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Abstract

Heterogeneity of income per capita across countries is one of the central issues in modern economics of growth. In the past Socialist economies fell behind the West in levels of income per capita. By early 1990-s, when the command-economy experiment was over, perspectives for growth in these economies seemed optimistic. Surprisingly, after two decades of transition in Central-East European economies (CEE) and Russia (CEER) the gap in GDP per capita with Western Europe and the US still exists and mostly caused by labour productivity backwardness of CEERs. To what extent the present backwardness of Eastern Europe and Russia in labour productivity levels is related to such shared features of a past of economic planning as little technological change and distorted economic structure?

We compare three CEE – early reformers (the Czech Republic, Hungary and Slovenia) and a late reformer, Russia, in 1995-2007, focusing three particular issues. First, by means of a detailed industry growth accounting study we show that industrial origins of productivity growth in CEEs and Russia are rather similar. It is driven mainly by industries in the manufacturing sector that appear to be far away from the technology frontier. Second, we analyze the contribution of labour reallocation between industries to aggregate growth. This was expected to be substantial because of elimination of multiple planned economy distortions in the industrial structure. We find that the structural bonus did not materialize in CEEs, and only to a small extent in Russia. The reason for this is that the *initial* variation of productivity levels across industries in first years of transition was relatively low such that the scope for reallocation gains was only small. Third, we analyze patterns in multi-factor productivity growth since 1995 to see, what industries are driving productivity, and why there is a difference in the speed both across industries within a country as well as across countries. To do so, we relate MFP growth to the

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initial technological gap, measured by the level of MFP in 1995. We find that the initial technological gap was deep, such that it would take more time to catch up than had been expected before transition.

1. Introduction

Heterogeneity of income per capita across countries is one of the central issues in modern economics of growth (Acemoglu 2009). In the past Socialist economies fell behind the West in levels of income per capita (Bergson 1987). By early 1990-s, when the command-economy experiment was over, perspectives for growth in these economies seemed optimistic. Indeed, they had already passed the first phase of structural change, industrialization, and their labour force was educated and relatively healthy. The level of technological sophistication was high in some sectors of the economy, notably the advanced defense equipment industries with potential for diffusion to other industries (Campos and Coricelli 2002). With the opening for international trade and investment an inflow of state-of-the-art technologies from developed economies was to be expected, and given the seemingly high level of absorptive capacity, these could be quickly put to efficient use. In addition, there was a high potential for structural change to contribute to growth. Given the large differences in efficiency levels across and within industries, a reallocation of labour and capital from less to more productivity activities would boost aggregate growth.

[Table 1 is about here]

These expectations did not materialize. Surprisingly, after two decades of transition in
Central-East European economies (CEE) and Russia (CEER)[2] the gap in GDP per capita with
Western Europe and the US still exists[3]. Table 1 summarizes GDP per capita and labour
productivity levels of eight post-transition economies in 2007, just before the global financial
crisis, relative to Germany - the European productivity leader. As can be seen in column 1,
even the GDP per capita of the most advanced economy, Slovenia, is below 70% of the level of
Germany. Levels of other post-transition economies hoover around 40-60 % of the German
level. Is this due to structural characteristics of the labour force, such as participation rates,
unemployment or hours worked, or due to differences in labour productivity, which can be
considered as a broad measure of the technology level in the economy? Table 1 reports that
the gap in labour productivity, which is defined as real value added per hour worked, explains
the major part of the difference in GDP per capita levels. Cross-country variation in the
amount of hours worked per worker or the labour force participation rates (the involvement
of population in working age in production) does not explain much of the gap. On the
contrary, working hours are longer in most countries, and participation rates higher. For
example, the level of GDP per capita in Slovenia is 68.6 per cent, whereas the labour

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[2] The paper considers Russia and eight East-European economies: the Czech Republic, Hungary, Slovenia,
Estonia, Latvia, Lithuania, Poland and Slovakia. However, because of data availability more attention will be paid to
the first four.
[3] According to Sonin (2013), this point was made by Daniel Treisman, who noted that convergence of post-
transition economies took much longer, than expected, so the level of developed economies has not been
achieved yet.

productivity level equals 57.3 per cent. The difference of 11.3 percentage points is explained by the effect of working hours (a higher number of hours worked by an average Slovenian worker in comparison with a German one); while a lower employment-population ratio reduces the gap by 3.9 percentage points. As a result, the levels of labour productivity of post-transition economies (column 4) are even lower that corresponding levels of GDP per capita (column 1) in all countries, except Poland. A similar picture emerges when one focuses on that part of the economy that can be well measured, namely the market economy[4], see column (5). We conclude that it is labour productivity backwardness, which causes the gap in incomes between post-transition and developed economies.

In this context, a general question can be raised, to what extent the present backwardness of Eastern Europe and Russia in terms of labour productivity levels is related to shared features of a past of economic planning that resulted in a long period of extensive growth based on heavy investment[5], but with little technological change[6] and distorted economic structure, tilted towards heavy industrial sectors[7]. At the same time it is clear, that in past two decades different developments paths have been followed and country-specific features have become more important in driving development. These include differences in the integration into European markets, including the importance of foreign direct investments (Campos and Kinoshita 2002), and in "the great divide" of institutions (Berglof and Bolton 2002). Also differences in resource abundance played an increasing role. From this perspective, the fact

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[4] Market economy aggregates correspond to the total economy ones except public administration, education, real estate activities, and health and social work, as discussed in (Timmer and Voskoboynikov 2013).
[5] (Kaplan 1969; Ofer 1987; Krugman 1994)
[6] (Gomulka and Nove 1984; Holliday 1984)
[7] (Bergson 1964)

that, say, Russia and the Czech Republic were command economies in the past, should nowadays be less relevant for understanding the difference in their current performance than the facts that Russia has abundant natural resources and the Czech Republic is closer to European markets, a member of the European Union and deeply integrated into European production chains. These idiosyncratic factors also influenced the speed of transition and restructuring (Ahrend, de Rosa, and Tompson 2006) and it is useful to split the former planned economies into two groups: *early reformers,* which include the Central-East European countries, and *late reformers,* which are mostly the former republics of the Soviet Union, including Russia (Roland 2000, Ch. 1).

This paper analyses developments in post-transition economies, and provides a comparison of the drivers of productivity growth in early and late reformers from the industry level perspective[8]. Although economic growth processes in early reformers (CEEs) have already been discussed in the literature[9], little is known, to what extent these findings are applicable to late reformers. Russia is by far the largest, and arguably the most interesting country among late reformers. Accordingly, the novelty of the present study is adding Russia into the comparative analysis across post-transition economies on the basis of a detailed recently developed dataset (Voskoboynikov 2012) and using a productivity level comparison method to measure technology gaps, using a newly developed set of relative output prices (PPPs).

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[8] At the same time, micro-level comparisons of productivity sources for manufacturing firms were carried out in (Brown, Earle, and Telegdy 2006; Brown and Earle 2008).
[9] (World Bank 2008; Fernandes 2009; Timmer and others 2010; Havlik, Leitner, and Stehrer 2012)

We analyze the period up to 2007 which is just before the global financial crisis of 2008, in order to focus on the long-run trend after transition. We focus on three particular issues. First, by means of a detailed industry growth accounting study we show that industrial origins of productivity growth in CEEs and Russia are rather similar. It is driven mainly by industries in the manufacturing sector that appear to be far away from the technology frontier. Second, we analyze the contribution of labour reallocation between industries to aggregate growth. This was expected to be substantial because of elimination of multiple planned economy distortions in the industrial structure. We find that the structural bonus did not materialize in CEEs, and only to a small extent in Russia. The reason for this is that the *initial* variation of productivity levels across industries in first years of transition was relatively low such that the scope for reallocation gains was only small. Third, we analyze patterns in multi-factor productivity growth since 1995 to see, what industries are driving productivity, and why there is a difference in the speed both across industries within a country as well as across countries. To do so, we relate MFP growth to the initial technological gap, measured by the level of MFP in 1995. We find that the initial technological gap was deep, such that it would take more time to catch up than had been expected before transition. We also find beta-convergence in all aggregated sectors of CEERs to Germany, the benchmark advanced economy, and demonstrate that the speed of convergence is higher in manufacturing than in market services.

The rest of the paper is divided into six sections, including this introduction. Section 2 presents the approach to comparisons of MFP levels, which is used for the measurement of the distance to the technological frontier. Section 3 deals with the labour reallocation effect in comparison with other sources of labour productivity growth (capital deepening and MFP

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growth). Section 4 focuses in depth on MFP growth, breaking it down by industries and highlighting the role of manufacturing industries. The fifth section provides novel measures of the distance of industry technologies in CEER to the technology level in advanced countries, represented by Germany. Combining these technology gap measures with MFP growth rates, it uncovers a strong convergence process of CEERs. The last, sixth section summarizes results and concludes the paper.

2. Data

A decade ago, reviewing the literature on economic performance in transition Campos and Coricelli (2002) pointed out to data quality as a limitation in understanding growth in transition. Although there has been no remarkable progress with data in the early transition period yet, for years after 1995 new datasets of macro time series for some economies in transition have become available. These are EU KLEMS (Timmer and others 2010)[10] and Russia KLEMS (Voskoboynikov 2012). Both datasets are consistent and constructed to study the relationship between skills formations, investments, technical change and growth. These databases form a dataset of the present study.

The dataset is based on the consistent accounting framework, which is rooted in the neoclassical production function theory and provides an opportunity to decompose output growth rates into contributions of inputs and multifactor productivity[11]. Although such assumptions of the neoclassical approach as perfect competition and constant returns to scale,

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[10] Release of November 2009

[11] (Solow 1956; Solow 1957; Jorgenson and Griliches 1967; Jorgenson, Gollop, and Fraumeni 1987; Jorgenson, Ho, and Stiroh 2005)

which are essential for MFP measurement, might not hold for certain countries, the neoclassical framework is standard for international comparisons. Growth accounting is implemented not only for developed economies, but also for developing economies, command economies and economies in transition[12]. This framework could also be considered as the benchmark for alternative calculations invoking different assumptions such as non-constant economies of scale and mark-ups (Barro 1999; Basu and Fernald 2001).

The dataset includes measures of output, inputs and derived variables like multifactor productivity (MFP). EU/Russia KLEMS dataset covers all EU members, including eight former Socialist economies, the United States, Japan and Russia. The number of industries and years covered varies across countries. It is based on data of the System of National Accounts and other macro indicators, provided by national statistical offices. Time series of economies in transition cover the period from 1995 to 2007[13] for industries at the two-digit level of classification NACE 1.0 (see the list in the Appendix).

The number of indicators also varies across countries. While data on labour and output is available for all countries in the dataset, only most advanced economies and four economies in transition are presented with the series of capital services and multifactor productivity. These economies are the Czech Republic, Hungary, Slovenia and Russia.

The EU KLEMS database has been constructed for many countries with a broad set of input measures, which are capital (K), labour (L), energy (E), materials (M) and services (S). This set is

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[12] See, e.g., (Kaplan 1969; Ofer 1987; Krugman 1994).
[13] Data for Poland and Slovenia covers years till 2006.

sufficient for construction of gross output-based growth accounting. However, only a more restrictive value added-based growth accounting for the Russian economy is possible. In case of Russia main limitation is the absence of time series of supply and use table of an adequate quality. Another important restriction of the Russian segment of the database is an absence of labour quality indicators. For this reason an increase of labour services because of a higher share of educated workers in total amount of hours worked will lead to the overestimation of multifactor productivity growth[14].

Capital input in the EU/Russia KLEMS database is based on the concept of capital services, suggested by Jorgenson (1963). The flow of capital services of a particular type of assets is proportional to its stock. Growth rates of each type of capital are aggregated to the total growth rates of capital with weights, which are calculated on the basis of rental prices of capital. These prices depend on depreciations rates being higher for assets with shorter service life. That is why the contribution in the total flow of capital services of a computer for 1000 dollars per year with service life of five years is higher than a railway sleeper of the same purchasing price with service life 25 years. In case of stock-based capital measures both the computer and the sleeper would generate the same amount of capital input per year. In EU/Russia KLEMS database eight types of assets are taken into account, which are split into two groups. The group of ICT assets includes computing equipment, communication equipment and software, whereas the group of Non-ICT assets is composed from residential structures, non-residential structures, machinery and equipment, transport, and other assets.

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[14] The quantitative estimations of the influence of these deviations on growth accounting was discussed by Timmer and others in (2010, ch. 3).

Implementation of the concept of capital services mitigates the problem of "communist capital", which is specific for economies in transition in general and for Russia in particular. The term "communist capital" was suggested by Campos and Coricelli (2002). The communist capital is the set of investment goods, which was put into operation before transition and has been remaining idle after transition. At the same time, this stock is presented in capital stock statistics. Taking into account substantial overinvestment into production of non-competitive goods before transition and multiple difficulties with measurement of capital after transition[15], its share of capital stock could be huge.

Difficulties with measurement of communist capital were broadly discussed in the literature[16]. In case of capital services the problem of overestimated capital stocks is relevant for values of net stocks by the end of 1995 and influences growth rates of capital stocks only for the period of service life of a particular asset. Consequently, for the whole group of ICT capital with service live around three years this bias is negligible. For machinery and equipment, transport and other assets with maximum service life 12 years the influence of the communist capital bias disappears by 2000s. The problem could be serious for buildings and constructions with longer service lives, but the share of idle capital among these assets seems to be lower, because buildings and infrastructure, put into operation before transition, abandoned less frequently than old machinery[17].

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[15] See more about capital measurement problem in economies in transition in (Ritter 1997; Bratanova 2003)

[16] (McKinsey 1999; Darvas and Simon 2000; Kushnirsky 2001; Izyumov and Vahaly 2008)

[17] We do not consider non-market services.

Another problem of capital estimation, essential for transition economies, is remarkable variations in capital utilization. During the post-transition period economies experienced huge changes in capacity utilization. For example, in Russian manufacturing it varied from 87.7 per cent in 1990 to 45.5 per cent in 1998 (Bessonov 2004). Hulten (1986) pointed out to theoretical inconsistencies when using of such measures of capital utilization within the neoclassical growth accounting framework. A standard theory-based solution, which is used in the present paper, is the implementation of ex-post rates of return in calculations of capital services. This way changes in capital utilization are taken into account as they will be reflected in the fall of rental prices of capital instead of physical measures of capital stock. However, there are some limitations in this approach. First, as Schreyer (2004) identified the problems with capital measurement when the set of assets is not full. Second, Balk (2009) showed that such assumptions of the ex-post approach, as a perfect foresight, constant returns to scale and perfectly competitive markets, which mostly do not hold in reality.

Comparing different measures of capital services on data for the US economy, Inklaar (Inklaar 2010) opted for the external rate of return-based approach. However, in case of the US economy in almost thirty years (1977-2005) variations in capacity utilization could be not as important as for post-transition economies in a shorter period. For the present paper we use the internal rate of return approach. At the same time, the ERR-based version is used for the robustness check.

Finally, following Timmer and others (2010, ch. 3), a number of caveats with possible interpretations of MFP on the basis of the EU/Russia KLEMS dataset need to be noted regarding

to the present study. The standard interpretation of MFP growth is an increase of the technology level. However, MFP growth can also reflect reorganization of firms, unmeasured inputs such as R&D, and multiple deviations from the neoclassical assumptions. Industrial MFP captures also the reallocation effects between firms of the same industry and various measurement errors like biases in ICT-investment deflators.

3. Methods

3.1. Labour productivity growth

The growth accounting methodology allows a breakdown of output growth rates into a weighted average of growth in various inputs and productivity change. It is based on the neoclassical framework of Solow (1956; 1957), Jorgenson and Griliches (1967), Jorgenson, Gollop and Fraumeni (1987) and Jorgenson, Ho and Stiroh (2005).

Under the assumptions of competitive markets of inputs, full input utilization and constant returns to scale the multifactor productivity of industry j (A_j) is defined as a function of real value added (Z_j), capital services (K_j) and hours worked (H_j)

(1) $\Delta \ln A_j \equiv \Delta \ln Z_j - \bar{v}_{K,j}^Z \Delta \ln K_j - \bar{v}_{L,j}^Z \Delta \ln H_j,$

where $\bar{v}^Z_{\circ,j}$ is the period-average share of the input in the nominal value added. The value

shares of capital and labour are defined as $v^Z_{K,j} = \frac{p^K_j K_j}{p^Z_j Z_j}$; $v^Z_{L,j} = \frac{p^L_j H_j}{p^Z_j Z_j}$. Growth rates of capital

services can be decomposed to capture growth contributions of each type of asset (l):

(2) $\Delta \ln K_j = \sum_l \bar{v}^K_{j,l} \Delta \ln K_{j,l}$,

where $v^K_{j,l} = \frac{p^K_{j,l} K_{j,l}}{\sum_l p^K_{j,l} K_{j,l}}$, $K_{j,l}$ – capital stock of assets of type l and $p^K_{j,l}$ is the rental price of

capital of type l.

As shown by Stiroh (2002), labour productivity growth ($z = Z/H$) can be represented as a

function of capital intensity ($k = K/H$) and the reallocation of hours (R):

(3) $\Delta \ln z = \sum_j \bar{v}^{GDP}_{Z,j} \cdot \Delta \ln z_j + \left(\sum_j \bar{v}^{GDP}_{Z,j} \cdot \Delta \ln H_j - \Delta \ln H \right) = \sum_j \bar{v}^{GDP}_{Z,j} \cdot \Delta \ln z_j + R.$

The reallocation term R captures changes in labour productivity growth because of the

difference of the share of an industry in value added and in hours worked. It is positive if

industries with an above average share of value added show positive growth of hours worked

or industries with the below average share of value added have declining hours worked.

Combination of (3) with (1) for industries gives us the final decomposition of aggregate labour productivity growth rates:

(4) $\Delta \ln z = \sum_j \bar{v}_{Z,j}^Z \left(\sum_l \bar{v}_{j,l}^K \Delta \ln k_{j,l} + \Delta \ln A_j \right) + R$,

which represents contributions of capital intensities of different types of assets, MFP and labour reallocation to aggregate labour productivity growth rates. From (4) one can derive the contribution of capital intensity of a certain asset l in industry j as $\bar{v}_{Z,j}^Z \bar{v}_{j,l}^K \Delta \ln k_{j,l}$ as well as the contribution of MFP of industry j as $\bar{v}_{Z,j}^Z \Delta \ln A_j$.

An important limitation of this value-added based approach is that it treats capital and labour in comparison with intermediate inputs asymmetrically. Consequently, the substitution of some labour and capital services with intermediate inputs, which takes place in case of outsourcing, in this set up will be treated as change in multifactor productivity. For a better alternative, the gross-output based version of growth accounting, we need time series of supply and use tables, which are not available for Russia.

3.2. Productivity levels

The technology gap models such as (Acemoglu, Aghion, and Zilibotti 2006) explain differences in productivity growth with differences in distances to the technological frontier. This section presents our methodology of comparing levels of MFP for the estimation of the distance to the technological frontier. This approach is called "level accounting". In contrast with growth accounting, in which growth rates of a single country are compared in two different moments in time, level accounting compares two countries at the same moment (Caves, Christensen, and Diewert 1982a). For the first time the bilateral production model was

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applied by Jorgenson and Nishimizu (1978) for the value-added based cross-country

comparison. The approach of the present paper is based on (Timmer and others 2010, Ch. 6).

Taking into account the necessary assumption for producer equilibrium in each country, the

corresponding index of MFP for a country *c* relative to the level of Germany (GER) is defined as

the function of differences in value added Z_c, capital services K_c and labour services L_c or,

alternatively, labour productivity $z_c = \frac{Z_c}{H_c}$ and capital intensity $k_c = \frac{K_c}{H_c}$:

$$(5) \qquad \ln A_c^Z \equiv \ln \frac{Z_c}{Z_{GER}} - \overline{w}_K^Z \cdot \ln \frac{K_c}{K_{GER}} - \overline{w}_L^Z \cdot \ln \frac{H_c}{H_{GER}} = \ln \frac{z_c}{z_{GER}} - \overline{w}_K^Z \cdot \ln \frac{k_c}{k_{GER}}$$

where weights $\overline{w}^Z$ are shares of each factor in nominal value added averaged over the two

countries.

We assume constant returns to scale, so the sum of the shares of labour and capital

compensation in value added are equal to one.

Equation (5) shows that comparable volume measures of value added, labour and capital

are necessary. In case of a single output or input, which can be measured in physical units such

as cars or hours worked, the issue is trivial. However, dealing with the measures at the

aggregate level corresponding quantity indices should be calculated implicitly with relevant

price deflators. Levels of output and inputs between countries can be matched by means of

relative prices to express these values in the same currency. The use of exchange rates for this

will probably lead to substantial errors. There are well-known reasons why exchange rates and

relative prices differ (Inklaar and Timmer 2008). For non-tradable goods there are no reasons why exchange rates and relative prices should be equal. For tradable goods the two economies or corresponding sectors could have different degrees of monopolistic power. Another reason is the existence of time lags in response of prices to exchange rate movements. At the same time, the movements could be influenced by short-term international capital reallocations, originated from monetary policy, speculations or fluctuations of world prices, and not related with changes in output or productivity.

Necessary comparable volume measures of output and inputs can be obtained with purchasing power parity (PPP) which indicates the price of the volume measure relative to another country. Such value added volume index for country *c* is defined as

$$(6) \qquad Z_c = \frac{V_c^Z}{PPP_c^Z},$$

where V_c^Z is nominal value added in country *c* at national prices and PPP_c^Z the price of value added in country c relative to that in USA. Finally, for capital services in country *c* we have:

$$(7) \qquad K_c = \frac{V_c^K}{PPP_c^K}$$

with V_c^K the nominal value of capital compensation in country c and PPP_c^K the relative price of capital services in country *c* as

$$(8) \qquad PPP_{k,c}^{K,US} = PPP_{k,c}^{I,US} \frac{(p_{k,c}^K/p_{k,c}^I)}{(p_{k,US}^K/p_{k,US}^I)},$$

where $PPP_{k,c}^{I,US}$ are PPPs for investment goods for types of assets k relative to US, $p_{k,c}^K/p_{k,c}^I$ – the ratio of price deflators on capital services and investment goods of assets of type k. This ratio equals

$$(9) \qquad \frac{p_{k,c}^K}{p_{k,c}^I} = r_{c,t} + \delta_k - \frac{p_{k,c,t}^I - p_{k,c,t-1}^I}{p_{k,c,t}^I},$$

where δ is a corresponding depreciation rate and *r* is the nominal rate of return[18].

In is important to note that PPP_c^K in (7-9) depends on the method we use for calculations of the rate of return in capital services. Theoretically consistent approach is the implementation of ex-post rates of return. However, Inklaar and Timmer (2008) noted that for cross-countries comparisons its drawbacks could be more substantial than for inter-temporal comparisons within a country. Indeed, deviations from the neoclassical assumptions of perfect markets and constant return to scale change slowly within a country in time, while they may be substantial in cross-countries comparisons. That is why we use ten-years government bond yields from the

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[18] $PPP_{k,c}^{K,US}$ is calculated in (8) relative to the US price level. However, according to (Caves, Christensen, and Diewert 1982b), to make data comparable across countries, one more step is necessary.
$\ln PPP_c^K = \sum_k \bar{v}_k^K \left(\ln PPP_c^{K,US} - \ln \overline{PPP}^K \right)$, where $\ln \overline{PPP}^K = \frac{1}{N} \sum_c^N \ln PPP_c^{K,US}$ and N is the number of countries in the sample. In this exercise for level comparisons of MFP along with CEERs, Germany and US we used EU KLEMS data for all countries, for which growth accounting is possible and the PPPs are available. These countries are Austria, Denmark, Spain, Finland, Italy, the Netherlands, the United Kingdom and France.

IMF statics as ex-ante rates of return[19], following the approach of (Inklaar and Timmer 2008).

Data on PPP for value added in industries is available in (Inklaar and Timmer 2012), whereas

PPPs for investments by type of assets ($PPP_{k,c}^{I,US}$) have been calculated on the basis of detailed

Eurostat/OECD PPP data for 2005[20].

For extensions of MFP levels from the benchmark year 2005 till 2007 and back to 1995 we

use productivity volume growth rates and apply them to the levels in 2005.

4. Labour reallocation

The transition from a plan to a market economy is a process of reallocation of resources on the

basis of market incentives (Campos and Coricelli 2002). Many studies have attempted to

investigate this structural change process in a three-sectoral framework (agriculture, industry

and services) following the tradition of Kaldor, Maddison, Kuznets and Chenery. For example,

Döhrn and Heilemann (1996) used the Chenery Hypothesis, which links the sectoral structure of

an economy with its stage of development, size and the endowment with natural resources.

They found that by 1988 manufacturing was oversized in many Socialist countries, while

services were small and underdeveloped. The authors projected a substantial shift of economic

activity from manufacturing to services after transition. This shift occurred as was later

documented and discussed in the literature[21].

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[19] The only exception is the Russian economy, for which interest rates of government bonds lead to negative rental prices of capital in many cases. In case of the Russian economy we implement the fixed exogenous real interest rate 4 per cent a year, as recommended by the OECD Productivity Manual (Schreyer 2001, p. 133).

[20] Detailed PPPs for investments by type of asset were kindly provided by Robert Inklaar.

[21] See, e.g. (De Broeck and Koen 2000a; De Broeck and Koen 2000b; Raiser, Schaffer, and Schuchhardt 2004; Lazarev and Gregory 2007; World Bank 2008; Bah and Brada 2009)

However, the more recent literature[22] on issues of structural change, productivity and growth in comparative perspective argues for the need for more detailed analysis. Indeed, the three-sectoral framework may be misleading in light of new stylized facts of development, suggested by Jorgenson and Timmer (2011). They showed that reallocations between *Agriculture* and *Manufacturing* in the post-industrialized world are marginal in comparison with reallocations within *Services*, which now account for around 70 per cent of value added and hours worked in developed economies. Timmer and De Vries (2009) found a similar pattern for Latin-America since the 1980s. That is why it is important to consider performance of different groups of sub-industries within *Services*. In addition, the estimation of the role of reallocation on productivity is more accurate when more detailed industrial level is considered. De Vries and others (2012, tab. 11) have shown that the estimation of the reallocation effect is sensitive to the level of disaggregation. Finally, the use of more detailed data in analysis of structural change provides an opportunity of a more flexible industry grouping depending on country-specific issues. For example, to deal with the transfer pricing and vertical integration of large mining firms in Russia it is necessary to group *Mining* and *Fuel* from Manufacturing and *Wholesale Trade* from Services into one sector *Extended Mining*[23].

[Fig. 1. Intra- and inter-industry components of labour productivity growth in post-transition economies and Germany]

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[22] See, e.g., (van Ark, O'Mahony, and Timmer 2008; Lin 2010; McMillan and Rodrik 2011).
[23] See detailed discussion of this in (Timmer and Voskoboynikov 2013).

Fig. 1 represents the Stiroh (2002) decomposition of labour productivity growth in eight CEERs and Germany. As can be seen, the role of labour reallocation is relatively modest, explaining at best half of a percentage point of growth. The notable exception is Russia where the contribution of labour reallocation is 1.1 out of 4.6 percentage points, or about a quarter of total growth. In this context there is a concern that a substantial labour reallocation during the years of transition, which was expected to eliminate huge planned economy distortions, did not provide a sizable increase in an aggregate labour productivity level. Explaining this, it makes sense to compare post-transition economies with developing economies, in which the reallocation of labour from sectors with a low productivity level to high productive ones, which is referred to as a structural bonus, provides a more substantial contribution.

[Fig. 2. Shares of hours worked in 1995 and 2007 in sectors]

Post-transition countries differ in two aspects. The first is a different direction of labour flows. In developing economies labour reallocates from low productive agriculture to high productive manufacturing. This is clearly not the case for CEERs, which passed industrialization no later than in the second half of 20th century. Instead, structural transformation in CEERs is more about labour reallocation from manufacturing to services, confirming the prediction of Döhrn and Heilemann (1996). This is illustrated in fig. 2, which represents shares of hours worked in 1995 and 2007 in Czech Republic, Hungary, Russia and Slovenia with Germany. In the

remainder of the paper we will focus on these 5 countries as the necessary data is not available for the other CEEs. We distinguish four sectors, which are high skill intensive goods (HSI goods), low skill intensive goods (LSI goods), high skill intensive services (HSI services) and low skill intensive services (LSI services)[24]. Indeed, both the low skills intensive and the high skills intensive services in CEERs are expanding, while manufacturing in most cases is contracting not only in CEERs, but also in Germany, leaving the market for China. At the same time, advanced manufacturing in the Czech Republic, Hungary and Slovenia (HSI Goods) gains. Havlik, Leitner and Steher (2012) explained this by pointing at factors like the educated labour force, closeness to the Western Europe, outsourcing, and substantial FDI inflows, in particular from Germany and Austria (Marin 2009)[25]. Another remarkable point is differences in structural change in services between CEEs and Russia. By analogy with the developed economies trend, high skills intensive services (financial intermediation and business services) expanded more in CEEs, while in Russia this effect is almost absent. As for the sector of low skill intensive services, which includes such industries as retail and construction, extension is the largest in Russia, being smaller in CEEs and negative in Germany. This could reflect the limited development of this type of services in initial years of transition in Russia.

[Fig. 3. Inter-sectoral productivity gaps and aggregate labour productivity levels in 1995]

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[24] See detailed sectoral composition in Appendix A3.

[25] With firm-level data of German and Austrian multinationals, Marin (2009) showed that this outsourcing was caused by the abundance of high skill labour in East European economies, including Russia and Ukraine, in comparison with Germany and Austria. Interestingly, according to this paper, comparative advantages in high skill labour are applicable to all East European economies, but the lion's share of FDI were hosted by CEEs, rather than Russia, Ukraine and other CIS countries. This can be interpreted as the effect of the EU membership.

The second distinction of post-transition economies compared to other countries is a low variation of productivity levels across industries. As McMillan and Rodrik (2011, fig. 2) showed, there is a negative correlation between the level of inter-industry productivity variation and average labour productivity of a country. For this, they use the variation coefficient of (the logarithm of) industrial labour productivity as a measure of inter-industry productivity variation. Labour productivity here is defined as the GDP PPP converted value added to the number of hours worked. We extend their analysis (McMillan and Rodrik (2011, fig. 2) and perform it for data on thirty nine countries in Figure 3. At the vertical axis is the coefficient of variation of labour productivity levels across 30 industries in a particular country. On the horizontal axis is the (log) level of aggregate labour productivity in the country relative to Germany. Data for forty developed, developing and post-transition economies are plotted and a dotted OLS regression line is given as well. As can be seen in Fig. 3, the observations for the post-transition economies fit the regression line[26]. It means that in 1995 the level of cross-sectoral variation of productivity in CEERs is much closer to developed, than developing economies, and the potential for the structural change bonus was only limited.

Only the Russian case is exceptional as the contribution of labour reallocation in the Russian economy is comparable with India and higher than in China[27]. Half of this is explained by the

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[26] Table A4 in the Appendix presents the results of the regression. Negative slope coefficient in Fig. 3 is highly significant and the deviation of the slope coefficient from the trend for CEERs (CEER x the log of the aggregate labour productivity level) is also significant.

[27] Of 7.6 % of yearly average labour productivity growth of market economy in China, labour reallocation contributed 0.4%. For India corresponding values are 5.3 and 0.9. These results are consistent with findings of de Vries and others (2012), obtained with a different approach.

expansion of Oil and Gas sector, a unique Russian feature[28]. The other half could be explained

by an earlier stage of transition in Russia in comparison with CEEs in 1995. Indeed, working with

the manufacturing firms' level data of early reformers (Hungary and Lithuania) and late

reformers (Georgia, Romania, Russia, and Ukraine), Brown and Earle (2008) showed how the

role of reallocation changed in time. Before transition the contribution of labour reallocation to

productivity growth was low in all these economies. In first years of transition the contribution

of labour reallocation was higher in early reformers, diminishing in the following years. In turn,

late reformers demonstrated the peak of the labour reallocation effect with a delay. The

authors explained this pattern with a more intensive cleansing of less productive firms in early

reformers in first years of transition, which intensified labour reallocation.

A more accurate econometric analysis of the sample in this scatterplot unveils a specific

feature of the post-transition economies. Although these economies demonstrate a negative

dependence of sectoral productivity variation on the level of aggregate labour productivity, as

can be seen in Fig. 3, the slope is flatter. In other words, in comparison with developing

economies an increase of labour productivity in post-transition countries is accompanied with a

smaller decline in sectoral productivity variation. This finding confirms the idea, broadly

discussed in the literature (Döhrn and Heilemann 1996; Gregory and Stuart 2001, ch. 16), that

overinvestments in the planned economy period distorted the economy in favor of

manufacturing. Transition is accompanied by a negative labour reallocation effect as labour

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[28] To show this, I represent the reallocation effect as a sum of industrial components: $R = \sum_j \bar{v}_{Z,j}^{GDP} \cdot \Delta \ln \frac{H_j}{H}$.
Each sectoral component is, in turn, the product of the change of labour share of this sector $\Delta \ln \frac{H_j}{H}$ and the
average share of its value added $\bar{v}_{Z,j}^{GDP}$. Grouping industries by sectors I decompose total reallocation R into
contributions of each sector. Of total 1.1 per cent of reallocation the contribution of *Extended Mining* is 0.62,
which is the product of the change of labour share, 2.35 per cent, and the time average VA share 26.4 %.

moves from a more productive, but artificially inflated manufacturing sector, to less productive services.

Given the minor role of labour reallocation in driving aggregate growth, we need to analyze in-depth the sources of productivity growth within industries, which is the topic of the next section.

5. Sectoral drivers of aggregate productivity growth

Using the growth accounting formula (3), we can analyze the sources of intra-industry productivity growth and compare it to the role of labour reallocation in driving aggregate growth. According to table 2, which summarizes all components of labour productivity growth in the four CEERs and Germany, MFP growth in sectors is an important source of aggregate labour productivity growth in all countries. Moreover, it is MFP which makes labour productivity growth in CEERs higher than in Germany. Indeed, the Czech Republic, which had the lowest average MFP growth rates among CEERs, still has double the growth rate in Germany, while MFP in the Russian economy exceeds Germany by a factor of more than 3.5.

[Tab. 2. Labour productivity growth rates decomposition of Slovenia, Russia, Hungary, the Czech Republic and Germany in 1995-2007]

[Tab. 3. MFP growth rates and contributions of sectors of Market economy in 1995-2007]

One step further is identifying key sectors and industries in CEERs, which drive this MFP growth. Table 3 demonstrates sectoral MFP growth rates and contributions in CEERs in comparison with Germany. Growth rates of MFP in sectors are given in the upper panel, while contributions of sectors to aggregate MFP growth are given in the lower panel. The latter are derived as a sector's MFP growth times its share in value added. As can be seen, the goods sector in the CEERs, including both high skills and low skills intensive goods, outperforms Germany. MFP growth rates of advanced manufacturing industries (High Skills Goods) in CEERs demonstrate growth around 6 per cent per year against 3.5 p.p. in Germany, while traditional manufacturing (Low Skills Intensive Goods) shows 3 – 4 p.p. versus 1.8 p.p. in Germany. Further, in all economies, except Russia, it is the goods sector that contributes the lion's share of multifactor productivity growth. The role of market services in MFP growth is substantial only in Russia with outstanding 9.4 percent growth of high skills intensive services. In Hungary MFP growth in low-skilled intensive services was particularly important.

[Fig. 4. Harberger diagrams for MFP in CEER; highlighting of industries which catch up Germany]

To get a more detailed view of which sectors are leading, we zoom in at a more detailed industry level, considering 30 industries in total. By means of Harberger diagrams for MFP growth rates. These are presented in fig. 4[29]. These diagrams provide an explicit and intuitive

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[29] See (Harberger 1998; Timmer and others 2010) for a more detailed description of the Harberger diagram technique.

way of identifying if aggregate growth rate is produced by a few industries (a mushroom pattern) or widespread (a yeasty pattern). The upper curve in each panel is for a CEER country. In order to compare with Germany, the German curve is included in each panel as well (the lower one in each of the four graphs). As can be seen, in all post transition economies MFP growth is mushroom-like and more concentrated than in Germany. The curvature in CEERs varies from 0.37 in Slovenia, which corresponds to the highest degree of concentration, to 0.61 in the Czech Republic, which is close to the level of Germany, 0.64. The figure also provides evidence that MFP growth rates mostly originate from goods both in CEERs and in Germany (corresponding points are filled). Such industries are mostly on the upward sloping parts of the diagrams. Moreover, the diagrams show that many manufacturing industries in CEERs perform better than in Germany. This can be seen from the slope of the diagram curve to the left of the industry dot. For example, Other Machinery (code 29) in Hungary, the second industry from the origin, grows much faster than in Germany, because the diagram in the vicinity of 29 for Hungary is much steeper, than for Germany. In total, there is a core of five manufacturing industries in CEERs, in which MFP growth exceeds the German. These are Paper and Publishing (21t22), Rubber and Plastic (25), Non-metal minerals (26), Other Machinery (29), Electrical Equipment (30t33) and Other Manufacturing (36t37).

6. Distance to the technology frontier and convergence

As it has been discussed in the previous section, aggregate MFP growth in CEERs is mostly driven by manufacturing subsectors. This raises the question what is driving this rapid growth. In a famous article, Gerschenkron (1962) argued that backward economies could catch up to the productivity level of advanced economies by adapting frontier technologies. He

hypothesized that the larger the distance to the technology frontier the more options for improvements are available, driving higher productivity growth. If productivity growth in a country depends positively on its distance to the global technology frontier, a process of convergence will occur in which countries grow towards a similar level of productivity. More recently, Acemoglu, Aghion and Zilibotti (2006) provide a formal model of this idea, in addition arguing that optimal policies need to be adapted, depending on the distance to the frontier. They suggest that the institutional environment relevant for investments- and adaptation-based strategy is not optimal anymore once the economy is close to the technology frontier.

It is well known that CEERs were far remote from the technology frontier in the period before transition. Gregory and Stuart (2001, pp. 187-9) reviewed the literature and summarized that economic development of the Soviet Union took place at the background of a large technology gap, which either increased or, at best, remained constant during the Soviet period, while technology levels in the US and Western countries continued to push out the global frontier. Nevertheless, there were areas, such as metallurgy, aeronautics and military production, in which the Soviet technologies were close to the frontier, at least in the early period. Technological weakness of the Soviet economy in comparison with developed economies is well documented not only by Western scholars, but also by the official Soviet statistics. According to an official survey, by April 1, 1986, only 6.5% of the total amount of machine tools in the Soviet economy was considered as "confirmed to the up-to-date world technology level"; 45% met the domestic technological requirements and 48.5% were obsolete and were entitled to updates, which never materialized (Rosstat 1989, p. 225). The literature

also provides multiple evidences of technological inferiority of CEEs before transition(Gomulka and Nove 1984).

A natural approach to explain variations in productivity growth across industries in CEERs after transition is thus to relate them to the initial distances to the technology frontier at the beginning of transition. We will use comparative industry MFP levels to measure this distance, following (Timmer and others 2010). Such analyses are scarce at the industry level, because the estimation of MFP levels is a sophisticated and data demanding exercise. Timmer and others (2010), which covers OECD countries including three CEEs, is the only example of this approach in the literature built on the basis of a representative macro data[30]. However, other more indirect evidence of technology convergence is also available in the literature. On the basis of high MFP growth rates Havlik and others (2012) showed that catching up in CEEs was faster in skill intensive manufacturing industries because of well-educated workforce, FDI inflows and stimulated outsourcing activities. Fernandes (2009) investigated labour productivity in the service sector of CEEs and confirmed the Gerschenkron hypothesis for productivity growth in services. So far, however, there are no studies of this type which put Russia in a comparative perspective with the early reforming CEEs.

[Fig. 5. Aggregate multifactor productivity level of CEE economies and Russia relative to Germany in PPP USD 2005.]

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[30] The World Bank (2008) also reported data on MFP levels for total economies on the basis of the micro database "Amadeus".

[Tab. 4 MFP levels in the four CEE economies and Russia relative to Germany in 2007* in PPP USD]

We use equation (5) to derive comparative MFP levels for the market economy and these are shown in Figure 5 for 1995 and 2007. This shows how much of the initial technological gap has been overcome since 1995. As can be seen from Fig. 5, in the most advanced post-transition economy, Slovenia, MFP level has grown from 60 per cent of the German one in 1995 to 74 per cent in 2006, reducing the distance by almost 14 percentage points in eleven years. But large distances remain for the other CEEs. In 1995, Russian productivity levels were only 42 per cent of Germany and was the weakest economy of all. By 2007, Russia has closed only 10 percentage points of the gap, which still stands large at about half the German level. On the whole, technology catch up in CEERs was slow and the scope for future growth based on further catch up is still large.

This is true for almost all sectors. Table 4 provides the distance to the global frontier in 1995 for the 4 major sectors. It shows that in 1995 the distance to the frontier for *Goods* was larger than for *Market Services,* which might explain higher MFP growth rates in goods than in market services in tab. 3. In turn, the technology gap is larger for *HSI Goods* in comparison with *LSI Goods*, which could reflect advantages of developed economies in HSI activities. The technology level in high skills intensive services in Hungary and Slovenia in early transition was surprisingly high. These results predetermine a more formal testing of the convergence hypothesis.

[Tab. 5. Convergence regressions, sectoral MFP]

29

Using the framework of Bernard and Jones (1996), I have tested the existence of beta-convergence across CEERs both at the aggregate level and in sectors. For each industry i it is assumed that MFP growth rates averaged over the period 1995-2007 ($\Delta \ln MFP_i$) depend on the (logarithm of the) distance to the frontier in 1995 ($\ln MFP_i^{1995}$).

(10) $\Delta \ln MFP_i = \alpha + \beta \ln MFP_i^{1995} + \varepsilon_i.$

If the catch up hypothesis of Gerschenkron holds, the estimator of β should be significantly negative. We estimate equation (10) on a set of 26 industries for four countries[31]. Table 5 reports the results. As can be seen, CEERs demonstrate convergence with strong statistical significance in all sectors, which make the post-transition economies different from advanced OECD economies. As Bernard and Jones (1996) demonstrated, in the latter group of countries there was no evidence of convergence in manufacturing. Next I look at the speed of convergence, which is expected to be higher in industries with higher MFP growth rates. The speed of convergence (λ) is calculated from the estimates of β using the following definition: $\beta = -\frac{1-(1-\lambda)^T}{T}$ (Bernard and Jones 1996). Standard errors are obtained from the heteroskedasticity consistent covariance matrix (White) estimator.

Results also shown in table 5. In this setting the interpretation of the speed of convergence (λ) is the rate at which the level of productivity is approaching to a worldwide (German) productivity level. As can be seen, *Goods* are converging with a rate of almost 12 per cent a

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[31] The total amount of industries of Market economy in three CEEs is 26. In the Russian economy the number of industries is 24, because the basic set of industries is the same, but the Extended Mining is considered as one industry instead of Mining (C), Fuel(23) and Wholesale trade(51).

year, while *Market Services* – just with the rate slightly higher than 3 per cent. The speed of convergence also differs within Market Services, being 5 percentage points higher in *HSI Services* in comparison with *LSI Services.*

The findings of this subsection confirm that technological catch up in CEERs is taking place, but at a slow pace. It will take more time before even the most advanced economies among CEERs achieve the level of developed economies. The productivity gap is persistent, in particular for Russia.

7. Conclusion

The purpose of this paper was to determine the role of technology catching up and labour reallocation in the productivity performance of formerly centrally planned economies in Europe. We compared early reformers (represented by the Czech Republic, Slovenia and Hungary) and a late reformer (Russia). These countries share various characteristics in terms of structural change and drivers of productivity growth. Since 1995 technology catching up was a substantial driver of productivity growth in all these economies, confirming the findings of Havlik, Leitner and Steher (2012) and Fernandes (2009). This conclusion is clearly supported by our finding of MFP dominance among sources of labour productivity growth, and our confirmation of the convergence hypothesis. Compared with technology catching up, the contribution of labour reallocation to aggregate productivity growth is minor. We found that the potential for the structural change bonus stressed in McMillan and Rodrik (2011) was low to begin with as productivity level variation across industries in post-transition economies was already limited in 1995. Another similarity in the growth process of these economies is the role

of manufacturing industries. Being initially more remote from the technology frontier than market services, they have demonstrated higher speed of convergence.

This study also revealed important differences in post-transition development between CEEs and Russia. Various skill-intensive manufacturing industries (such as transport equipment manufacturing) perform well in the CEEs, while their progress in Russia is relatively modest. Development of these industries in CEEs is clearly linked to the outsourcing strategies of major European firms (Havlik, Leitner, and Stehrer 2012) The second difference is a remarkable productivity growth performance of high skills intensive services in Russia relative to the CEEs. But this is a sign of Russia catching up with the CEEs, rather than forging ahead, given the extremely low levels of productivity in Russia in initial years of transition. Finally, the contribution of labour reallocation in Russia was found to be higher than in CEEs. We found that this should be attributed to the Russia-specific abundance of natural resources, which exploration attracted factor resources. This process cannot be a permanent source of growth.

This research has thrown up many questions in need of further investigation. This study is the first attempt to make productivity comparisons of early and late reformers at the detailed industry level. It would be useful to consider other late reform countries, such as Ukraine, which is similar to Russia in many aspects except abundance of natural resources. One more direction is an attempt to answer the question what factors influence the speed of convergence in post-transition economies. In a broader context this question is linked to the determinants of the speed of transition, which could depend on differences in reform paths and strategies, macroeconomic stability after liberalization, enterprise performance in response in changes in

ownership and corporate governance (Roland 2000; Dell'Anno and Villa 2013). Next, while we were able to study structural change in CEERs in more detail than most of the studies, it is important to recognize that the industry perspective might still be too restrictive. Micro studies, such as of Bartelsman, Haltiwanger, and Scarpetta (2013), showed, that distortions in the allocation factors at the level of firms can lead to substantial differences in aggregate performance across countries. Early studies of labour reallocation and productivity in manufacturing firms showed this might be also important in understanding of differences of performance in CEERs after transition.[32] Lastly, the current analysis might fail to pick up resource reallocation between formal and informal sectors of the economy. Given the substantial presence of an informal economy in many post-transition countries this might be an additional driver or hindrance to growth.

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[32] There are some comparative studies of manufacturing (Ahrend, de Rosa, and Tompson 2006; Brown, Earle, and Telegdy 2006; Brown and Earle 2008), but the comprehensive industry-level picture is still absent.

Tables

Tab. 1. GDP per capita and labour productivity differences in post-transition economies relative to Germany in 2007

	GDP per capita (Germany = 100)	Effect of		Labour productivity (Germany = 100)	
		working hours	employment - population ratio	Total economy	Market economy
	1	2	3	4 = (1)-(2)-(3)	5
Czech Rep.	64.8	16.3	3.3	45.1	44.8
Estonia	56.4	15.2	2.2	39.0	39.2
Germany	100.0	0.0	0.0	100.0	100.0
Hungary	51.2	17.8	-12.4	45.9	41.0
Latvia	48.5	13.0	-6.4	41.9	41.2
Lithuania	44.9	3.3	0.9	40.7	41.5
Poland[*]	40.8	12.6	-15.7	44.0	39.1
Russia	43.0	13.7	1.4	27.9	27.5
Slovakia	57.0	12.9	-11.9	56.0	52.4
Slovenia[*]	68.6	15.2	-3.9	57.3	56.3

NOTES:

[1] Converted to USD at 2005 PPPs from (Inklaar and Timmer 2012).

[*] 2006 for Poland and Slovenia

Numbers may not sum because of rounding.

SOURCES: Author's calculation; EU KLEMS; Russia KLEMS; Penn World Tables, ver. 7.1. See main text.

Tab. 2. Labour productivity growth decomposition for 1995-2007
(percentage points)

	Russia	Czech Rep.	Hungary	Slovenia*	Germany
Aggregate labour productivity, due to	4.60	3.63	3.66	4.67	1.70
Labour reallocation	1.05	0.03	0.21	0.52	0.11
Labour productivity, due to	3.56	3.60	3.45	4.14	1.59
Multifactor productivity	2.71	1.52	2.49	2.43	0.75
Capital intensity	0.85	2.08	0.96	1.71	0.84

Notes: (*) – 2006.
Numbers are average productivity growth rates and refer to Market economy
Source: Author's calculation; see main text.

Tab. 3. Multifactor productivity growth rates and contributions of Market economy for 1995-2007

	Russia	Czech Rep.	Hungary	Slovenia[**]	Germany
Growth rates, p.p.					
Market economy, total	2.71	1.52	2.49	2.43	0.75
HSI Goods	6.46	5.94	6.22	6.13	3.51
LSI Goods	3.05	3.19	3.81	4.17	1.83
HSI Services	9.40	1.00	0.57	0.35	-2.24
LSI Services	1.60	0.51	2.04	0.91	1.02
Mining, Fuel*	1.05	-9.24	-3.84	5.15	-1.23
Contributions, p.p.					
Market economy, of which	2.71	1.52	2.49	2.43	0.75
HSI Goods	0.25	0.51	0.59	0.61	0.45
LSI Goods	0.67	0.88	0.98	1.34	0.39
HSI Services	0.90	0.13	0.10	0.06	-0.51
LSI Services	0.61	0.24	0.92	0.37	0.43
Mining, Fuel*	0.28	-0.25	-0.10	0.05	-0.01

NOTES:

* For Russia this is *Extended Oil and Gas* sector, which includes Mining, Fuel and Wholesale trade. In other countries Wholesale trade is included into LSI Services. A more detailed table, in which these industries are separated, is given in Appendix A1.

** For Slovenia average growth rates have been calculated in 1995-2006

Numbers may not sum because of rounding.

Source: Author's calculation; see main text.

Tab. 4. Multifactor productivity levels relative to Germany in 1995 in PPP USD 2005

(Germany = 100)

	Russia	Czech Rep.	Hungary	Slovenia*
Multifactor productivity, Germany = 100				
Market economy, total	42.3	57.6	47.6	59.9
HSI Goods	12.3	28.4	30.3	36.9
LSI Goods	23.2	40.2	33.8	44.4
HSI Services	12.1	53.1	66.4	66.7
LSI Services	64.4	79.7	54.0	83.4
Mining, Fuel*	83.0	99.7	95.8	35.5

NOTES:

This table presents results of level accounting, for which PPPs have been aggregated using the multilateral translog price indices (Caves, Christensen, and Diewert 1982a). In line with this approach, an artificial country is formed by averaging across all countries in the dataset. This artificial country is used as a bridge for making binary comparisons between any two countries. Since Estonia, Latvia, Lithuania, Poland and Slovenia are not included into this dataset for level accounting, labour productivity levels in table 1 slightly differ from the corresponding values in the present table.

* For Russia this is *Extended Oil and Gas* sector, which includes Mining, Fuel and Wholesale trade. In other countries Wholesale trade is included into LSI Services. A more detailed table, in which these industries are separated, is given in Appendix A2.

Source: Author's calculation; see main text.

Tab. 5. Convergence regressions, sectoral multifactor productivity

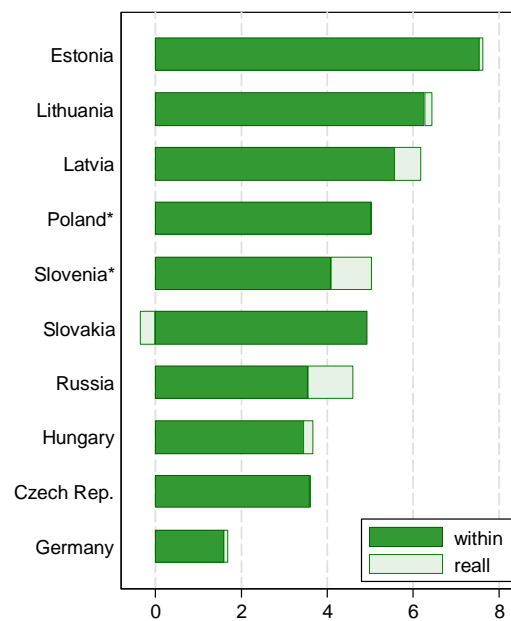|	β	SE	λ	R^2	Obs.
Market economy, total	-0.048***	0.005	0.069	0.52	102
Goods	-0.065***	0.007	0.118	0.63	58
HSI Goods	-0.039**	0.011	0.050	0.57	12
LSI Goods	-0.068***	0.008	0.132	0.64	46
Market Services	-0.028***	0.005	0.034	0.42	43
HSI Services	-0.050***	0.009	0.073	0.84	8
LSI Services	-0.022***	0.006	0.025	0.29	35

NOTES:

Coefficients are estimated from the following equation $\Delta \ln MFP_i = \alpha + \beta \ln MFP_i^{1995} + \varepsilon_i$ with the speed of convergence (λ) calculated from $\beta = -\frac{1-(1-\lambda)^T}{T}$ (Bernard and Jones 1996). We use OLS with the heteroskedasticity robust White estimator of the covariance matrix.

The number of industries in the three East-European economies is 26 and 24 for Russia as Mining (C), Fuel (23) and Wholesale trade(51) are combined.

* - significance at the 10% level; ** - 1% level; *** - 0.1% level.

Figures

Fig. 1. Intra- and inter-industry components of labour productivity growth in post-transition economies and Germany for 1995-2007
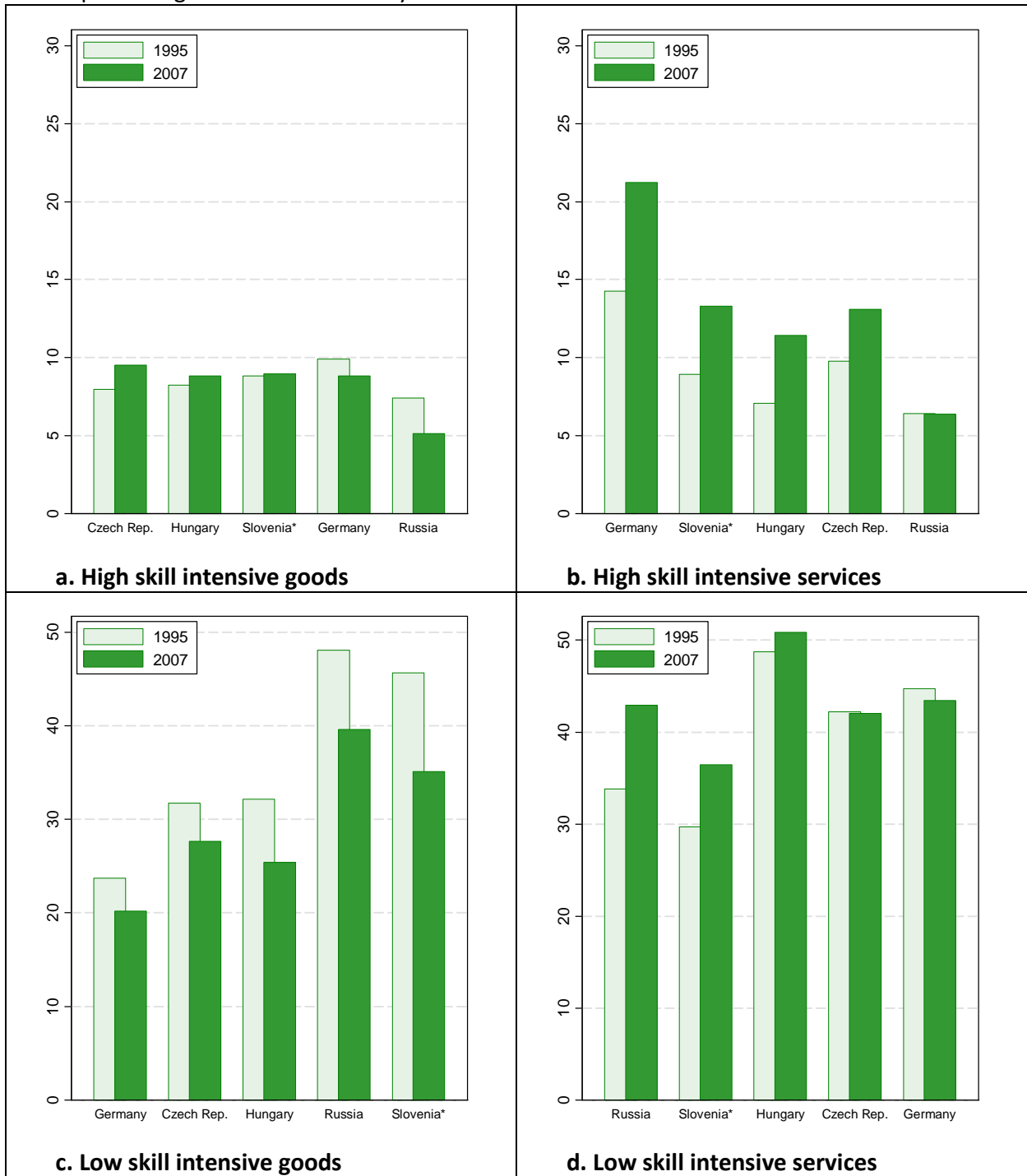

Notes:
(*) – 2006.
Decomposition of aggregate labour productivity growth into the intra-industry growth (within) and labour reallocation (reall) components in CEE economies, Russia and Germany in 1995-2007[*] (percentage per year)
Source: Author's calculations based on the EU KLEMS and Russia KLEMS datasets.

Fig. 2. Shares of hours worked in 1995 and 2007

In percentage of Market economy

a. High skill intensive goods

b. High skill intensive services

c. Low skill intensive goods
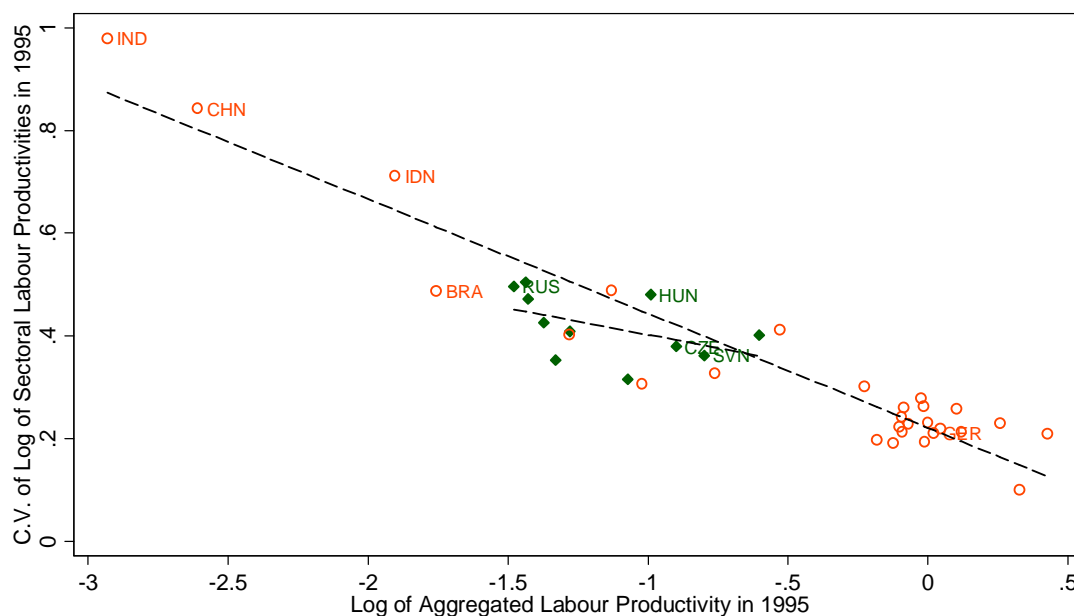
d. Low skill intensive services

Sources: Author's calculations based on the EU KLEMS and Russia KLEMS datasets.

Notes: Arranged by the descending difference of the shares

*) For Slovenia values are calculated for 1995 – 2006

Fig. 3. Inter-sectoral productivity variation and aggregate labour productivity levels in 1995

SOURCES: Own calculations on the basis of WIOD Social Economic Accounts; EU KLEMS; Russia KLEMS; (Inklaar and Timmer 2012).
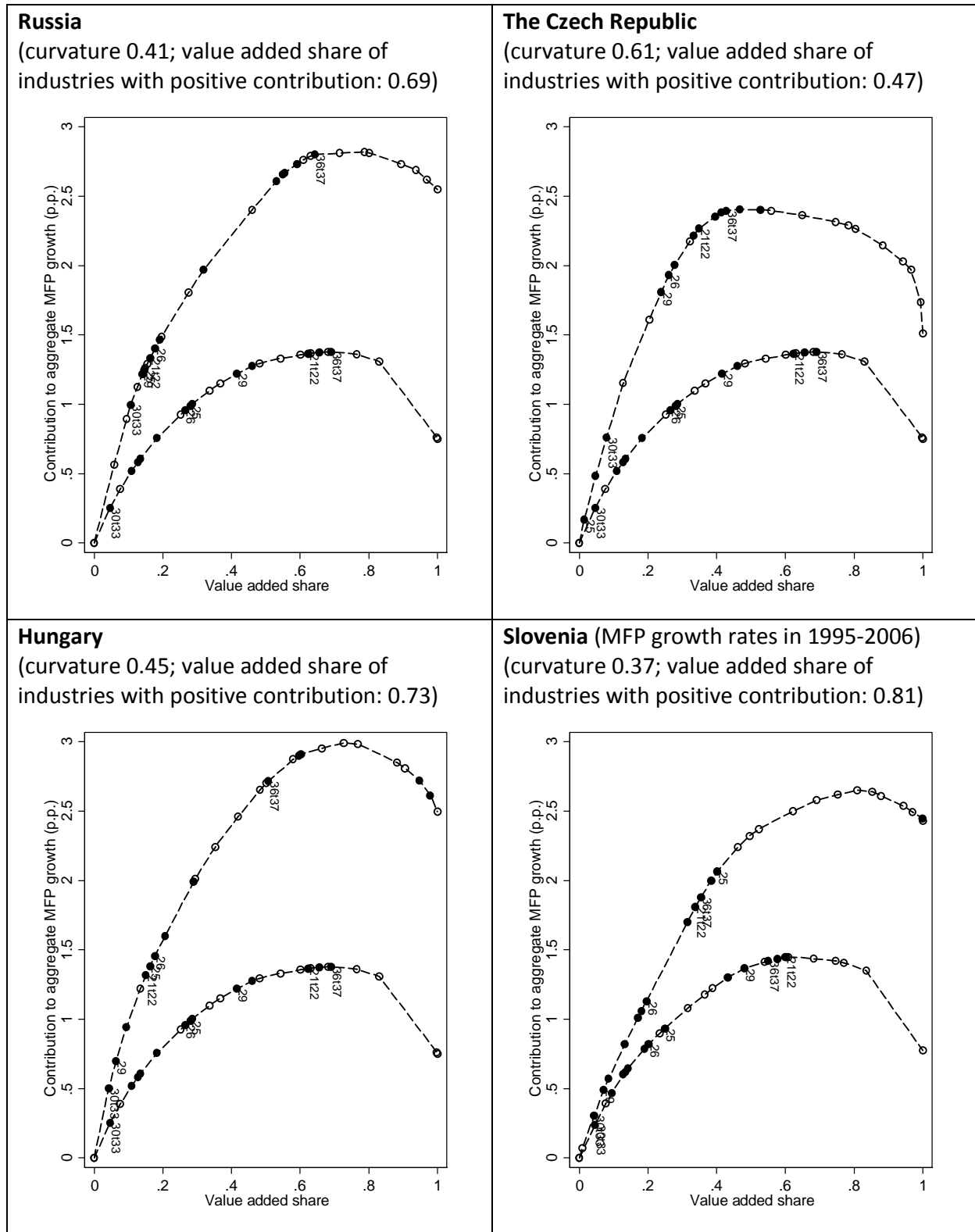
NOTE: Post-transition economies are highlighted in green

Coefficient of variation of (the log of) labour productivity in 31 industries is presented on a vertical axis. Labour productivity is defined as value added per hour worked, converted with GDP PPP 2005 from (Inklaar and Timmer 2012) to constant 2005 US dollars and projected to 1995.

Labour productivity levels of market economies (horizontal axis) are value added over hours worked, converted with GDP PPP to constant 2005 US dollars from (Inklaar and Timmer 2012), projected to 1995 and normalized to the level of Germany.

Dash lines correspond to the OLS regression (see estimated parameters in Tab. A4 of the Appendix).

Fig. 4. Harberger diagrams for multifactor productivity growth in 1995-2007

Russia
(curvature 0.41; value added share of industries with positive contribution: 0.69)

The Czech Republic
(curvature 0.61; value added share of industries with positive contribution: 0.47)

Hungary
(curvature 0.45; value added share of industries with positive contribution: 0.73)

Slovenia (MFP growth rates in 1995-2006)
(curvature 0.37; value added share of industries with positive contribution: 0.81)

NOTES: Filled dots correspond to industries, which belong to Goods, empty dots – to Market Services. The upper curve in each curve belongs to a corresponding country, while the lower curve is of Germany

Fig. 5. Multifactor productivity levels relative to Germany.

Notes:

(*) – 2006.

Calculations have been made for Market economy in PPP USD 2005.

Source: Own calculations on the basis of EU KLEMS, Russia KLEMS, and (Inklaar and Timmer 2012).

Appendix

Tab. A1. MFP growth rates and contributions in Low Skills Intensive Services, Wholesale trade, Mining and Fuel in 1995-2007

	Russia	Czech Rep.	Hungary	Slovenia[**]	Germany
Growth rates, %					
LSI Services	-	0.51	2.04	0.91	1.02
LSI Services, excl. Wh. trade	1.60	-0.53	1.89	0.56	0.73
Wholesale trade	-	5.97	3.01	2.88	2.47
Mining, Fuel*	1.05	-9.24	-3.84	5.15	-1.23
Contributions, %					
LSI Services	-	0.24	0.92	0.37	0.43
LSI Services, excl. Wholesale trade	0.61	-0.21	0.73	0.20	0.26
Wholesale trade	-	0.46	0.19	0.18	0.17
Mining, Fuel*	0.28	-0.25	-0.10	0.05	-0.01

NOTES:

* For Russia this is *Extended Oil and Gas* sector, which includes Mining, Fuel and Wholesale trade (see section 4.2 for details)

** For Slovenia average growth rates have been calculated in 1995-2006

Numbers may not sum because of rounding.

Tab. A2. MFP levels in Low Skills Intensive Services, Wholesale trade, Mining and Fuel in 1995 in PPP USD

	RUS	CZE	HUN	SVN
Multifactor productivity, GER = 100				
LSI Services	-	79.7	54.0	83.4
LSI Services, excl. Wholesale trade	64.4	94.5	51.7	88.5
Wholesale trade	-	32.0	76.0	60.0
Mining, Fuel*	83.0	99.7	95.8	35.5

NOTES: This table presents results of level accounting, which PPPs have been aggregated using the multilateral translog price indices (Caves, Christensen, and Diewert 1982a). In line with this approach, an artificial country is formed by averaging across all countries in the dataset. This artificial country is used as a bridge for making binary comparisons between any two countries. Since Estonia, Latvia, Lithuania, Poland and Slovenia are not included into this dataset for level accounting, labour productivity levels in table 1 slightly differ from the corresponding values in the present table.

Tab. A3. List of sectors and industries

NACE 1.0 Code	Name of a sector/industry used in the paper
	TOTAL ECONOMY
	<u>Market Economy</u>
	Goods
	High Skill-intensive
24	Chemicals and Chemical Products
29	Machinery, Nec
30t33	Electrical and Optical Equipment
	Low Skill-intensive
AtB	Agriculture, Hunting, Forestry and Fishing
15t16	Food, Beverages and Tobacco
17t18	Textiles and Textile Products
19	Leather, Leather and Footwear
20	Wood and Products of Wood and Cork
21t22	Pulp, Paper, Paper , Printing and Publishing
25	Rubber and Plastics
26	Other Non-Metallic Mineral
27t28	Basic Metals and Fabricated Metal
34t35	Transport Equipment
36t37	Manufacturing, Nec; Recycling
	Market Services
	High Skill-intensive
J	Financial intermediation
71t74	Renting of Machinery and Equipment and Other Business Activities
	Low Skill-intensive
E	Electricity, Gas and Water Supply
F	Construction
H	Hotels and Restaurants
50	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles
52	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods
60t63	Transport and transport services
64	Post and Telecommunications
O	Other Community, Social and Personal Services
	Extended Mining
23	Fuel
C	Mining and quarrying
51	Wholesale trade
	<u>Non-Market Economy</u>
70	Real Estate Activities
L	Public administration and defence; compulsory social security
M	Education

Tab. A4. Dependence of the (log of the) variation coefficient of industries labour productivity levels from the (log of the) aggregate labour productivity levels in 1995

	Coef.	s.e.	t-stat.	p-value
The log of the aggregate labour productivity level	-0.22	0.019	-11.93	0.000
CEER dummy	0.08	0.058	1.39	0.174
[CEER]x[The log of the aggregate labour productivity level]	0.12	0.050	2.37	0.023
Constant	0.22	0.011	19.14	0.000

NOTES:

The sample consists of 39 developed, developing and post-transition economies (see the list in tab. A5 of the Appendix). The determination coefficient R^2 = 0.89.

CEER dummy equals one for post-transition economies (see the list in Table A5 of the Appendix) and null for the other countries.

We use OLS with the heteroskedasticity robust White estimator of the covariance matrix.

Tab. A5. The list of countries, country codes and groups

Code	Country	Group (developing; developed; post-transition)
AUS	Australia	developed
AUT	Austria	developed
BEL	Belgium	developed
BGR	Bulgaria	post-transition
BRA	Brazil	developing
CAN	Canada	developed
CHN	China	developing
CYP	Cyprus	developed
CZE	the Czech Republic	post-transition
DNK	Denmark	developed
ESP	Spain	developed
EST	Estonia	post-transition
FIN	Finland	developed
FRA	France	developed
GER	Germany	developed
GRC	Greece	developed
HUN	Hungary	post-transition
IDN	Indonesia	developing
IND	India	developing
IRL	Ireland	developed
ITA	Italy	developed
JPN	Japan	developed
KOR	Korea	developed
LTU	Lithuania	post-transition
LUX	Luxemburg	developed
LVA	Latvia	post-transition
MEX	Mexico	developed
MLT	Malta	developed
NLD	The Netherlands	developed
POL	Poland	post-transition
PRT	Portugal	developed
ROU	Romania	post-transition
RUS	Russia	post-transition
SVK	Slovakia	post-transition
SVN	Slovenia	post-transition
SWE	Sweden	developed
TUR	Turkey	developing
UK	the United Kingdom	developed
US	the United States	developed

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