not only on the stock of the respective primary factors (most often assumed to be quasi-fixed), but also on the intensity with which they are used, so that one can write:

$$\tilde{K} = UK,$$
$$\tilde{L} = HL, \quad (2)$$

where K denotes the capital stock and U is its utilisation, whereas L stands for the number of people employed and H is the average number of hours worked.

The obvious simplification at this stage is an implicit assumption of constant effort of the workers, which, if allowed to vary and if properly measured (or indirectly implemented), might add a second dimension to the utilisation of the factor labour. Unfortunately, both an indirect approach to accounting for time-varying effort (i.e. relying on an optimising behaviour of the firms, see Basu and Kimball (1997)) and a direct one (proposed by Shea (1990) and used e.g. by Carlsson (2000)) require estimation, which is not pursued in this paper for lack of good instrumental variables needed to obtain unbiased estimators.

Another simplification inherent in (2) is neglecting the difference between the (market) value of the capital stock and its rental price. Similarly, changes in the quality of inputs are not taken into account. These problems are well known in the growth accounting literature at least since the works of Jorgenson and Griliches (1967), Gordon (1990) or Hulten (1992), and may seriously affect the relative contribution of changes in factor inputs and technological change to overall growth performance.[10] Unfortunately, these issues cannot be addressed in this paper for lack of appropriate data at an industry level.

[9] According to OECD Manual (2001), A can be classified as KLEMS MFP (capital-labour-energy-materials-services multi-factor productivity), as opposed to capital-labour MFP based on a value-added concept of output.

[10] See Sakellaris and Vijselaar (2004) for implications of using quality-adjusted measures of the capital stock in the euro area, and Groth, Gutierrez-Domenech, Srinivasan (2004) for quality-adjusted vs. quality-unadjusted measures of labour input in the United Kingdom.

Taking logs on both sides of (1), differentiating with respect to time, assuming that technology can be written as Hicks-neutral and using (2) yields the following formula for gross-output-augmenting technology change:

$$da = dq - s_{\tilde{K}}(du + dk) - s_{\tilde{L}}(dh + dl) - s_M dm - s_E de\,, \tag{3}$$

where lower-case letters denote natural logarithms and $s_J \equiv \frac{dQ}{dJ}\frac{J}{Q}$ is the gross output elasticity with respect to input J.

Constant returns to scale and perfect competition (pricing at marginal cost) imply that the elasticities s_J sum to one and are equal to each factor's revenue shares.[11] Then the only unobserved variable on the right-hand side of equation (3) would be capital utilisation U. This can be dealt with by imposing a priori restrictions on the production function and exploiting implied thereby links between capital utilisation and other observed variables.

In the case of manufacturing industries, a sensible approximation would be that there is very little substitutability between capital services and energy use (see e.g. Jorgenson and Griliches (1967)).[12] It allows one to rewrite (1) as:

$$Q = F(G(\tilde{K}, E), \tilde{L}, M, A)\ . \tag{4}$$

On the assumption that the elasticity of substitution between capital services and the use of electricity is zero, sub-function G represents Leontief technology ($\beta > 0$):

$$G = \min(\tilde{K}, \beta E)\,, \tag{5}$$

which means that energy input is a perfect index of capital services. As a result, equation (3) in terms of the observable variables finally becomes:

$$da = dq - (s_{\tilde{K}} + s_E)de - s_{\tilde{L}}(dh + dl) - s_M dm\,. \tag{6}$$

Equation (6) holds true for any production function that satisfies the assumptions made so far. However, in order to compare productivity across countries, an explicit functional form of F is needed at least to pin down the levels of productivity in the base year.

Following the mainstream of literature, it will be assumed that productivity levels for the base year in the compared economies can be derived from a Cobb-Douglas

---

[11] The possible departures from these assumptions and their impact on the results obtained in the econometric analysis will be discussed in section 4.3.

[12] As pointed out by Basu and Fernald (2000), this assumption is reasonable for the services of heavy machinery and not necessarily for the services of other types of capital (e.g. structures, computer equipment). Therefore, this approach seems to be particularly valid for manufacturing.

production function. As pointed out by Bernard and Jones (1996), if the shares of inputs differ across countries, comparisons of this measure of MFP can be misleading and even depend on the choice of the units of measurement for the inputs. To get round this problem they propose an value-added-based index of total technological productivity (TTP), which differs from the standard MFP measure in that its calculation is based on normalised inputs. A modified gross-output-based version of it can be written as:

$$a = q - s_{\tilde{K}}(\tilde{k} - \tilde{k}_0) - s_{\tilde{L}}(\tilde{l} - \tilde{l}_0) - s_M(m - m_0) - s_E(e - e_0)\,, \qquad (7)$$

where variables with a subscript 0 are calculated as cross-country averages for a base year.[13] This measure has the desired interpretation while using it for international comparisons: it shows which country would produce more output if all of them employed exactly the same quantities of inputs.

The choice of a Cobb-Douglas production function implies that the input shares s_J are constant over time, which makes the calculations relatively easy. This might be viewed as too restrictive, but there are reasons to maintain it as a baseline specification. A most appealing extension could be to assume that a production function F has a Translog form, which provides a second-order approximation to any production function (see Diewert (1974)). However, as pointed out by Basu and Fernald (2000), the second order approach, while bringing the potential benefits, increases the likelihood of misspecification. The source of the problem is that the observed input shares might not be allocative period-by-period because of implicit contracts or quasi-fixity. This might be particularly true for disaggregate data and seems to be confirmed by relatively high volatility of input shares at an industry level. However, even having in mind these limitations, an extension of the baseline model to more general functional forms might be useful anyway, and will be performed as a robustness check for the results obtained from the baseline model.

2.2. Explaining productivity growth in catching-up economies

The derivations from the previous section were carried out at a firm level, whereas the empirical analysis will be concentrated at an industry level. Following endogenous growth models,[14] positive externalities may be expected to emerge while aggregating innovation activity of individual firms via knowledge spillovers or incomplete property rights.

[13] An alternative would be to hold factor shares constant across countries, which, however, neglects the possibility that different industries in different countries may have access to different technologies.

[14] See e.g. Griliches (1979) and Romer (1986).

Before we introduce knowledge as one of the factors driving productivity growth, it is useful to see how innovation activity is considered in national accounts. It has to be noted that national accounts data include all inputs employed by an industry, and not only those used directly in the production process. This means that firm-specific innovation activity is partly considered in inputs, in that they include e.g. research workers, capital used for research or non-capital innovation expenditures (i.e. those classified in national accounts as intermediate input). However, as pointed out by Romer (1990), knowledge is unrivalled[15] and only partly excludable, which allows one to write an industry's MFP level (*A*) as a function of effective industry-specific stock of knowledge (*W*) and other factors (*V*):[16]

$$A = f(W, V). \tag{8}$$

It is important at this stage to see that this formulation, by allowing for knowledge spillovers, implies increasing returns to scale at an industry level, hereby incorporating this crucial postulate of endogenous growth theory.

On the assumption of separability between effective stock of knowledge and other inputs (capital, labour and intermediate inputs), the rate of MFP growth can be derived from equation (8) by logarithmic differentiation with respect to time:

$$da = e^{W} dw + e^{V} dv, \tag{9}$$

where $e^{W} \equiv \frac{dQ}{dW}\frac{W}{Q}$ and $e^{V} \equiv \frac{dQ}{dV}\frac{V}{Q}$ are elasticities of output with respect to knowledge stock and residual influences respectively, and lower case letters denote natural logarithms. Further assuming zero or very small depreciation of the stock of knowledge, equation (9) can be rewritten as:

$$da = \rho \frac{R}{Q} + e^{V} dv, \tag{10}$$

[15] The unrivalled nature of knowledge, together with the fact that it is partly included in inputs, shows that the assumption on *F* being homogeneous of degree one at a firm level is stronger than it looked at first glance. However, since the fraction of inputs employed at innovation activities is usually small on average, this should not have serious consequences for further analysis.

[16] See e.g. Griliches and Lichtenberg (1984) for a similar formulation of industry-level productivity.

where R is real expenditure on knowledge and $\rho \equiv \frac{dQ}{dE}$ is the marginal product of knowledge.[17] Moving to discrete time finally yields:

$$\Delta a_t = \rho \frac{R_{t-1}}{Q_{t-1}} + e^V \Delta v_t \,. \tag{11}$$

This specification implies a direct effect of investment in knowledge on productivity growth, which is consistent with standard theoretical models of endogenous growth. The natural extension of equation (11) is to substitute the abstract term $e^V \Delta v_t$ for variables representing factors other than innovation that might have an impact on MFP growth.

Following Griffith, Redding and Van Reenen (2001), we first allow for the transfer of technology from the technology leader (called the frontier country) to a country behind the technological frontier.[18] First, the transfer might be instantaneous, meaning that MFP growth in the frontier country induces faster MFP growth in the catching-up country in the current period. Second, taking into account convergence effects, the rate of MFP growth should depend on the gap between the frontier and non-frontier country. Thus, equation (11) becomes:

$$\Delta a_t = \rho \frac{R_{t-1}}{Q_{t-1}} + \alpha_1 \Delta a_t^F + \alpha_2 \left(a_{t-1} - a_{t-1}^F \right), \tag{12}$$

where superscript F corresponds to the frontier country.

Furthermore, MFP growth may depend on a set of institutional factors (e.g. product and labour market regulations – see Scarpetta and Tressel (2002)), market structure (e.g. ownership, monopolisation), market openness (measured for instance as import penetration), international competitiveness (usually approximated by export share) or other characteristics influencing efficiency. Including such a set of variables might be particularly important in the case of transition economies, implementing reforms that lead to rapid transformation of economic environment. A general review of the data shows that a significant part of efficiency gains in Poland's manufacturing firms was achieved by

[17] More precisely, since various components of knowledge expenditures were already accounted for while deriving productivity from a production function, ρ should be viewed as an excess social marginal product of knowledge rather than the total rate of return to knowledge (see Cameron (1998) or Guellec and Van Pottelsberge (2001) for more detailed comments or references, and Schankerman (1981) for a discussion of the exactness of this interpretation).

[18] Technology transfer is understood as not only that involving genuine technical improvements, but also organisational progress, including e.g. adoption of more effective management solutions.

cuts in employment,[19] which was possible (or necessary) only after some barriers had been removed. Adding variables that could capture this and similar transition-related effects is crucial for robustness of estimates obtained for other variables, including measures of innovation activity. Thus, our specification becomes:

$$\Delta a_t = \rho \frac{R_{t-1}}{Q_{t-1}} + \alpha_1 \Delta a_t^F + \alpha_2 \left(a_{t-1} - a_{t-1}^F \right) + \sum_k \beta_k X_{kt-1} \,, \qquad (13)$$

where X_k is the set of variables representing the above mentioned factors.

The next step is to expand the dimension by disaggregating the variables and allowing for industry specific effects. If technology can be transferred only between the same types of industries in the frontier and non-frontier country and if all other variables in equation (13) have an industry dimension, the final specification becomes:

$$\Delta a_{it} = \rho \frac{R_{it-1}}{Q_{it-1}} + \alpha_1 \Delta a_{it}^F + \alpha_2 \left(a_{t-1} - a_{t-1}^F \right) + \sum_k \beta_k X_{kit-1} + s_i \,, \qquad (14)$$

where subscript i stands for a given industry and s_i denotes its specific characteristics (constant over time).

Similarly to Griffith, Redding and Van Reenen (2001), if we assume that equation (14) holds true for the frontier country as well (the only difference is that there is no technology transfer to the frontier country, i.e. $\alpha_1 = 0$ and $\alpha_2 = 0$), long-run determinants of the MFP level can be derived by considering a steady-state equilibrium. In a steady-state equilibrium, independent variables are constant over time and MFP in industry i grows at the same constant rate both in the frontier and non-frontier country. Combining equation (14) for the frontier and non-frontier country and solving for the level of MFP in the non-frontier country yields:

$$a_i = a_i^F - \frac{1}{\alpha_2} \left(\rho \frac{R_i}{Q_t} + \sum_k \beta_k X_{ki} + s_i - (1-\alpha_1) \left(\rho \frac{R_i^F}{Y_i^F} + \sum_k \beta_k X_{ki}^F + s_i^F \right) \right). \qquad (15)$$

Catching-up implies $\alpha_2 < 0$, so the level of MFP in the follower country depends positively on its own investment in innovations and the speed of technology transfer. Since the level of MFP in the non-frontier country is also dependent on the MFP level in the frontier country, it depends indirectly on investment in knowledge undertaken by the technology leader.

[19] From 1994 to 2002, total employment in Poland's manufacturing was decreasing at an average annual rate of over 2%.

3. Variable description, measurement issues and data

3.1. MFP in Polish and German manufacturing

The econometric analysis that follows in section 4 will be conducted on a panel of manufacturing industries, consisting of yearly observations for 21 industries (two- or three- digit industries according to the ISIC classification) covering the period 1994-2002.[20]

For lack of consistent time series for other new member states (particularly on hours worked and capital stock), the rest of the paper concentrates on the case of Poland. Although all ten countries that joined the EU on 1 May 2004 are not a homogenous group, at least the largest of them (Poland, Hungary, the Czech Republic, Slovakia, Slovenia, Lithuania, Latvia and Estonia) share similar experiences over last decades. This makes one hope that the results obtained for Poland, whose GDP accounts for nearly a half of the ten new members' GDP, can be viewed as a very rough approximation for the whole region. On the other hand, some empirical research suggests that there might be significant differences in the sources of growth across the Central and Easter European countries in terms of the relative importance of changes in factor inputs and productivity (see e.g. Doyle, Kuijs, Jiang (2001)). Therefore, one has to be cautious while extrapolating the results obtained in this paper to other new member states.

According to the framework derived in section 2.2, one of the sources of MFP growth in a catching-up economy is technology transfer from the technology leader. Ideally, we would like to have a_i^F denoting MFP level of a world technology leader in industry *i*.[21] In the context of this paper, a natural candidate for the frontier country could be a hypothetical economy consisting of industries with the highest MFP level among EU-15 countries. Unfortunately, consistency and comparability of disaggregate data for the old EU member states are far from perfect. For this reason, Germany was chosen as a technology frontier country for Poland. What justifies this choice is that Germany is the biggest economy in the EU, the most important trade partner and major FDI exporter to most of the new member states. From a practical point of view, it is also important that there is a high degree of comparability between Polish and German statistics.

[20] The productivity measures are derived for an individual enterprise, so ideally one would prefer to use firm-level data at this stage. As pointed out by Basu and Fernald (2000), productivity aggregation might not be trivial if firms are not homogenous. However, this is likely to be a marginal problem at a two-digit level of aggregation.

[21] This approach is followed by Griffith, Redding and Van Reenen (2001) or Scarpetta and Tressel (2002). Both papers deal with MFP convergence across developed countries.

There are still some issues that have to be addressed before applying the formulas derived in the previous section to calculating MFP growth and levels. For a Cobb-Douglas production function, the input shares are constant by assumption, so one can easily rewrite equation (6) in discrete time using first difference operators:

$$\Delta a = \Delta q - (s_{\tilde{K}} + s_E)\Delta e - s_{\tilde{L}}(\Delta h + \Delta l) - s_M \Delta m . \qquad (16)$$

While, with the assumptions made so far, equation (16) can be used to calculate MFP growth in a way that controls for time-varying capacity utilisation, the comparisons of MFP levels are more problematic. To see this, it suffices to notice that formula (5) could be applied to the levels only if we knew the values of β, or at least the proportion between β's for the compared country-industries. Not having such a priori knowledge, the relative MFP levels for a base year will be calculated using the raw capital stock for 2001, with an implicit assumption that for that year utilisation of the capital stock in both countries was similar. Given relative MFP levels in the base year, the remaining levels will be calculated by compounding MFP growth rates obtained from equation (16). Unless changes in capital utilisation are perfectly synchronised between the compared countries, the estimates of the relative MFP levels are not robust to the choice of the base year.

This is not the only problem with comparing MFP levels across different objects. In general, there is no known measure of relative MFP that does not rely on some additional assumptions. In particular, a somewhat arbitrary, though natural, assumption inherent to the measure used in this paper (defined by equation (7)) is to choose K_0, L_0, M_0, E_0 as cross-country averages instead of using e.g. the values for only one chosen country.[22] Another problem are cross-country differences in the quality of the inputs. Needless to say, some distortions due to imperfections in comparability of data across countries cannot be excluded, either. All these considerations lead to a conclusion that one should be very cautious while interpreting relative MFP levels across different objects. Fortunately, as it will be discussed later, the estimates obtained from the econometric analysis in the next section are not sensitive to the measure used for relative MFP levels in the base year, since the differences enter the equations in a log-additive way and are netted out by industry-specific constants.

The data needed to calculate MFP growth and levels for Poland and Germany for the period 1994-2002 was taken from each country's national accounts (gross output, intermediate consumption, labour compensation of employees, total employment, capital stock) and supplemented by industry statistics (hours worked, energy consumption). Most

---

[22] This may lead to different results only if the relative proportions of the inputs differ across countries, which is most often the case.

of this data can also be found in OECD Structural Analysis Database (STAN). All currency conversions were made with Purchasing Power Parities published by OECD.

Table 3. MFP in Polish and German manufacturing

Symbol	Industries	MFP level in Poland 1994[a]	MFP level in Poland 2001[a]	MFP growth in Poland[b]	MFP growth in Germany[b]
D	**Manufacturing**	66	79	2.7	0.3
15	Food products and beverages	78	91	2.0	-0.2
17	Textiles	66	81	2.1	-0.9
18	Wearing apparel and furriery	47	67	3.7	2.0
19	Leather and leather products	71	81	1.0	-0.6
20	Wood and wood, straw and wicker products	73	78	0.5	-0.1
21	Pulp and paper	74	88	2.8	0.5
22	Publishing, printing and reproduction of recorded media	87	95	2.5	0.8
23	Coke and refined petroleum products	86	82	-0.1	1.5
24	Chemicals and chemical products	75	82	2.5	0.5
25	Rubber and plastic products	58	81	4.5	0.0
26	Other non-metallic mineral products	54	81	4.4	-1.4
27	Basic metals	76	73	1.1	0.7
28	Metal products	56	80	4.6	-0.1
29	Machinery and equipment n.e.c.	52	71	5.3	0.7
30	Office machinery and computers	49	93	9.5	-0.4
31	Electrical machinery and apparatus n.e.c.	54	78	4.2	-0.6
32	Radio, television and communication equipment and apparatus	65	99	5.8	-0.1
33	Medical, precision and optical instruments, watches and clocks	63	87	4.1	1.1
34	Motor vehicles, trailers and semi-trailers	63	77	3.4	0.4
35	Other transport equipment	68	67	1.2	1.8
36	Furniture; manufacturing n.e.c.	67	80	2.9	-0.1

[a] relative to Germany (Germany=100).

[b] yearly average over 1994-2002.

Source: Own calculations.

Table 3 presents MFP developments in Polish manufacturing industries relative to their German counterparts. Point estimates of MFP levels are presented in order to provide some general overview.[23] However, in view of the limitations mentioned before, one should rather concentrate on MFP trends, which are robust to the choice of the base-year MFP level.

Looking at Table 3, a strong convergence effect between Poland and Germany can be seen in almost all manufacturing industries. The average rates of growth observed in Polish manufacturing industries were significantly higher than those of their German counterparts. This led to a sizeable decrease in the productivity gap between these two economies. Although, as mentioned before, the levels should be interpreted cautiously, the estimates presented in Table 3 seem to confirm the hypothesis that a substantial part of the labour productivity gap that still exists between Polish and German manufacturing is due to relatively low capital intensity in the former. This observation turned out to be robust to the choice of measure used for MFP level comparisons, i.e. the gap in MFP was always smaller than that in labour productivity.[24]

For the purpose of further analysis it might be interesting to decompose productivity growth in total manufacturing into within-industry and between-industry movements. This can be done according to the formula:[25]

$$\frac{\Delta A}{A} = \sum_j \frac{\Delta A_j}{A_j} \frac{A_j}{A} \overline{\omega}_j + \sum_j \Delta \omega_j \frac{\overline{A}_j}{A}, \tag{17}$$

where j indexes industries, A is MFP level and ω denotes weights calculated as ratios of an index of inputs in an industry to an index of inputs in manufacturing. Both A and ω are calculated using input shares for total manufacturing. The first term on the right-hand side of equation (17) captures the contribution of productivity growth within industries and will be called productivity growth effect. The second term measures how the reallocation of resources between industries contributes to growth in manufacturing (share effect).[26]

[23] See Appendix for a rough sensitivity analysis of the estimated relative MFP levels.

[24] Experimenting with various measures of productivity involved changing the base year for capital stock comparisons and normalisation of inputs.

[25] See Bernard and Jones (1996).

[26] Since in our framework we account for changes in factor utilisation, a positive contribution of the share effect does not necessarily mean that relatively more workers were hired or more investment took place in more productive industries. It could be as well that in more productive industries employees worked longer hours and capital was better utilised.

Table 4. Sources of productivity growth in manufacturing[a]

	Productivity growth effect	Share effect	Total
Poland	96.2	3.8	100.0
Germany	110.6	-10.6	100.0
Catch-up	94.6	5.4	100.0

[a] 1994-2002.

Table 4 presents the sources of productivity growth in manufacturing from 1994 to 2002, using the decomposition given by equation (17). It can be seen that productivity growth within industries accounts for a bulk of productivity growth in total manufacturing. The share effect was negligible in Poland and even negative in Germany, which may suggest the existence of barriers inhibiting effective reallocation of resources across industries.[27]

Differences in productivity growth rates within industries in both countries explain almost 95% of convergence that could be observed from 1994 to 2002. This implies that focusing on factors driving productivity growth within manufacturing industries provides a good approximation for the total manufacturing sector.

3.2. Structural variables

Using the derivations from section 2.2, one can classify the potential factors explaining MFP growth into four groups, so that the general model explaining changes in MFP in Poland can be formulated as:

$$\Delta a = f(\textit{Technology transfer, Innovation, Reforms, Individual characteristics}).$$

In the econometric analysis following in section 4, we consider several indicators representing each of these groups.

Given the data available, the most natural variables entering 'Technology transfer' block are the contemporaneous MFP growth rate in Germany and the difference between lagged MFP level in Poland and Germany. The former can be viewed as a proxy for immediate technology transfer from the technology frontier country, the latter corresponds

[27] Lenain and Rawdanowicz (2004) apply a conceptually similar decomposition of labour productivity growth at a more aggregate level in Poland, Hungary, Czech Republic and Slovakia, concluding that the contribution of the share effect in the region was disappointing, given the early stage of convergence.

to a standard convergence assumption, according to which the pace of catching-up process depends positively on the distance to the leader.[28]

As regards the 'Innovation' block, several variables will be taken into consideration. The most natural candidates are R&D or innovation intensity, defined as the ratio of R&D outlays or innovation expenditures[29] to gross output (*RDQ* and *INQ*, respectively). It would also be sensible to include in this group a variable approximating the level of human capital, although finding an appropriate indicator having an industry dimension is not easy. One of the variables we try will be the share of white-collar workers in total employment, serving as a proxy for employees' innovativeness and absorption capabilities (*WCO*).

As mentioned earlier, a large set of variables forming the block 'Reforms' could be considered. Our aim is to find those that could serve as a proxy for competition and efficiency. In order to extract the impact of market reforms contributing to an increase in efficiency and competitiveness of domestic enterprises, including their increased flexibility in cutting excessive employment, we use the Herfindahl-Hirschmann index of market concentration (*HHR*). Other variables that could be considered in this block are indicators reflecting competition from abroad. These will include: import penetration (*IMP*), defined as the share of imports in domestic demand, and export share in total output (*EXP*).

Following recent empirical studies underlining the importance of information and communication technologies (ICT) in explaining productivity growth in the 1990s,[30] a variable serving as a proxy for ICT investment intensity also will be considered. We define variable *ITQ* as a share in gross output of intermediate input of goods and services

[28] Looking at Table 3, this assumption seems to be confirmed by the data. The Polish industries that in 1994 were further behind their German counterparts, recorded on average higher rates of MFP growth in subsequent periods (the correlation between the third and the fifth column in Table 3 is –0.74).

[29] Innovation expenditures include R&D activity, acquisition of disembodied technology and know-how (patents, non-patented inventions, licences, disclosures of know-how, trademarks etc.), acquisition of fixed assets required for the introduction of innovation, preparations for the implementation of innovations, training directly linked to technological innovations and marketing for technologically new and improved products. See GUS (2004).

[30] See e.g. Jorgenson and Stiroh (2000) for the United States or Van Ark and Piatkowski (2004) for Europe, including the EU acession countries.

originating from two industries (both domestic and foreign), which are manufacture of office machinery and computers and computer services.[31, 32]

The last structural indicator we consider is the share of foreign capital in an industry's total assets (*FCA*). This variable cannot be easily classified, since it is likely to capture not only the effect of privatisation (block 'Reforms'), but also that of technology transfer accompanying FDI inflows.

Finally, individual characteristics of each industry will be considered by including industry-specific fixed effects into each regression.

The main sources of data were official publications of Poland's Central Statistical Office (GUS). One of the exceptions was the HH index, calculated using microdata from company reports (F-01). Indicators of import penetration and export share in sales were taken from OECD STAN database and are available for 18 manufacturing industries. All variables cover the period 1994-2002, except for *HHR* and *ITQ*, which start from 1995.

4. Empirical analysis

4.1. Econometric specification and estimation issues

Before proceeding to estimation of various versions of equation (14), several technical issues have to be addressed. The specification derived in section 2 allows for cross-section heterogeneity by including industry-specific constants, which suggests that the Within Groups estimator should be used, preferably also controlling for heteroscedasticity in the residuals.

However, it is important to notice that our specification is an equilibrium correction model (with additional explanatory variables), so it can be viewed as an

---

[31] This means that we account only for a part of ICT input defined by OECD and what we measure perhaps should be called IT input. Adding inputs from other ICT producing industries would require time series on a more disaggregate level, which are not available for Poland.

[32] There are at least two ways in which the impact of ICT can be introduced into the theoretical framework derived in section 2.2. One is to treat ICT as one of the general factors increasing efficiency, which means that ICT would be included in the vector X_k. Alternatively, ICT expenditures can be also viewed as investment in ICT knowledge, which would mean that it augments the total stock of knowledge (E). Assuming that ICT and non-ICT knowledge are separable and the elasticities of output with respect to these knowledge stocks might be not equal, and further proceeding similarly as while deriving (10), equation (14) could be augmented with the term $\delta \frac{I_{it-1}}{Q_{it-1}}$, where I is ICT expenditure and δ is the (excess) marginal product of ICT knowledge.

autoregressive distributed lag model (here ADL(1,1)) with a restriction imposed on long-run homogeneity.[33] This implies that the Within Groups estimator may be considerably biased if the number of time periods available is small.[34] Given the time dimension of the data set used in this paper, this bias should not be very large. However, it might be useful to assess the size of this bias.

Dynamic panel data models are usually estimated using Generalised Method of Moments (GMM) techniques in the framework developed by Arellano and Bond (1991) and then extended by Arellano and Bover (1995) and Blundell and Bond (1998). The approach proposed by the latter is often called system GMM and is particularly suited for persistent series, i.e. close to random walk. According to standard economic theory, productivity levels are usually assumed to have a unit root or at least to be highly persistent.[35] Therefore we use the system GMM estimator as a benchmark for the Within Groups estimator.

Table 4 presents the estimation results for a simple equilibrium correction model, based on ADL(1,1) process only, i.e. without additional explanatory variables. To control for possible heteroscedasticity, all residuals were weighted during estimation.

Table 5. Preliminary regressions

Regressors	Coefficients (standard errors)			
Δa_t^F	-0.054	-0.056	0.061	0.078
	(0.168)	(0.110)	(0.134)	(0.727)
$a_{t-1} - a_{t-1}^F$	-0.111	-0.107	-0.113	-0.112
	(0.039)	(0.025)	(0.025)	(0.024)
Autocorrelation[a]	-1.27	2.09	1.92	1.92
Sample (adjusted)	95-02	94-02	95-02	95-02
Method of estimation	System GMM	WG	WG	2SLS

[a] second-order autocorrelation test (asymptotically N(0,1)) for system GMM, first-order Durbin-Watson statistics for WG and 2SLS

[33] This means that MFP levels in a frontier and non-frontier country are assumed to be equal in equilibrium.

[34] See Greene (2001).

[35] Standard unit-root tests for panel data indicate that MFP levels in Polish and German manufacturing are integrated of the order one.

If the bias is significant, it should be observed in the coefficient corresponding to the gap term ($a_{t-1} - a_{t-1}^F$).[36] As it can be seen from Table 5, system GMM and WG estimates of the gap term coefficient are slightly different, provided that all available observations are used. However, in order to have a consistent instrument for the first observation, the system GMM estimator reaches deeper in the past, which truncates the effective sample. Adjusting the sample accordingly while using the Within Groups estimation makes the discrepancy hardly visible.

It seems that in our case the Within Groups estimator produces results very close to those obtained from the unbiased system GMM estimator. What is worth stressing, however, is that the Within Groups estimator is much more efficient and does not need to truncate the effective sample.[37] The latter advantage of the Within Groups estimator is particularly important in our case, since productivity growth is generally viewed as a long-term concept.

Finally, there is one more potential problem with estimating equation (14), which is the possible endogeneity of the immediate technology transfer term (Δa_t^F). As pointed out by Griffith, Redding and Van Reenen (2001), the weak exogeneity assumption for this term might not hold if there are common shocks in an industry that are not controlled for by other variables used in the estimated regressions. In order to check whether this may distort our results, we reestimate our preliminary specification instrumenting the immediate technology transfer term with past R&D intensity.[38] The results are reported in the last column of Table 5. As can be clearly seen, the point estimates do not change much compared to the results obtained from the Within Groups estimation run on an adjusted sample, while the instrumented term is estimated with a significantly lower precision.

Given the results of preliminary regressions, one can conclude that in our case the advantages of using instrumental variable procedures are rather small and seem to be outweighed by disadvantages resulting from the loss of precision in the estimates of structural parameters.[39] Thus, all estimation that follows in the next section will be run using the Within Groups estimator.

---

[36] This is where the autoregressive part is implicitly present.

[37] In general, system GMM estimator is best suited for models with a large number of cross-section units, each observed for a small number of time periods. See Bond (2002).

[38] This seems natural when one considers equation (14) rewritten for the frontier country.

[39] It has to be stressed that this sort of dilemmas are due to problems with finding good instruments for endogenous explanatory variables. This issue is particularly important in small samples, where weak instruments may lead to larger biases than simpler non-instrumental variable approaches (see e.g. Nelson and Startz (1990)).

4.2. Regression results

We use the variables described in section 3 to estimate a model explaining productivity growth in Poland's manufacturing, in line with the general specification given by equation (14). In order to avoid redundancy and collinearity problems, blocks 'Innovation' and 'Reforms' are represented by one variable each. The main results are reported in Table 6.

The estimates confirm the strong convergence effect between Polish and German manufacturing industries. The gap term enters negatively and is statistically significant in all specifications, implying that the larger the distance to the technology frontier, the higher the rate of productivity growth. The speed of convergence is nearly twice as high compared to international studies for developed economies (see e.g. Griffith, Redding and Van Reenen (2001)), meaning that the technological catching-up process in Poland was quite rapid.

In line with theories of endogenous growth, we interpret these results as a transfer of technologies that were developed or absorbed by the frontier economies some time ago. Contrary to this finding, the coefficient by the variable indicating contemporaneous productivity growth at the frontier is low and statistically insignificant in most of specifications, indicating that immediate technology transfer between Polish and German manufacturing industries might have been very limited.

We find a strong and positive effect of innovation intensity on productivity growth in Poland. The estimates are particularly high in the case of R&D intensity, which should not be surprising given its low level in Poland. In 2001, R&D share in gross output in Poland's manufacturing was only 0.3%, compared to 2.5% in Germany. Highly significant coefficients were also obtained for total innovation intensity, in which case the lower estimates reflect the fact that R&D expenditures in Poland accounted on average for only 10% of total innovation expenditures.

According to the estimation results, lower market concentration, measured as HH index, helped productivity to grow. This can be interpreted as a result of breaking-down and streamlining inefficient (mostly state-owned) enterprises and springing-up of small private companies, following the market-oriented reforms introduced in the 1990s.

There is some evidence that increased competition from abroad, measured by import penetration, also contributed positively to productivity growth. The estimated coefficient in regression 6 looks low, but it is statistically significant at 5% level. It is worth noting, however, that the potential impact of increased imports might be ambiguous. On the one hand, it is likely to stimulate efficiency in domestic enterprises.

On the other hand, too strong competition may crowd some of them out of the domestic market.[40]

The positive impact of reforms seems to be confirmed by regressions 9 and 10, in which the variable denoting the share of foreign capital enters positively and significantly. This might suggest that the privatisation process contributed to an increase in overall efficiency, probably by organisational improvements and acceleration of the technology inflow from foreign companies investing in Poland.

It is important to note that including variables from block 'Reforms' did not lead to sizeable changes in the contribution of innovation activity to explaining productivity growth. This indicates that innovation matters even if we control for transition-specific effects.

Finally, regressions 7 and 8 show that by increasing expenditures on information technologies, Poland's manufacturing companies could improve their productivity.

The regressions (not reported in Table 6) including two remaining variables (*WCO* and *EXP*) yielded estimates of the expected sign, however the coefficients were not significant at conventional levels. The problem with the variable defined as the share of white-collar workers in total employment is that it might be very weakly correlated with the actual level of human capital. For example, it fails to capture an increase in work experience of the staff. As regards the share of exports in total output, other studies suggest that causality may be from productivity to exporting, i.e. high productivity helps to compete with other countries rather than the presence on the world markets increases productivity.[41]

It is sometimes argued that the high contribution of innovation to productivity growth, found using an econometric approach similar to that followed in this paper, might result from omitting in the estimated regressions other important variables, most often the unobserved ones. Typical candidates here could be factors enhancing disembodied productivity, such as better managerial and organisational practices or learning by doing (see e.g. Comin (2004)). While these factors might be important for productivity growth, it is hard to explain why they should be correlated with past innovation effort.

[40] See e.g. Miller and Upadhyay (2002), who found that openness to foreign trade can have a particularly negative impact on productivity in countries with a low human capital stock.

[41] See Bernard and Jensen (1999).

Table 6. Regression results

Regressors		Coefficients (standard errors)									
		1	2	3	4	5	6	7	8	9	10
Techno-logy transfer	Δa_t^F	0.061	-0.065	0.032	-0.218	0.005	-0.188	-0.221	-0.190	-0.099	0.167
		(0.134)	(0.070)	(0.125)	(0.107)	(0.110)	(0.101)	(0.193)	(0.126)	(0.108)	(0.109)
	$a_{t-1} - a_{t-1}^F$	-0.113	-0.117	-0.124	-0.120	-0.141	-0.151	-0.117	-0.136	-0.191	-0.191
		(0.025)	(0.018)	(0.016)	(0.021)	(0.031)	(0.023)	(0.024)	(0.024)	(0.024)	(0.024)
Innovation	RDQ_{t-1}		4.522		5.215		5.166	5.163	4.401	5.635	5.434
			(0.904)		(0.755)		(0.666)	(0.685)	(1.088)	(0.896)	(0.959)
	INQ_{t-1}			0.451		0.406					
				(0.190)		(0.170)					
Reforms	HHR_{t-1}				-0.282	-0.246			-0.379		
					(0.095)	(0.176)			(0.174)		
	IMP_{t-1}						0.045				
							(0.022)				
	ITQ_{t-1}							0.345	0.423		0.294
								(0.138)	(0.132)		(0.169)
	FCA_{t-1}									0.302	0.170
										(0.053)	(0.104)
DW		1.92	1.95	1.96	2.18	2.26	1.78	2.22	2.30	1.90	2.18
Sample (adjusted)		95-02	95-02	95-02	96-02	96-02	95-02	96-02	96-02	95-02	96-02

As mentioned before, another dimension omitted in this paper due to data availability is improvement in quality of the inputs. However, a variable controlling for high and low investment periods[42] did not enter the regressions in a statistically significant way and adding it did not lead to changes in the main results. Finally, even if innovation effort is highly correlated with (unobserved) labour quality, then this might indicate that the former enhances absorptive capacities of the labour force. However, this still should be viewed as an argument supporting the significance of innovation for productivity growth.

4.3. Robustness of results

As discussed before, several vital assumptions were made while deriving productivity measures. In this section we check whether alternative specifications relying on different assumptions lead to results other than those obtained in the previous section.

First, it has to be noted that the regression results are not sensitive to the choice of a base-year MFP level in Poland relative to that in Germany, as long as the remaining levels are constructed by cumulating the MFP growth rates. This is because of the presence of industry-specific effects in the estimated equations, which net out any changes in MFP levels that enter in a log-additive way. In particular, it means that the results obtained in the previous section remain unchanged whenever we use different measures of K_0, L_0, M_0, E_0 in equation (7), compare MFP levels in the base year using different assumptions on the level of capital utilisation in both countries or apply alternative currency conversions for the base year (e.g. market exchange rates instead of PPPs). In view of it, the estimated industry-specific constants are likely to contain not only individual characteristics of the industries, but also measurement errors.

Changes in the assumptions made while deriving productivity growth rates may have much more serious consequences. The assumptions that need to be addressed include constant returns to scale, perfect competition and a Cobb-Douglas functional form.

Both constant returns to scale and perfect competition assumptions seem to be relatively strong. Unfortunately, there are no reliable studies for European transition economies at an industry level that could verify either of these two hypotheses. Using data from US two-digit manufacturing industries, Basu and Kimball (1997) did not find significant departures from the constant returns to scale assumption. On the other hand, the results obtained by Martins, Scarpetta and Pilat (1996) for 14 OECD countries point to

[42] A rationale for this is that new vintages of capital are introduced more intensively during the periods of high investment activity, which improves the average quality of the capital stock.

positive and statistically significant mark-ups in almost all manufacturing industries, ranging from zero to 30 per cent.

Given the above considerations, we check whether our results change if we relax the assumption on perfect competition.[43] We correct the factor shares by industry specific mark-ups, using estimates from Martins, Scarpetta and Pilat (1996). The authors provide mark-up estimates only for a number of developed economies, including Germany, but not for Poland. Therefore, we assume that the mark-ups are the same in both countries. Allowing for imperfect competition does not significantly change our main results. The precision of the estimates is on average even better compared to our baseline specification.

Finally, since a standard Cobb-Douglas model is sometimes questioned as too restrictive, we reestimate all regressions using MFP growth rates derived from a translog production function.[44] For this functional form, Törnqvist indexes are exactly correct and calculating them only requires replacing constant input shares in formula (16) with average input shares in adjacent periods.[45] Allowing for a more flexible production function does not lead to sizeable changes in the estimated regressions, so we conclude that our results are robust to this more general specification.[46]

5. Conclusions and policy implications

This paper considers productivity developments in the new EU member states and, concentrating on Poland's manufacturing, provides evidence on factors driving productivity growth in these countries over the last decade. One of the reasons why an average worker in the new EU member states still produces only about half the amount of goods and services that are produced in the pre-enlargement EU are differences in capital intensity. However, it is rapid growth in (multifactor) productivity that seems to be crucial for the pace of convergence.

---

[43] As pointed out by Romer (1990), monopolistic profits might be an essential incentive for the firms to invest in innovation. This idea goes back at least to Schumpeter, see also Nordhaus (1969).

[44] See e.g. Greene (2001).

[45] See Caves, Christensen and Diewert (1982) for derivation.

[46] It is often argued that high volatility of factor income shares at a disaggregate level is due to measurement errors. While still assuming that output elasticities may change over time, a smoothing procedure might be justified (see e.g. an approach proposed by Harrigan (1997), exploiting the properties of a translog production function). This would bring the regression results obtained from a translog production function even closer to our baseline specification.

Analysing a panel of Polish and German manufacturing industries, a significant convergence effect can be found, resulting in a sizeable decrease in the productivity gap between most of respective manufacturing industries in both countries. A more in-depth analysis of factors behind this catch-up process leads to the following findings.

First, companies in Poland seem to benefit significantly from transfer of technologies that have been accumulated in more developed economies some time ago. By contrast, we find no strong evidence on significant contribution of immediate technology transfer. Second, there is a statistically and quantitatively significant effect of domestic innovation activity on productivity growth in Poland. Finally, there are signs that market reforms, including privatisation and liberalisation, also boosted efficiency, whereas the effect of reallocation of production factors towards more productive activities was marginal.

In view of possible methodological and data-related caveats, caution is required while interpreting the results. Moreover, since the econometric analysis focuses on the case of Poland, the findings may not necessarily be relevant for all other new EU member states. However, bearing in mind all these limitations, several policy implications could be ventured.

An important condition for fast convergence towards EU-15 countries is to support innovation in new member states. This is in contrast to some of opinions claiming that, following EU-entry, an increased foreign direct investment inflow will suffice to ensure fast technological progress in the medium term and that domestic innovation gains much importance only when the technology gap becomes relatively small. This paper suggests that it might be as well possible that a sizeable part of the potential technology transfer has already taken place and foreign companies might tend to use brand-new technologies rather domestically, transferring them abroad with a significant lag. Moreover, if the level of innovativeness in a country is low, possible positive spillovers from foreign direct investment might be very limited (see e.g. Kinoshita (2001)). Adding to it stalled reforms in some sectors, inhibiting reallocation of resources to more productive industries, could then result in a sizeable deceleration in productivity growth in the new member countries over the medium term. This issue is even more important, given that most of "easy" gains in productivity resulting from removing inefficiencies accrued over the command-economy period have already dried up.

This paper shows that all these aspects should be taken into account while assessing growth perspectives in the new EU members over the medium to long term perspective. In particular, domestic innovation activity should not be neglected while building endogenous growth models for catching-up economies, which makes the case for models based on the concept of conditional rather than unconditional convergence.

References

Arellano M., Bond S.R., 1991, Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations, Review of Economic Studies Vol. 58

Arellano M., Bover O., 1995, Another Look at the Instrumental-Variable Estimation of Error-Components Models, Journal of Econometrics Vol. 68

Basu S., Fernald J., 2000, Why is Productivity Procyclical? Why do we care?, NBER Working Paper No. 7940

Basu S., Kimball M., 1997, Cyclical Productivity with Unobserved Input Variation, NBER Working Paper No. 5915

Bernard A.B., Jensen J.B., 1999, Exporting and Productivity, NBER Working Paper No. 7135

Bernard A.B., Jones C.I., 1996, Comparing Apples to Oranges: Productivity Convergence and Measurement Across Industries and Countries, American Economic Review Vol. 86 No. 6

Bernard A.B., Jones C.I., 1996, Productivity across Industries and Countries: Time Series Theory and Evidence, The Review of Economics and Statistics Vol. 78 No.1

Blundell R.W., Bond S.R., 1998, Initial Conditions and Moment Restrictions in Dynamic Panel Data Models, Journal of Econometrics Vol. 87

Bond S.R., 2002, Dynamic Panel Data Models: A Guide to Micro Data Methods and Practice, Working Paper No. 09/02, Institute for Fiscal Studies, London

Bruno M., 1978, Duality, Intermediate Inputs and Value Added, In: Fuss M., McFadden D. (Eds.), Production Economics: A Dual Approach to Theory and Applications Vol. 2, North-Holland, Amsterdam

Cameron G., 1998, Innovation and Growth: a survey of the empirical evidence, Nuffield College, Oxford

Carlsson M., 2000, Measures of Technology and the Short-Run Responses to Technology Shocks – Is the RBC-Model Consistent with Swedish Manufacturing Data?, Working Paper Series 2000:20, Uppsala University, Department of Economics

Caves D.W., Christensen L.R., Diewert W.E., 1982, The Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity, Econometrica Vol.50

Comin D., 2004, R&D: A Small Contribution to Productivity Growth, NBER Working Paper No. 10625

Diewert W.E., 1974 Applications of Duality Theory, In: Intriligator M.D., Kendrick D.A. (Eds.), Frontiers of Quantitative Economics Vol. 2, North-Holland, Amsterdam

Doyle P., Kuijs L., Jiang G., 2001, Redl Convergence to EU Income Levels: Central Europe from 1990 to the Long Term, IMF Working Paper No. 01/146

Estevão M.M., 2004, Why Is Productivity Growth in the Euro Area So Sluggish?, IMF Working Paper No. 04/200

Gordon R.J., 1990, The Measurement of Durable Goods Prices, University of Chicago Press

Greene W.H., 2001, Econometric Analysis, Prentice Hall International

Griffith R., Redding S., Van Reenen J., 2001, Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries, IFS Working Paper No. 02/00

Griliches Z., Lichtenberg F., 1982, R&D and Productivity Growth at the Industry Level: Is There still a Relationship? NBER Working Paper No. 850

Griliches Z., 1979, Issues in Assessing the Contribution of Research and Development to Productivity Growth, Bell Journal of Economics No. 10

Grossman G.M., Helpman E., 1991, Innovation and Growth in the Global Economy, MIT Press, Cambridge

Groth C., Gutierrez-Domenech M., Srinivasan S., 2004, Measuring total factor productivity for the United Kingdom, Quarterly Bulletin Spring 2004, Bank of England

Guellec D., van Pottelsberghe de la Potterie B., 2001, R&D and Productivity Growth: Panel Data Analysis of 16 OECD Countries, OECD Economic Studies No. 33

GUS, 2004, Statistical Yearbook of Industry 2003, Warsaw

Harrigan J, 1997, Technology, Factor Supplies and International Specialisation, American Economic Review Vol. 87

Hulten C.R., 1992, Growth Accounting When Technological Change is Embodied in Capital, American Economic Review Vol. 82

Jorgenson D.W., Griliches Z., 1967, The Explanation of Productivity Change, Review of Economic Studies No. 34

Jorgenson D.W., Stiroh K.J., 2000, Raising the Speed Limit: U.S. Economic Growth in the Information Age, Brooking Papers on Economic Activity No. 1

Kinoshita Y., 2001, R&D and Technology Spillovers through FDI: Innovation and Absorptive Capacity, CEPR Discussion Paper No. 2775

Lenain P., Rawdanowicz L., 2004, Enhancing income convergence in Central Europe after EU accession, Working Paper No. 392, OECD, Economics Department

Martins J.O., Scarpetta S., Pilat D, 1996, Mark-up Ratios in Manufacturing Industries. Estimates for 14 OECD Countries, Working Papers No. 162, OECD, Economics Department

Miller S.M., Upadhyay M.P., 2002, Total Factor Productivity, Human Capital and Outward Orientation: Differences by Stage of Development and Geographic Regions, Working Paper No. 2002-33, Department of Economics, University of Connecticut

Nelson C.R., Startz R., 1990, The Distribution of the Instrumental Variables Estimator and Its t-Ratio When the Instrument is a Poor One, The Journal of Business Vol. 63

Nordhaus W.D., 1969, An Economic Theory of Technological Change, American Economic Review Vol. 59

OECD, 2001, Measuring Productivity: Measurement of Aggregate and Industry-Level Productivity Growth, OECD Manual, Paris

Romer P.M., 1986, Increasing Returns and Long-Run Growth, Journal of Political Economy Vol. 94

Romer P.M., 1990, Endogenous Technological Change, Journal of Political Economy Vol. 98

Sahlman W.A., 1999, The New Economy is Stronger than You Think, Harvard Business Review, November-December

Sakellaris P., Vijselaar F., 2004, Capital Quality Improvement and the Sources of Growth in the Euro Area, ECB Working Paper No. 368

Scarpetta S., Tressel T., 2002, Productivity and Convergence in a Panel of OECD Industries: Do Regulations and Institutions Matter? Working Paper No. 28, OECD, Economics Department

Schankerman M., 1981, The Effects of Double-Counting and Expensing on the Measured Returns to R&D, Review of Economics and Statistics Vol. 63

Schreyer P., Pilat D., 2001, Measuring Productivity, Economic Studies No. 33, OECD

Shea J., 1990, Accident Rates, Labor Effort And The Business Cycle, Working Papers 90-28, Wisconsin Madison – Social Systems

Solow R.M., 1957, Technological Change and the Aggregate Production Function, Review of Economics and Statistics Vol. 39

Van Ark B., Piatkowski M., 2004, Productivity, Innovation and ICT in Old and New Europe, Research Memorandum GD-69, University of Groningen

Appendix

As pointed out in section 3.1, there is substantial uncertainty connected with the calculated relative MFP levels presented in Table 3. It may be useful to examine, how much these estimates are sensitive to the assumptions made in our baseline specification. We repeat our calculations, each time changing the base year for capital stock comparisons, using different normalisation of inputs (each country's values of inputs instead of cross-country average values of inputs) or holding factor shares constant across countries.

Table A1. Estimates of MFP level in Polish manufacturing in 2001 (Germany=100)

Symbol	Industries	Minimum	Maximum	Average	Baseline
D	**Manufacturing**	75	83	79	79
15	Food products and beverages	90	98	93	91
17	Textiles	80	86	82	81
18	Wearing apparel and furriery	56	103	80	67
19	Leather and leather products	79	95	84	81
20	Wood and wood, straw and wicker products	76	86	80	78
21	Pulp and paper	85	92	88	88
22	Publishing, printing and reproduction of recorded media	88	105	97	95
23	Coke and refined petroleum products	82	86	84	82
24	Chemicals and chemical products	78	84	82	82
25	Rubber and plastic products	79	90	83	81
26	Other non-metallic mineral products	79	89	84	81
27	Basic metals	70	75	73	73
28	Metal products	76	88	81	80
29	Machinery and equipment n.e.c.	68	76	72	71
30	Office machinery and computers	79	102	92	93
31	Electrical machinery and apparatus n.e.c.	73	83	78	78
32	Radio, television and communication equipment and apparatus	88	106	97	99
33	Medical, precision and optical instruments, watches and clocks	79	97	86	87
34	Motor vehicles, trailers and semi-trailers	74	86	79	77
35	Other transport equipment	65	69	67	67
36	Furniture; manufacturing n.e.c.	74	93	82	80

Source: Own calculations.

The results are reported in Table A1. As expected, the dispersion of MFP level estimates may be quite substantial. Using most extreme assumptions one can even find that in some industries Poland has already surpassed Germany in terms of productivity. However, in all but one industry (wearing apparel and furriery), the average values obtained using various assumptions are very close to our baseline estimates reported in Table 3. All in all, the results confirm that one should rather concentrate on MFP growth rates, using the cross-country relative level estimates for a cautious general overview.

European Central Bank working paper series

For a complete list of Working Papers published by the ECB, please visit the ECB's website (http://www.ecb.int)

435 "Reforming public expenditure in industrialised countries: are there trade-offs?" by L. Schuknecht and V. Tanzi, February 2005.

436 "Measuring market and inflation risk premia in France and in Germany" by L. Cappiello and S. Guéné, February 2005.

437 "What drives international bank flows? Politics, institutions and other determinants" by E. Papaioannou, February 2005.

438 "Quality of public finances and growth" by A. Afonso, W. Ebert, L. Schuknecht and M. Thöne, February 2005.

439 "A look at intraday frictions in the euro area overnight deposit market" by V. Brousseau and A. Manzanares, February 2005.

440 "Estimating and analysing currency options implied risk-neutral density functions for the largest new EU member states" by O. Castrén, February 2005.

441 "The Phillips curve and long-term unemployment" by R. Llaudes, February 2005.

442 "Why do financial systems differ? History matters" by C. Monnet and E. Quintin, February 2005.

443 "Explaining cross-border large-value payment flows: evidence from TARGET and EURO1 data" by S. Rosati and S. Secola, February 2005.

444 "Keeping up with the Joneses, reference dependence, and equilibrium indeterminacy" by L. Stracca and Ali al-Nowaihi, February 2005.

445 "Welfare implications of joining a common currency" by M. Ca' Zorzi, R. A. De Santis and F. Zampolli, February 2005.

446 "Trade effects of the euro: evidence from sectoral data" by R. Baldwin, F. Skudelny and D. Taglioni, February 2005.

447 "Foreign exchange option and returns based correlation forecasts: evaluation and two applications" by O. Castrén and S. Mazzotta, February 2005.

448 "Price-setting behaviour in Belgium: what can be learned from an ad hoc survey?" by L. Aucremanne and M. Druant, March 2005.

449 "Consumer price behaviour in Italy: evidence from micro CPI data" by G. Veronese, S. Fabiani, A. Gattulli and R. Sabbatini, March 2005.

450 "Using mean reversion as a measure of persistence" by D. Dias and C. R. Marques, March 2005.

451 "Breaks in the mean of inflation: how they happen and what to do with them" by S. Corvoisier and B. Mojon, March 2005.

452 "Stocks, bonds, money markets and exchange rates: measuring international financial transmission" by M. Ehrmann, M. Fratzscher and R. Rigobon, March 2005.

453 "Does product market competition reduce inflation? Evidence from EU countries and sectors" by M. Przybyla and M. Roma, March 2005.

454 "European women: why do(n't) they work?" by V. Genre, R. G. Salvador and A. Lamo, March 2005.

455 "Central bank transparency and private information in a dynamic macroeconomic model" by J. G. Pearlman, March 2005.

456 "The French block of the ESCB multi-country model" by F. Boissay and J.-P. Villetelle, March 2005.

457 "Transparency, disclosure and the Federal Reserve" by M. Ehrmann and M. Fratzscher, March 2005.

458 "Money demand and macroeconomic stability revisited" by A. Schabert and C. Stoltenberg, March 2005.

459 "Capital flows and the US 'New Economy': consumption smoothing and risk exposure" by M. Miller, O. Castrén and L. Zhang, March 2005.

460 "Part-time work in EU countries: labour market mobility, entry and exit" by H. Buddelmeyer, G. Mourre and M. Ward, March 2005.

461 "Do decreasing hazard functions for price changes make any sense?" by L. J. Álvarez, P. Burriel and I. Hernando, March 2005.

462 "Time-dependent versus state-dependent pricing: a panel data approach to the determinants of Belgian consumer price changes" by L. Aucremanne and E. Dhyne, March 2005.

463 "Break in the mean and persistence of inflation: a sectoral analysis of French CPI" by L. Bilke, March 2005.

464 "The price-setting behavior of Austrian firms: some survey evidence" by C. Kwapil, J. Baumgartner and J. Scharler, March 2005.

465 "Determinants and consequences of the unification of dual-class shares" by A. Pajuste, March 2005.

466 "Regulated and services' prices and inflation persistence" by P. Lünnemann and T. Y. Mathä, April 2005.

467 "Socio-economic development and fiscal policy: lessons from the cohesion countries for the new member states" by A. N. Mehrotra and T. A. Peltonen, April 2005.

468 "Endogeneities of optimum currency areas: what brings countries sharing a single currency closer together?" by P. De Grauwe and F. P. Mongelli, April 2005.

469 "Money and prices in models of bounded rationality in high inflation economies" by A. Marcet and J. P. Nicolini, April 2005.

470 "Structural filters for monetary analysis: the inflationary movements of money in the euro area" by A. Bruggeman, G. Camba-Méndez, B. Fischer and J. Sousa, April 2005.

471 "Real wages and local unemployment in the euro area" by A. Sanz de Galdeano and J. Turunen, April 2005.

472 "Yield curve prediction for the strategic investor" by C. Bernadell, J. Coche and K. Nyholm, April 2005.

473 "Fiscal consolidations in the Central and Eastern European countries" by A. Afonso, C. Nickel and P. Rother, April 2005.

474 "Calvo pricing and imperfect common knowledge: a forward looking model of rational inflation inertia" by K. P. Nimark, April 2005.

475 "Monetary policy analysis with potentially misspecified models" by M. Del Negro and F. Schorfheide, April 2005.

476 "Monetary policy with judgment: forecast targeting" by L. E. O. Svensson, April 2005.

477 "Parameter misspecification and robust monetary policy rules" by C. E. Walsh, April 2005.

478 "The conquest of U.S. inflation: learning and robustness to model uncertainty" by T. Cogley and T. J. Sargent, April 2005.

479 "The performance and robustness of interest-rate rules in models of the euro area" by R. Adalid, G. Coenen, P. McAdam and S. Siviero, April 2005.

480 "Insurance policies for monetary policy in the euro area" by K. Küster and V. Wieland, April 2005.

481 "Output and inflation responses to credit shocks: are there threshold effects in the euro area?" by A. Calza and J. Sousa, April 2005.

482 "Forecasting macroeconomic variables for the new member states of the European Union" by A. Banerjee, M. Marcellino and I. Masten, May 2005.

483 "Money supply and the implementation of interest rate targets" by A. Schabert, May 2005.

484 "Fiscal federalism and public inputs provision: vertical externalities matter" by D. Martínez-López, May 2005.

485 "Corporate investment and cash flow sensitivity: what drives the relationship?" by P. Mizen and P. Vermeulen, May 2005.

486 "What drives productivity growth in the new EU member states? The case of Poland" by M. Kolasa, May 2005.