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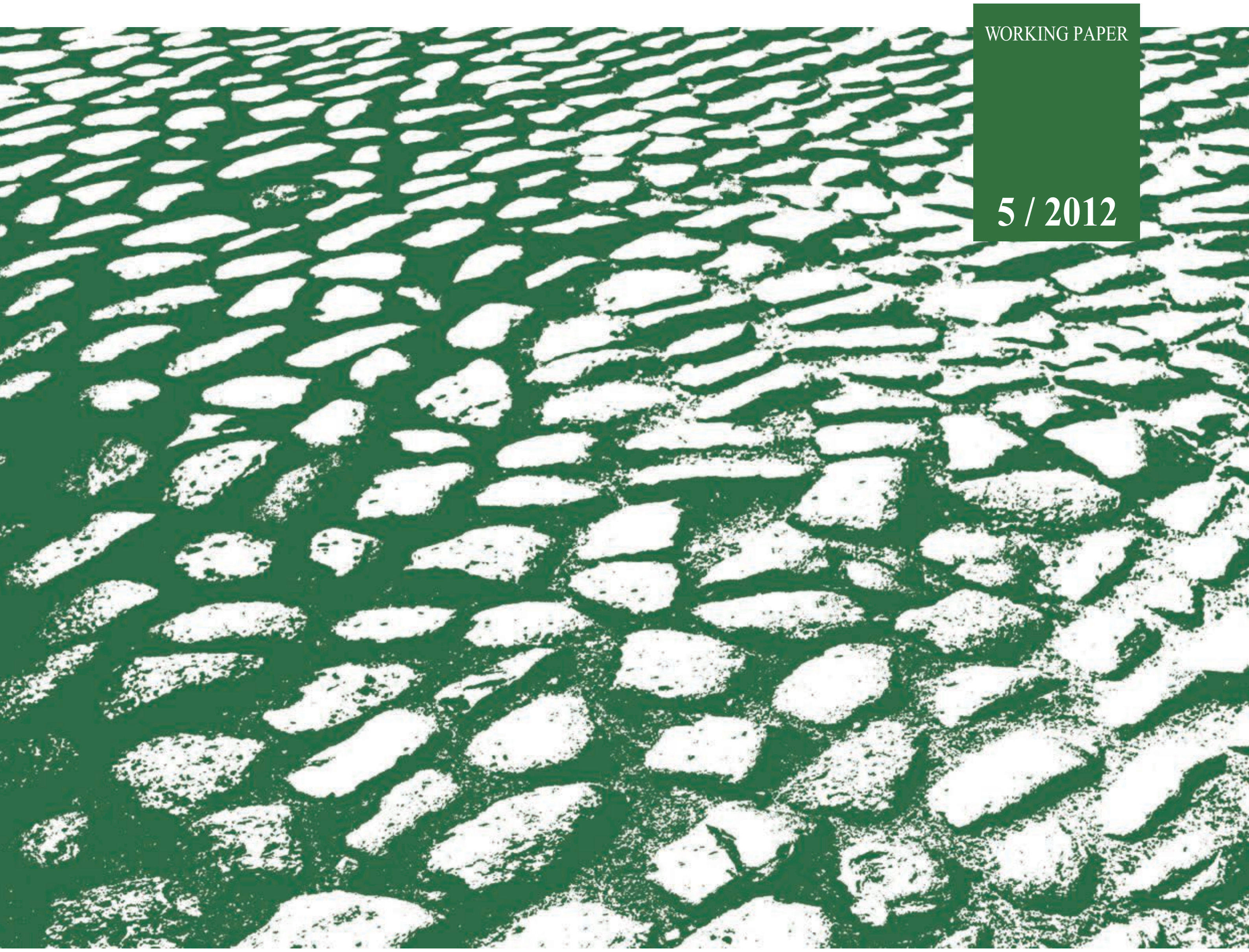
HOW IMPORTANT IS TOTAL FACTOR PRODUCTIVITY FOR GROWTH IN CENTRAL, EASTERN AND SOUTHEASTERN EUROPEAN COUNTRIES?



WORKING PAPER

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CONTENTS

ABBREVIATIONS

CESEE – Central, Eastern and Southeastern Europe
CIS – Commonwealth of Independent States
CPA – Statistical classification of products by activity (2002)
EU – European Union
FDI – foreign direct investment
GDP – gross domestic product
NACE – Statistical classification of economic activities in the European Community
SVAR – structural vector autoregression
SUT – supply and use table
TFP – total factor productivity
ToT – terms of trade
TSLS – two stage least squares
US – United States
WIOD – World Input-Output Database

ABSTRACT

The evolution of total factor productivity (TFP) is a key determinant of long-run economic growth of a country. In this paper we analyse the contributions from technological change at the industry level to an economy's aggregate growth performance. Our derivation of total TFP growth entails three major improvements over the traditional Solow residual approach. First, we allow for non-constant returns to scale as well as changes in the utilisation of input factors in our estimation of industry TFP growth. Second, we use a novel approach to aggregate TFP from industry level to macro level, which incorporates both direct and indirect effects through intermediate linkages within an economy. Third, we take account of open economy characteristics by assigning an explicit role to terms-of-trade shocks. Our calculations for the sample of 10 Eastern European EU Member States over the time period from 1995 to 2009 are based on the newly available World Input-Output Database (WIOD).

Keywords: total factor productivity, terms of trade, utilisation, input-output table, Central, Eastern and Southeastern Europe

JEL codes: C23, D24, E23, O47

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INTRODUCTION

The global economic crisis has shown a severe impact on Central, Eastern and Southeastern Europe (CESEE), a region which is still in the process of catching-up with their Western European peers. The catching-up process has only started a bit more than two decades ago with the fall of the iron curtain and the transition from centrally planned to market economies. From the mid-1990s to 2008, CESEE countries recorded substantial economic growth supported by strong production factor accumulation, large inflows of foreign capital, and ample credit availability. The "traditional" CESEE growth model has come into question in the recent crisis as credit conditions deteriorated and foreign capital inflows receded. This redirects the focus of attention towards domestic growth drivers and the role of technological change for the region's growth potential. In the present paper we analyse growth drivers in order to allow for a deeper understanding of these countries' "technology improvement" structure. In particular, we shift attention to TFP as a part of economic growth, which cannot be attributed to accumulation and varying utilisation of production factors.

Literature on the growth potential of an economy is extensive but – for reasons of data availability – biased towards industrialised countries, often towards the US. Especially filtering methods require long time series, therefore calculations for the relatively young transition countries in Central and Eastern Europe are less abundant. Nevertheless, early interest on the region arose in connection with the recovery from the transformation shock in the early 1990s. Later on, the EU accession of this group of countries raised interest in the quantitative assessment of the speed of convergence, as the Central and Eastern European accession countries joined the EU with a considerably lower per-capita-income level in comparison with the countries from previous enlargements.

Berg et al. (1999) assessed the importance of macro variables, structural policies and initial conditions for the long-run growth prospects or recovery in the former socialist countries. According to their findings, the structural reform dominates the other two sets of determinants in terms of shaping the recovery path. They further observe rather diversified recovery paths. While U- and V-shaped rebounds were most commonly observed, the Baltics as well as Russia and other CIS countries often showed considerably slower rebounds. Pursuing almost the same research question, Majcen and Damijan (2001) first identify not only the initial conditions but also structural reforms and macroeconomic and institutional environment as important factors for the growth potential of Slovenia after a transformation shock. Room (2001) estimates potential output for Estonia based on an improved production function approach, whereby she corrects for changes in the quality of labour. She then uses the coefficients obtained for Estonia to calculate potential output for Latvia, Lithuania and the Czech Republic. She finds that potential output lies above actual output in almost all periods, except some short-lived boom periods in the Czech Republic, Latvia and Estonia. Benk et al. (2005) use a variety of techniques (univariate filters, production function, multivariate HP filter, SVAR and an unobserved components model) to calculate the output gap for the Hungarian economy. According to their estimates, capital accumulation has been the main growth driver in Hungary, with the contribution of labour, while still positive, declining from 2001 onwards. Their output gap estimate for Hungary is more volatile than similar estimates for the euro area or the US, which is in line with similar estimations for other transition countries. Moore and Vamvakidis (2007) estimate potential growth for Croatia to lie between 4% and 4.5% prior to the recent crisis. They arrive at this range by using a variety of alternative methods, such as HP-filter, Cobb-Douglas production function for the aggregate economy and coefficient estimates from a cross-country growth regression.

A number of features characterise the growth potential in CESEE. First, initial conditions at the outset of transformation period have shaped the recovery path in the long-run. Second, the structural reform, to a large extent representing the heart of the transition process, has played an important role. With respect to the TFP measurement, this renders the simple production function approach questionable. Very often, the production function approach is based on a one-sector model of the economy, which, by definition, cannot take account of structural changes. This simplification is clearly unrealistic and possibly misleading already when applied to the countries with long, uninterrupted economic history. It is all the more inappropriate in the context of transition countries with a short history of impressive convergence towards more advanced economies. Thus, multi-sector models taking into account linkages between sectors as well as changes in the economic structure over time are certainly required. Third, most authors find rather strong fluctuations in potential output for these countries (see Benk et al. (2005)). This may simply reflect the fact that these countries are still away from their true long-run equilibrium. They are likely to be going through different phases of the adjustment process towards mature market-based economies. It may, however, also suggest that cyclical factors are not fully identified by the estimation methods used so far.

Even in a more general setting, the estimation of TFP opens up a range of crucial questions. Ideally, TFP should be measured at the most detailed industry level in order to take account of different production technologies in different activities. Working at the industry level enables us to overcome a major shortcoming of previous production function approaches, i.e. measuring the TFP growth in CESEE region on the basis of one-sector models of the economy. Moreover, our estimations of TFP consider differences in the production function of individual sectors and allow for non-constant returns to scale and variation in the utilisation of input factors. By doing this, we are able to improve the traditional Solow residual approach and to separate the TFP growth from such non-technological effects as the changes in capacity utilisation.

Not only the accurate estimation of TFP rates but also the correct aggregation of industry specific results to the country level is a non-trivial task. If correctly done, however, this allows for highly policy-relevant conclusions concerning the contribution of individual sectors to overall TFP growth. Our input-output based approach yields an estimate of total economy-wide TFP growth accounting for both direct and indirect effects. Thus, a technological change in a certain sector not only directly influences the aggregate TFP growth but also produces indirect effects through the use of intermediate goods in production.

Finally, we focus special attention on the fact that CESEE countries are small and open; hence their growth potential is strongly influenced not only by their domestic production structure but also by their external linkages (purchase of intermediate inputs from abroad and their ability to export).

We base our estimations on the newly available World Input-Output Database (WIOD), which combines information on input-output tables and international trade in a global input-output table. The use of input-output tables and the time dimension implicit in WIOD also takes into account the impact of structural changes, a factor which is heavily stressed in the existing literature on the economic growth in transition countries. As mentioned above, the transition process implies, almost by definition, a great deal of structural change in these economies with strong implications for potential growth prospects.

The paper is organised as follows. Section 1 guides through the theoretical framework which spans the topics from the estimation of industry TFP growth rates to their aggregation through input-output tables and allocation to final use components of the economy. We take account of the high degree of openness of these economies by allowing changes in ToT to affect final consumption, investments and exports in Subsection 1.3. Section 2 describes WIOD and explains some technical details concerning necessary data transformations. The results are given in Section 3, and the final Section concludes.

1. THEORETICAL FRAMEWORK

1.1 Derivation of TFP by industry

The traditional measure of TFP growth is the Solow residual, which is calculated under a set of very restrictive assumptions: perfect competition and constant returns to scale, costless adjustment and, consequently, full utilisation of production factors. As a result, the Solow residual systematically includes non-technological effects like changes in capital utilisation or variations in the intensity of workload. Basu and Kimball (1997) pioneered an approach based on more realistic assumptions, including imperfect competition and unobserved changes in utilisation, which was further developed by Basu et al. (2001), Basu et al. (2006) and Groth et al. (2006). This approach was also used for CESEE countries by Kátay and Wolf (2008), and Fadejeva and Melihovs (2009).

Our approach to evaluate TFP growth at the level of individual industries follows Basu and Kimball (1997). As in the standard approach, a representative firm produces gross output using capital, labour and intermediate inputs. However, in addition, there are adjustment costs for changing the level of capital and labour. Alternatively, a firm may change the utilisation of inputs, which also requires some costs, like higher wage rates for extra hours worked, premium payments for extra efforts of workers due to utilisation of labour, and a more rapid depreciation with respect to higher capital utilisation. The representative firm then solves the following intertemporal cost minimisation problem (time and industry subscripts are omitted for ease of notation):

$$\min_{S,E,H,N,I,R} E\left(\sum_{\tau=0}^{\infty} \beta^{\tau}\left(wLG(E,H)V(S) + wL\Psi(R/L) + P^{I}K\Phi(I/K) + P^{N}N\right)\right) \qquad (1)$$

so that

$$Y = F(KS, LHE, N, Z) = Z\left((KS)^{s_K}(LHE)^{s_L}N^{s_N}\right)^{\gamma} \qquad (2),$$

$$\dot{K} = (1-\delta(S))K + I \qquad (3),$$

$$\dot{L} = R \qquad (4).$$

The production function F is assumed to be a Cobb-Douglas function, where s_K, s_L and s_N are the shares of inputs in total costs and are constant. This framework is not restricted to perfect competition and constant returns to scale, as γ denoting the degree of returns to scale can differ from unity. The representative firm produces gross output Y using capital K, which is adjusted for the intensity of capital utilisation S and labour L (the number of employees), which in turn is adjusted for changes in working hours per worker H and the level of efforts E. The production function further includes intermediate inputs N and technology Z.

According to equation (1), the firm chooses intensity of capital utilisation, number of hours worked per worker, level of efforts, volume of intermediate inputs, flows of investment I, and hiring net of separations R that minimise the present value of the sum of current and future costs complying with the conditions of the production function in equation (2), capital formation in equation (3) and labour formation in equation (4). Costs in each period include costs for labour, capital and intermediate inputs. Labour costs depend on the basic wage w, the number of employees, shifts in the basic wage depending on hours worked, efforts and capital utilisation. The effects of hours and efforts on wage are given by $G(E,H)$, while the impact of capital utilisation on labour is given by $V(S)$. Both functions are increasing and convex. In addition, as the amount of labour is quasi-fixed, there are costs associated with changes in the number of employees $wL\Psi(R/L)$, where Ψ is an increasing and convex labour adjustment cost function.

Capital costs are determined by the costs of capital adjustment $P^I K\Phi(I/K)$, where P^I is the price of investment, and Φ is an increasing and convex capital adjustment cost function. The rate of depreciation is variable and given by $\delta(S)$. Costs of intermediate inputs are simply the product of intermediate inputs volume N and prices P^N.

By solving the first-order conditions of the dynamic cost minimisation problem in equations (1)–(4), deriving the Euler equations for capital and labour, log-linearising around the steady state values and rearranging terms, one can obtain the following dynamic production function (for technical details see Basu and Kimball (1997)):

$$dy = \gamma^* d\chi + \gamma^* du + dz \tag{5}$$

where $d(.)$ denotes the growth rate of the variable, lower-case letters refer to natural logarithms, and * implies the steady state value. Accordingly, dy is output growth, du denotes changes in utilisation, and dz corresponds to changes in TFP. Term $d\chi$ measures the overall input growth based on observable variables: changes in capital stock (dk), changes in total amount of employees (dl), changes in hours worked per worker (dh), and changes in volume of intermediate inputs (dn):

$$d\chi = s_K dk + s_L\left(dl + dh\right) + s_N dn \qquad (6).$$

Unobservable growth in utilisation can be expressed by growth rates of the following observable variables:

$$du = \beta_1 dh + \beta_2\left(dp^N + dn - dp^I - dk\right) + \beta_3\left(di - dk\right) \tag{7}$$

where β_1, β_2, and β_3 are complex functions of input cost shares, returns to scale, elasticities of depreciation rate and adjustment cost functions (see Basu and Kimball (1997)), and therefore could be treated as unknown constants. The intuition for the change in hours per worker as a proxy for the dynamics of labour utilisation is simple: in order to increase utilisation, the firm has to use more labour (more hours per worker or a shift in efforts). Thus, when the number of hours worked increases, the unobserved utilisation also increases and coefficient β_1 is positive. The intuition for the second term (changes in the ratio of real intermediate inputs to capital) in the utilisation equation is related to the nature of capital and intermediate inputs: it is much easier to adjust the volume of intermediate inputs than that of capital or labour as there are no costs for changing the volume of intermediate inputs. It is, therefore, likely that a firm uses existing capital more intensively when the ratio of intermediate inputs and capital rises. This positive relationship implies a positive sign for coefficient β_2.

The interpretation of the third term, the ratio of investment to capital, is more complex. On the one hand, higher utilisation intensity of capital is associated with a higher rate of depreciation and, therefore, also higher investment. On the other hand, a higher investment-to-capital ratio boosts adjustment costs, and firms may, therefore, temporarily decrease capital utilisation in order to reduce the depreciation rate and overall capital costs. Overall, the net effect of the third term depends on the relative size of the two effects above.

Given that the values of β_1, β_2, β_3, and γ^* are known, equations (5)–(7) can be used to estimate dz, i.e. changes in TFP. If γ^* is restricted to 1 and the level of utilisation is assumed to be constant, equation (5) reduces to $dy = d\chi + dz$ and dz corresponds to the traditional Solow residual.

1.2 Measuring aggregate productivity from industry contributions

While the estimation of productivity growth should preferably be done at a disaggregate level in order to account for differences in production functions across industries, the aggregate effect of changes in TFP are of most interest for researchers and policy makers. Groth et al. (2006) note that such an aggregation requires the derivation of a relation between gross output and value added at the industry level, otherwise the aggregated contribution of productivity will be underestimated. In an input-output framework, Basu et al. (2010) go one step further and take advantage of the use table to derive direct and indirect effects of productivity changes. We follow the spirit of this latter approach here.

The previous section described the derivation of TFP growth at the industry level. However, in such a way, only the direct effects of technological change are measured, while those coming indirectly through the use of intermediate inputs are not taken into account. The best way to derive both direct and indirect effects of the industry-level TFP growth at macro level is through the use of input-output tables, as they provide information on the use of intermediate products. Table 1 shows a very simplified version of an input-output table for a closed economy with only 2 products[1], the same product price regardless whether it is consumed or used as an intermediate input, and a restriction to only one type of final use (consumption), while taxes and transport margins are ignored. Despite the above restrictions, this table is still useful for understanding how a positive technology shock in one industry transmits into other sectors of the economy and affects final use.

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[1] Herein we assume that product and industry are synonyms, i.e. each commodity is produced only within one corresponding industry. This assumption will be relaxed in Subsection 3.2.

Table 1
Stylised input-output table

		Product 1	**Product 2**	**Consumption**	**Total output**
Domestic	Product 1	P_1N_{11}	P_1N_{21}	P_1C_1	P_1Y_1
	Product 2	P_2N_{12}	P_2N_{22}	P_2C_2	P_2Y_2
Value added		VA_1	VA_2	...	VA
Total input		P_1Y_1	P_2Y_2	P^CC	

Note: P_i is the price of product i, P^C – the price of consumption basket, N_{ij} – intermediate input of product j used in production of i, VA_i – value added of product i, Y_i – gross output of product i, C_i – consumption of product i, and C – total consumption.

The assumption of a Cobb-Douglas production function F implies that the shares of inputs in total costs are unchanged; in other words, the structure of the first two columns in Table 1 is constant. Another important assumption is that consumer utility is also represented by a Cobb-Douglas function, which implies constant nominal expenditure shares. From those assumptions it follows that the whole nominal structure of input-output table depends solely on structural parameters of production and utility functions and is, therefore, unchanged.

The dynamic production function in equations (5)–(6) is rewritten, taking into account the fact that the number of intermediate inputs can exceed 1 and adding the product/industry subscript i:

$$dy_i = \gamma_i^*\left(s_{Ki}dk_i + s_{Li}\left(dl_i + dh_i\right) + \sum\nolimits_j s_{Nij}dn_{ij}\right) + \gamma_i^* du_i + dz_i \qquad (8).$$

The constant structure of the nominal input-output table implies that the growth of real gross output, real net output (consumption) and real intermediate consumption of a product are equal $\left(dy_i = dc_i = dn_{ji}\right)$, which means that the production function of gross output in equation (8) can be replaced by the production function of net output:

$$dc_i = \gamma_i^*\left(s_{Ki}dk_i + s_{Li}\left(dl_i + dh_i\right) + \sum\nolimits_j s_{Nij}dc_j\right) + \gamma_i^* du_i + dz_i \qquad (9).$$

Now we can express equation (9) in a matrix form and apply inverse transformation:

$$dc = \gamma s_K\, dk + \gamma s_L\left(dl + dh\right) + \gamma B^T dc + \gamma du + dz \qquad (10),$$

$$dc = \left(\mathrm{I} - \gamma B^T\right)^{-1}\gamma s_K\, dk + \left(\mathrm{I} - \gamma B^T\right)^{-1}\gamma s_L\left(dl + dh\right) + \left(\mathrm{I} - \gamma B^T\right)^{-1}\gamma du + \left(\mathrm{I} - \gamma B^T\right)^{-1} dz \qquad (11)$$

where $dc = \left\|dc_i\right\|_{J,1}$, $dk = \left\|dk_i\right\|_{J,1}$, $dl = \left\|dl_i\right\|_{J,1}$, $dh = \left\|dh_i\right\|_{J,1}$, $du = \left\|du_i\right\|_{J,1}$, $dz = \left\|dz_i\right\|_{J,1}$, $B = \left\|s_{Nij}\right\|_{J,J}$, $\gamma = diag\left(\gamma_i^*\right)_{J,J}$, $s_K = diag\left(s_{Ki}\right)_{J,J}$, $s_L = diag\left(s_{Li}\right)_{J,J}$, I is J by J identity matrix, and J is the number of products/industries.

The production function in equation (11) contains both direct and indirect effects of the changes in capital, labour and TFP on net output in different products/industries. In this paper, we are primarily interested in the last term $\left(\mathrm{I} - \gamma B\right)^{-1} dz$, which shows the full effect of a change in technology (or a technology shock). The final step is to aggregate the contribution of a technology shock in all products/industries, taking into account their shares in final consumption (which are constant and given by a Cobb-Douglas utility function):

$$dz_C = s_C\left(\mathrm{I} - \gamma B^T\right)^{-1} dz \tag{12}$$

where dz_C is the contribution of technology shock to real consumption growth[2], and s_C is the share of product/industry i in total nominal consumption[3].

1.3 Open economy and ToT

The input-output framework in Table 1 has a very restrictive assumption of a closed economy that is absolutely unrealistic in today's world. To show how the inclusion of international trade will affect the analysis, we need to modify the stylised input-output table by including export and import flows.

In addition to real domestic industries producing commodities 1 and 2, Table 2 also includes a "virtual" trade product/industry. It was pointed out by Basu et al. (2010) that the process of international trade can be viewed as a synthetic industry: in order to obtain imported goods, a country is forced to involve into export activities. Using production function terminology, exports are the inputs of "virtual" trade industry and imports are the output.[4] As total nominal imports are equal to the sum of nominal exports and net financial inflows (given by negative net exports $P^M M - P^X X$), the production function of this "virtual" trade commodity can be expressed by the following equation:

$$M = F_{trade}\left(X, P^M M - P^X X, P^X / P^M\right) = \left(X + \left(P^M M - P^X X\right)\right)\left(P^X / P^M\right) \qquad (13).$$

Under the assumptions that preferences of foreign consumers are also described by a Cobb-Douglas utility function and that the ratio of financial inflows to GDP is constant, the structure of nominal inputs of "virtual" trade product/industry is constant and its dynamic production function is given by:

$$dm = dx + \left(dp^X - dp^M\right) \tag{14}$$

where $dp^X - dp^M$ denotes simply the changes in ToT and is similar in spirit to the changes in technology in equation (5). Indeed, improvements in ToT have the same effect as a positive technology shock for a domestic product/industry: for the same amount of real exports (inputs) a country can obtain (or "virtually produce") a larger amount of imports (outputs). That is why ToT can be regarded as a specific type of TFP affecting final use and, hence, should be included in the analysis.

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[2] In this simplified example real consumption coincides with real value added and real GDP.

[3] It can be replaced by the nominal structure of government consumption, gross fixed capital formation, exports, etc. to calculate the contribution of technology shock to the growth of any final use component.

[4] This might sound counter-intuitive, but it should be remembered that we focus on the domestic absorption. Thus imports represent foreign produced substitutes for domestically produced goods. Since the latter are clearly the output of domestic industries, imports are consequently considered to be the output of "trade industry", while exports generate the revenue, which is necessary to buy these imports from abroad. By selling exports, an economy can consume imports. Hence exports serve as inputs for the trade industry. See, e.g. Krugman (1993) for intuitive reasoning.

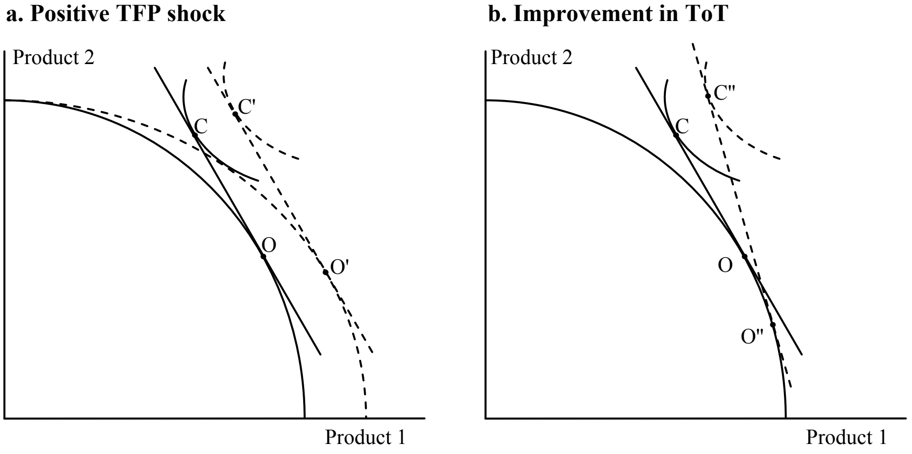
Table 2
Stylised input-output table with external sector

		Product 1	**Product 2**	**Trade product**	**Consumption**	**Total input**
Domestic	Product 1	P_1N_{11}	P_1N_{21}	P_1X_1	P_1C_1	P_1Y_1
	Product 2	P_2N_{12}	P_2N_{22}	P_2X_2	P_2C_2	P_2Y_2
Trade product		$P^M{}_1M_1$	$P^M{}_2M_2$	...	$P^M{}_CC^M$	P^MM
Value added		VA_1	VA_2	...	...	VA
Financial account		...	...	$P^MM–P^XX$	...	...
Total output		P_1Y_1	P_2Y_2	P^MM	P^CC	

Note: $P^M{}_i$ is the price of imported intermediate inputs in product i, $P^M{}_C$ – the price of imported consumption goods, P^M – the price of total imports, P^X – the price of total exports, M_i – imported intermediate inputs used in production of i, C^M – imported consumption, M – total imports, X_i – exports of product i, and X – total exports.

Chart 1 illustrates the abovementioned effect by referring to the production possibilities frontier and isovalue lines. This simple textbook example shows how the technology and ToT shocks impact on consumption and output. Higher utility represented by reaching a higher indifference curve, can be achieved in two ways. A positive technology shock at home leads to a (biased) shift in production possibilities thus achieving higher output and consumption (Chart 1a). Alternatively, a higher consumption level can be the result of a positive shock in ToT, illustrated as an increase in the slope of the isovalue line (Chart 1b). However, in this case, the output remains on the unaltered production possibilities frontier, meaning that value added is unaffected by ToT.[5]

Chart 1
Effects of TFP and ToT shocks



Note: The concave production possibilities frontier defines all possible output combinations with full utilisation of inputs, while the isovalue line determines all combinations of consumption which can be achieved via international trade for a given ratio of export and import prices (ToT).

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[5] In the case of non-constant returns to scale, a ToT shock may shift the volumes of value added, yet in most cases this effect remains marginal.

To analyse the aggregate contribution of changes in TFP and ToT, one can still use equation (12), although with a slight modification to include the "virtual" trade product/industry (thus, the number of products/industries increases to $J + 1$). The "virtual" industry has constant returns to scale, thus the diagonal of γ is augmented by 1. In the open economy case, the column vector dz contains all J product/industry-specific domestic technology shocks and changes in ToT as the last element. Matrix B now contains cost shares of domestic intermediate inputs, cost shares of imported intermediate inputs (last row), and shares of nominal exports of commodity i to total nominal imports (last column). The row vector s_C also includes the share of imported consumption.

It is important to note that in the presence of external sector total value added is no longer equal to total consumption, and to evaluate the contribution of TFP changes to value added, s_{VA} is used instead of s_C in equation (12):

$$s_{VA} = \left\lfloor \left(P_1 Y_1 - \sum\nolimits_i P_1 N_{i1}\right)\big/ VA, \quad \ldots, \quad \left(P_J Y_J - \sum\nolimits_i P_J N_{iJ}\right)\big/ VA, \quad -\left(\sum\nolimits_i P_i^M M_i\right)\big/ VA \right\rfloor \quad (15).$$

Value added is equal to the sum of domestic final use net of imported intermediate inputs. The final element of s_{VA} in equation (15) is negative, which ensures that the total effect of changes in ToT on value added is zero.

2. DESCRIPTION OF DATABASE

2.1 Description of WIOD

We base our calculations on the newly available World Input-Output Database (WIOD, Timmer et al. (2012)), which is especially suited for our purpose as it combines harmonised national supply and use tables with international trade data. The national supply and use tables are not only harmonised across countries in this dataset but also extrapolated and interpolated over time, thus yielding a panel data set which spans 40 countries over the years 1995–2009.[6] The sample includes all 27 EU Member States as well as 13 other major countries (such as the US, Japan, China, Russia, India, etc.). National accounts and trade data have been integrated into sets of intercountry (world) input-output tables and supplemented by satellite accounts containing environmental and socio-economic indicators.

For our estimation of industry-level TFP growth rates, we make use of socio-economic accounts as they provide us with all necessary information on factor inputs, cost shares, utilisation and effort at the sector level. WIOD provides information for 35 goods and services producing industries. Data is available on gross output, value added, capital stocks, employment levels, intermediate inputs, hours worked, factor compensations, and the respective deflators. With this data set at hand, we are able not only to adjust for changes in factor utilisation but also account for qualitative changes in capital and labour inputs, as according to Basu and Kimball (1997), unaccounted changes in the quality of input factors can be one

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[6] Most of CESEE countries have comparatively good availability of national supply and use tables by year. For example, the Czech Republic and Slovakia report the supply and use tables for each year between 1995–2005 and 1995–2006 respectively. Good coverage in recent years is provided by Estonia, Hungary and Slovenia. Most problematic situation is in Latvia where the national tables are available only for 1997–1998. The supply and use tables for 2007–2009 are obtained by extrapolation for all CESEE countries in WIOD.

of the reasons for cyclical fluctuations in the Solow residual. We account for quality of factors by using a composite of different asset types at different prices and, in the case of labour, a composite of different skill types at different wages.

We further add macroeconomic data from the World Bank database, which we are going to use as an instrument in our TFP estimations. These include information on global prices for oil and other commodities, interest rates, real effective exchange rates, government expenditures as well as global and national GDP and exports and are described in more detail in Subsection 3.1 below.

The second step in our analysis – proper aggregation of industry-specific TFP growth rates – requires the use of harmonised SUTs, which are the basic building blocks of WIOD. National SUTs are typically compiled for selected years (often every five years) and show methodological variations over time. One of the advantages of WIOD is the fact that SUTs have been harmonised both over time and across countries by benchmarking the available national SUTs on consistent time series from the System of National Accounts.[7]

2.2 From industry-specific technology to product-specific technology

Up to this moment, we assumed that product and industry are synonyms, i.e. each commodity is produced only within one corresponding industry. In reality, however, a commodity may be produced in different industries due to secondary production activities of firms. The types of secondary production include subsidiary products, by-products and joint products (see Eurostat (2008)). The data on gross output, value added and factor inputs available in WIOD allow us to estimate TFP growth at the industry level. This would correspond to an industry technology assumption, i.e. each industry has its own specific way of production irrespective of its product mix. According to this assumption, we can use the industry-by-industry input-output table which is available in WIOD, and thus the products in stylised Table 2 and equation (12) will be replaced by industries.

However, there is a widespread consensus in literature that a product technology assumption is more plausible from the theoretical point of view (see System of National Accounts, 1993). This assumption states that each product is produced in its own specific way irrespective of the industry where it is produced. The advantage of the product technology assumption consists in the fact that it is applicable in the case of subsidiary production while at the same time not excluding cases of by-products and joint production (Eurostat (2008)). Practical implementation of the product technology assumption may create some problems, however. The data needed for the estimates of TFP on a disaggregated level are classified by industry and not by product. Therefore, we would need to transform the industry-specific TFP changes into the product-specific TFP changes. Moreover, a product-by-product input-output table is not available in WIOD, although it can be constructed from the supply and use tables.

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[7] Harmonisation is based on Temurshoev and Timmer (2011), details of the various implementation issues in this respect are discussed in Timmer et al. (2012).

Table 3

Supply, use and product-by-product input-output tables

a. Supply table		
	Industries	**Supply**
Products	V^T	q
Output	g^T	

b. Use table			
	Industries	**Final demand**	**Use**
Products	U	Y	q
Value added	W		w
Output	g^T	y	

c. Product-by-product input-output table			
	Products	**Final demand**	**Output**
Products	S	Y	q
Value added	E		w
Input	q^T	y	

Note: V^T is supply matrix (industry by product), U – use matrix for intermediates (product by industry), W – value added matrix (component by industry), S – matrix for intermediates (product by product), E – value added matrix (component by homogenous branch), Y – final demand matrix (product by category), g – column vector of industry output, y – vector of final demand, q – column vector of product output, w – vector of value added.
Source: Eurostat (2008), Table 11.26.

Table 3 describes the main elements of the supply, use and product-by-product input-output table. While information on final demand (Y, y) and total output (q, w) can be obtained directly from the use table, the product-by-product matrix of intermediate inputs (S) and value added by product (E) are still missing and should be derived. According to Eurostat (2008), this can be done by combining information from both the use and supply tables:

$$S = U\left(V^T\right)^{-1} diag(q) \qquad (16),$$

$$E = W\left(V^T\right)^{-1} diag(q) \qquad (17).$$

There are two practical obstacles to implementing this simple procedure. The first obstacle is that in WIOD the number of products (59) exceeds the number of industries (35), which means that V^T is non-square and, therefore, cannot be inverted. In order to implement equations (16) and (17), we need to make the supply matrix square. One way to deal with the problem of non-square supply matrix is to split several industries. This, however, implicitly requires an industry technology assumption. Rather, we assign each product to a primary industry based on an official correspondence (see Appendix A), and this assignment of products to industries is then used to merge several products and to obtain a square supply matrix.

The second problem results from the fact that the transformation in equations (16) and (17) can produce negative elements in the input matrices S and E without economic meaning. To overcome this problem, we use the Almon iterative method (see Almon (2000)), which applies the product technology by calculating matrices S and E row by row. Negative values are eliminated as soon as they appear by reducing the amounts transferred. Although the row totals are unaffected, a drawback of the Almon method is that the column totals may be altered. Therefore, the results of the Almon method should be checked carefully by recalculating the use matrix:

$$U = \widetilde{S} diag(q)^{-1} V^T + \varepsilon \qquad (18)$$

where $\widetilde{S}$ is product-by-product matrix for intermediates evaluated by the Almon method, and ε is difference matrix. The analysis of ε for various country SUTs in

WIOD showed significant deviations in several industries. However, by joining several industries and thus reducing the size of SUTs from 35 x 35 to 28 x 28 (see the first column in Appendix A), we could avoid these deviations. In particular, we merged all three trade and repair sectors (NACE codes 50 to 52), all transport sectors (60 to 63), and the sector of private households and employed persons (P) reporting zero output in most countries with other community, social and personal services (O). Finally, we also merged coke, refined petroleum and nuclear fuel industry (23) with chemicals and chemical products (24).

After all abovementioned transformations, we obtained a product-by-product matrix as characterised by Table 3c. Further, we use data on intermediate inputs and value added by products from *S* and *E* to calculate the shares of inputs for matrix *B* in equation (12), and we use data on final demand from *Y* to obtain the product shares in final use components and total value added. The product-specific TFP changes are obtained from the industry-specific TFP changes (calculated in Subsection 3.1) using the Almon procedure without sign restriction.

3. RESULTS

3.1 Evaluation of TFP changes

Our empirical model for the estimation of industry TFP growth is given by equation (19) below, which combines equations (5), (6) and (7) and expresses all necessary elements, including utilisation of production factors, in terms of observable variables as explained in Subsection 1.1:

$$dy_{it} = b_0 + \gamma^* d\chi_{it} + b_1 dh_{it} + b_2\left(dp_{it}^N + dn_{it} - dp_{it}^I - dk_{it}\right) + b_3\left(di_{it} - dk_{it}\right) + \xi_{it} \qquad (19)$$

where $b_i = \beta_i \gamma^*$, intercept b_0 allows for the existence of a trend in technical change, and ξ denotes a residual term. By estimating equation (19), we can obtain parameters b_1, b_2, b_3 and γ^* (see Table 4 below), which allows us to evaluate changes in TFP ($dz = b_0 + \xi$). As we are working with a panel dataset spanning across countries, years and industries, we can choose between alternative estimation strategies. Ideally, the estimations are conducted at the most detailed available level, namely equation (19) is estimated for every single industry in each country. Unfortunately, this approach cannot be implemented here, as the time period covered in WIOD is rather short and contains only 14 observations between 1995 and 2009.

To increase the number of observations, we use panel estimates, whereby we can create the panel in three different ways. The global panel would include all industries and countries, where observations have to be stacked either by country or by industry. This approach is the simplest but, at the same time, overly restrictive, for it assumes that returns to scale and other fundamental parameters of the production function determining b_1, b_2, b_3 are the same in all industries across all countries. We can also construct a number of panels, separating the panel data sets either by industry or by country. We choose to work with 28 industry-specific panel data sets, whereby each panel contains a country and a time dimension. As the coefficients in equation (19) are driven by parameters which are specific to the underlying production and adjustment cost function of the respective industry, it seems reasonable to assume that coefficients of the same industry are homogenous across countries rather than to impose equal coefficients on different industries in one country.[8] We include country fixed effects to control for country-specific characteristics (therefore $\xi_{it} = \mu_i + v_{it}$). Although time-specific fixed effects would help isolate a world business cycle effect, these were not used in the regression. It is rather possible that the TFP dynamics are correlated across countries in some industries, e.g. due to world-wide technological progress. Thus, the inclusion of time-specific fixed effects would eliminate some part of TFP changes.

Another problem related to the empirical estimation is the potential correlation between input growth and technology shock. This endogeneity problem is also mentioned in Basu et al. (2006). We argue further that there may also be potential correlation between other right-hand variables and the technology shock. Changes in hours worked per worker can be affected by technological progress due to process innovation and, thus, better work organisation. New technologies may also improve energy efficiency and, hence, reduce the ratio of intermediate inputs to capital. Finally, a technological change is usually associated with the instalment of new equipment, which can increase investment to capital ratio.

Therefore, we draw on a range of instruments which are uncorrelated with technological change but correlated with the right hand variables[9] in the estimation of equation (19). The particular set of instruments used may differ from industry to industry. The instruments can be divided into four groups. The first group comprises industry-specific variables such as lagged values of input growth, changes in hours worked, intermediate inputs-to-capital and investment-to capital ratios. Variables in the second group describe changes in external demand, which is uncorrelated to domestic technology shocks while explaining changes in total inputs. This group contains global GDP growth as well as index of real external demand for each specific industry in every country (calculated using WIOD data and applied only to industries producing tradable goods). The third group includes instruments that correlate with country-specific business cycles and, therefore, correlate strongly with variables proxying for the level of factor utilisation.[10] These are changes in 3-month money market rate, changes in real effective exchange rate (both proxies for monetary policy), and changes in government expenditure to GDP (proxy for fiscal policy). Although monetary and fiscal policies both react to changes in output (albeit with some time lag), we take advantage of the fact that these policies in general respond to changes in overall output but not to fluctuations in the output of a specific industry.[11] Hence, we argue that the abovementioned instruments are uncorrelated with technology shocks at the industry-level. The final instrument group contains various world prices (here we follow Basu et al. (2006) who use oil prices). All

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[8] To test the poolability of the data, we ran the regressions for reduced samples (excluding individual countries one by one) and compared the coefficients with those estimated from the full sample. In the vast majority of cases, the coefficients from these reduced samples came to lie within the 95% confidence interval of the full sample coefficients. The exceptions are Transport Equipment (34–35) and Other Social Services and Employed Persons (O–P) when excluding Portugal.

[9] The results of the Sargan test for overidentifying restrictions are reported in Table 4. The null hypothesis is rejected for a vast majority of industries. The results of first stage regressions are available upon request.

[10] Basu et al. (2006) used Federal Reserve's "monetary shocks" from an identified VAR as an instrument. Our approach is somewhat similar, although we did not have an opportunity to estimate shocks from a VAR model due to the short length of data series.

[11] The recent global economic crisis has to some extent challenged this statement with respect to fiscal policies (recall the European car scrappage schemes in 2009). However, such policies were only applied in the minority of 40 countries in our sample.

equations include changes in a general world commodity price index as an instrument, while for several industries we add specific commodity price indices, e.g. food price index in the estimation for agriculture, hotels and restaurants, food, beverages and tobacco industry, a metal price index for the basic metals and fabricated metal industry, a hardwood price index for wood industry and construction.

The crucial condition in instrumental variable estimation is that the chosen instruments must be orthogonal to the error process. The orthogonality condition is verified by the Sargan test (called also J-test for overidentified restrictions). For all industries the null hypothesis that instruments are uncorrelated with the error term could not be rejected at 1% confidence level, while only for three industries (food, beverages and tobacco; pulp, paper, printing and publishing; refined petroleum, chemical products) the null hypothesis was rejected at 10% confidence level.

As a final technical detail, overall input growth $d\chi$ in equation (6) is defined as weighted growth of observed input factors: capital, hours worked, and the volume of intermediate inputs. Their weights in total factor input are given by their shares in total costs. In contrast to the theoretical model, these shares are varying in data, therefore we follow OECD (2001) and calculate $\widetilde{s}_K$, $\widetilde{s}_L$ and $\widetilde{s}_N$ as an average of input shares in the current and previous periods.

The estimation results of equation (19) are shown in Table 4. We observe almost constant returns to scale in most industries as indicated by coefficient $d\chi$ which is often near unity. The exceptions are agriculture, health and social work, education where estimated returns to scale are insignificant and close to zero (even negative for education), as well as mining, energy, trade, public administration and the manufacture of transport equipment with pronounced decreasing returns to scale. Most of these results seem plausible from the economic point of view. In the education sector, a doubling in the number of schools and teachers will not affect the number of pupils, and even if the quality of education increases it will most likely not double. A similar logic can be applied to public administration and health sectors. The output in mining and quarrying is obviously linked to the amount of natural resources within the territory of a country, and output of agriculture is to a large extent driven by weather conditions, which explains diminishing returns to scale in these industries.

As to proxies for the level of utilisation, all statistically significant coefficients have the expected sign: the increases in hours worked per worker and the intermediates-to-capital ratio lead to a higher output growth, while a higher investment-to-capital ratio lowers the output growth. The results in Table 4 suggest that all three proxies for utilisation are equally important, and they are restricting the analysis to only one proxy (e.g. the changes in hours, as in Basu et al. (2006), would imply a loss of important information). However, it should be noted that in many industries none of the abovementioned proxies is significant, which may be due to a certain lack of homogeneity in industries across countries. We made an attempt to improve the regression by adding several cross terms and allowing the coefficients to vary according to capital intensity of an industry or income level of a country. This did not lead to worthwhile improvements of the results.

Table 4
Estimation results

Industry	**Coefficients**				**No. of countries**	**No. of obs.**	**Sargan test (p-value)**
	$d\chi$	**dh**	**$dn + dp^N - dk - dp^I$**	**di – dk**			
Agriculture, hunting, forestry and fishing	0.032	–0.029	0.928***	0.018	40	360	0.620
Mining and quarrying	0.548***	0.171	0.121	–0.019	40	393	0.684
Food products, beverages and tobacco	1.076***	0.155	–0.049	0.012	40	407	0.017
Textiles and textile products	0.909***	0.052	0.122	–0.004	40	398	0.254
Leather and leather products	0.940***	0.040	0.180*	0.021	39	350	0.463
Wood and wood products	0.975***	0.296	0.199	–0.034	40	394	0.669
Pulp, paper, publishing and printing	1.001***	0.103	0.031	0.003	40	407	0.080
Petroleum, chemical products	0.998***	0.007	–0.082	0.012	40	404	0.019
Rubber and plastic products	0.936***	0.112***	0.120*	–0.007	40	407	0.705
Other non-metallic mineral products	0.997***	0.398	0.087	–0.018	40	404	0.226
Basic metals and fabricated metal products	0.841***	0.275	0.132	–0.009	40	407	0.327
Machinery and equipment n.e.c.	0.852***	0.447**	0.230	–0.051**	40	407	0.112
Electrical and optical equipment	1.159***	0.099	–0.113	–0.009	40	401	0.685
Transport equipment	0.497***	–0.073	0.734***	–0.069	40	399	0.599
Manufacturing n.e.c.	0.924***	0.281	0.147	–0.034	40	396	0.479
Electricity, gas and water supply	0.572***	–0.036	0.305**	0.011	40	403	0.134
Construction	0.942***	0.132	0.163*	–0.030	40	404	0.983
Wholesale and retail trade	0.745***	0.110	0.360**	0.005	40	407	0.169
Hotels and restaurants	0.919***	0.038	0.419	–0.026	40	394	0.508
Transport	0.909***	0.189	0.155*	0.004	40	402	0.494
Post and telecommunications	1.168***	0.075	–0.028	–0.015	40	404	0.392
Financial intermediation	1.131***	0.174	–0.154	–0.015	40	401	0.504
Real estate activities	1.103***	0.015	–0.083	–0.012	40	407	0.925
Other business activities	1.177***	0.527**	–0.180	0.006	40	405	0.562
Public administration and defence	0.773***	0.137	0.088	0.006	39	392	0.463
Education	–0.684	–0.065	0.502	0.055	40	401	0.908
Health and social work	0.021	0.439	0.160	–0.084*	40	394	0.649
Other social and personal services	1.377*	–0.827	0.073	–0.088	40	401	0.346

Notes: These estimates are obtained by TSLS allowing for country-specific fixed effects. The panel consists of 40 countries reported in WIOD, the adjusted time period is from 1997 to 2009. *(**)[***] denote significance at 10%(5%)[1%] level, heteroscedasticity and autocorrelation consistent (clustered) standard errors are used.

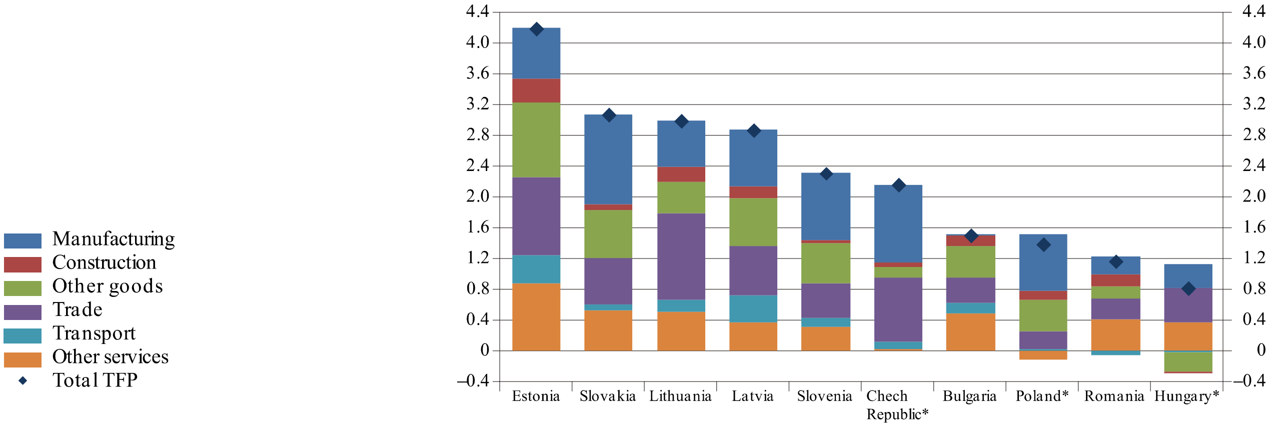
As mentioned above, one of the advantages of proposed TFP evaluation methodology over the traditional Solow residual approach is the ability to separate cyclical fluctuations in factor utilisation from technological effects. The absence of the former should lead to smaller correlation between the estimated TFP growth and changes in output over time. Such intuitive test was applied in Groth et al. (2006) and Fadejeva and Melihovs (2009), with both papers reporting smaller correlation coefficients for adjusted TFP. We report the results of similar calculations in Appendix B. TFP is not expected to be much correlated with business cycle, but technological changes still remain an important determinant of cross-country and cross-industry differences. That is why we are calculating correlation coefficients for within-transformed variables. Indeed, Appendix B shows that overall correlation with changes in output over time is two times smaller for adjusted TFP growth. The results for individual industries are not as straightforward: the correlation coefficients for adjusted TFP in mining and quarrying, education, health and social work are high and exceed those for simple Solow residuals. This can be explained by diminishing returns to scale, which increase the role of TFP in the dynamics of total output. However, for the majority of industries (17 of 28) the comparison of over-time correlations with output suggests the superiority of TFP adjusted to varying utilisation over traditional Solow residual.

3.2 Aggregate contribution of technology and ToT changes

Finally, we can now use the information on TFP growth in individual industries and calculate the contribution of TFP growth and ToT changes to the growth of real value added and various final use components. This is done in equation (12). Matrix γ is formed using the results reported in Table 4 (the negative and statistically insignificant coefficient reflecting negative returns to scale in the education sector was replaced by zero). Vector dz now contains product TFP changes. At first, we obtain industry-specific TFP changes from equation (19) using the industry coefficients from Table 4, and then transform them into product TFP vector using the Almon procedure (without sign restrictions). Similarly to the cost shares used in the previous subsection, matrix B and row vectors s_C and s_{VA} are calculated as an average of current and previous period weights.

Chart 2

TFP and industry contributions to value added growth (1996–2009)



* Average for 1996–2007.

Notes: Calculations are based on equation (12) and estimation results from Table 4. Contribution to logarithmic growth (100dy) is in percentage points. The results for 2008 and 2009 are missing for the Czech Republic, Hungary and Poland due to the switch to NACE 2 and the subsequent lack of NACE 1.1 data on capital stocks for those years.

Chart 2 depicts the average percentage point contribution of TFP to real domestic value added growth after the aggregation of industry-specific TFP growth rates for the ten CESEE EU Member States over the period from 1996 to 2009. The total contribution of TFP to real growth in the economy's value added (blue diamonds) is broken down into contributions of individual sectors (stapled columns) accumulating both direct and indirect effects. As a first observation, we see that the average contribution of TFP varied widely between the ten countries in the region. The Baltic States and Slovakia emerged as the top-performers over the given observation period, contributing above 2.5 percentage points on average per annum. Also, Slovenia and the Czech Republic showed high average annual contributions of TFP to value added growth of 2.3 and 2.2 percentage points respectively. The remaining four countries lagged behind, the average TFP contribution ranging between 0.8

percentage point in Hungary and 1.5 percentage points in Bulgaria. According to the calculations herein, Hungary had a reasonably high TFP growth in the period from 2000 to 2004.

One explanation for these differences might be found in the initial gap with regard to the technological frontier. For example, the comparison of Slovakia and the Czech Republic suggests that TFP growth (and hence its contribution to overall growth) was lower in the Czech Republic simply because of the higher degree of industrialisation of the economy at the beginning. As a result, foreign investors mainly acquired the existing factories and improved the existing technologies, while FDI in Slovakia was more often in the form of greenfield investment, thus laying the foundations for new technologies brought to the country. Another factor might be related to the exchange rate regime. With one exception (the Czech Republic), the highest contributions of technological change to total value added growth were recorded in countries with a fixed exchange rate at the end of the observation period. Fixing the exchange rate can act as a "structural whip", i.e. the lack of the exchange rate as a cushion to external shocks may foster structural change and thus raise the efficiency of the economy.[12] Clearly, this can only be an additional explanatory factor, as for some countries (e.g. Slovakia and Slovenia) frequent realignment or a crawling peg regime undermined the pressure on industrial restructuring.

Not only the magnitude of the overall TFP contribution, which we associate very broadly with technological change, but also the contribution of individual industries or sectors to overall TFP differs between individual countries. Technological progress in goods producing industries has contributed strongly to overall TFP growth in Poland, the Czech Republic, Slovenia and Slovakia. By contrast, services TFP drove economy-wide TFP growth in Bulgaria, Hungary and Lithuania. Estonia, Latvia and Romania show a more balanced mix between TFP growth in services and goods producing industries.

Within the goods sector, manufacturing TFP plays the most important role. It is worthwhile noting that also Hungary shows on average stable positive TFP growth in manufacturing industries. In the Baltic States and Bulgaria, technological progress also in other goods producing industries, agriculture, mining and energy among them, has had a stronger or equally strong influence on economy wide TFP growth as manufacturing TFP. In Bulgaria, the dismantling of the predominance of heavy industry and the re-orientation towards light industry implied an initially negative contribution of TFP growth in manufacturing; however, since 1998, manufacturing TFP (in particular in textiles and chemicals) has been contributing increasingly positively to the overall growth in value added. Within the services sector, it is mostly TFP in trade that impacts most strongly on total TFP growth. Yet financial and business services in Bulgaria and public services in Romania – (both under Other services in Chart 2) contributed most strongly to services TFP. In Latvia and Estonia, TFP growth also in the transportation industry is of major importance.

So far we have aggregated the contribution of domestic industry-specific TFP growth to total value added TFP growth. As we have explained above, there is no theoretical role for ToT effects when the focus is on total value added. Further on, we will trace out how industry TFP affects growth in different final use components

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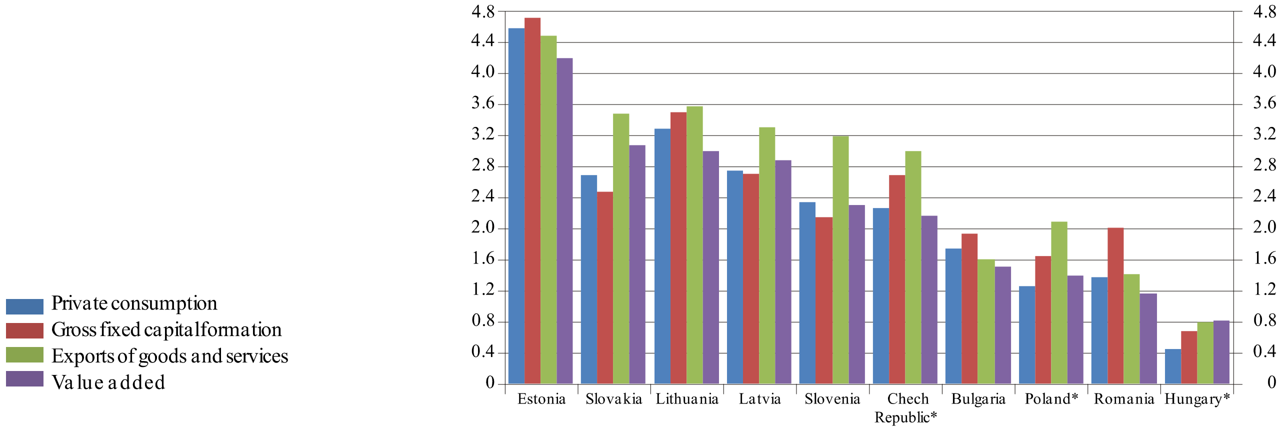
[12] Austria has experienced such a "structural whip" in the 1980s with the schilling-peg to the Deutsche Mark.

of economy. In this context, the changes in ToT may either improve or worsen consumption or investment opportunities of economy without altering those of production. Let us first compare the contribution of TFP growth to three important GDP components, i.e. private consumption, gross fixed capital formation and exports (see Chart 3). Most CESEE countries (the Czech Republic, Slovakia, Slovenia, Poland, Hungary, Lithuania and Latvia) show the highest contribution of TFP to exports, which points towards rapid TFP progress in outward oriented industries. Potential negative developments in external demand related to the euro area crisis for these countries in the near future set aside, this constitutes a solid foundation for future export-led growth. Strong productivity gains in exports are certainly related to substantial foreign investment in outward oriented industries. The analysis of explanatory factors behind TFP growth in this sector is, however, beyond the scope of this paper. Other CESEE countries exhibit the highest TFP contribution to the production of investment goods. Thus, in the given countries, the TFP change was fastest in the production of either investment or export goods, implying a sizeable long-term growth potential.

Chart 3

Comparison of TFP growth contributions across final use components (1996–2009)



* Average for 1996–2007.

Notes: Calculations are based on equation (12) and estimation results from Table 4. Contribution to logarithmic growth (100*dy*) is in percentage points. The results for 2008 and 2009 are missing for the Czech Republic, Hungary and Poland due to the switch to NACE 2 and the subsequent lack of NACE 1.1 data on capital stocks for those years.

Table 5 below displays more detailed results averaged over two periods of time: the pre-crisis period from 1996 to 2007 and the full sample period up until 2009. ToT changes only play a minor role as was to be expected; however, in some countries their contribution is non-negligible. In general, a positive contribution of ToT changes should go hand in hand with a real appreciation tendency: if export prices increase faster than import prices, more imports available for domestic absorption can be purchased for the same amount of exports in the short-run. However, as this also implies a loss in competitiveness, the substitution effect implies an ambiguous net effect. In Estonia, Lithuania, Romania and Bulgaria, the net effect was positive on average and the positive contribution of ToT changes to consumption and investment growth was rather sizeable. By contrast, in Slovakia and Hungary ToT changes affected consumption and investment growth negatively. In the remaining countries, the effects of ToT changes were negligible and a major part of TFP changes were driven by technology shocks.

Table 5

Average contribution of technology and ToT shocks to growth of real final use components in CESEE

	Private consumption			Gross fixed capital formation			Exports		
	TFP	Techno-logy	ToT	TFP	Techno-logy	ToT	TFP	Techno-logy	ToT
1996–2007									
Bulgaria	1.76	1.40	0.36	1.92	1.08	0.85	1.75	1.38	0.37
Czech Republic	2.27	2.28	–0.02	2.68	2.71	–0.03	2.99	3.03	–0.04
Estonia	5.10	3.83	1.28	5.14	3.41	1.73	5.04	3.78	1.25
Hungary	0.45	0.59	–0.14	0.67	0.84	–0.17	0.78	0.94	–0.16
Latvia	3.38	3.28	0.10	3.46	3.29	0.17	3.85	3.77	0.08
Lithuania	3.92	2.98	0.94	4.35	3.26	1.09	4.18	3.40	0.78
Poland	1.26	1.30	–0.04	1.64	1.70	–0.06	2.08	2.10	–0.02
Romania	1.43	0.78	0.65	2.31	1.19	1.12	1.64	1.01	0.64
Slovakia	2.77	3.02	–0.26	2.44	2.81	–0.38	3.54	3.81	–0.27
Slovenia	2.89	2.85	0.04	2.71	2.65	0.05	3.83	3.80	0.03
1996–2009									
Bulgaria	1.74	1.40	0.34	1.93	1.15	0.78	1.61	1.26	0.35
Czech Republic									
Estonia	4.59	3.64	0.95	4.72	3.38	1.34	4.50	3.54	0.96
Hungary									
Latvia	2.75	2.77	–0.02	2.71	2.73	–0.02	3.30	3.32	–0.01
Lithuania	3.29	2.54	0.74	3.50	2.62	0.88	3.58	2.96	0.62
Poland									
Romania	1.38	0.89	0.49	2.02	1.15	0.87	1.41	0.92	0.49
Slovakia	2.68	3.03	–0.34	2.48	2.94	–0.45	3.47	3.83	–0.35
Slovenia	2.34	2.21	0.13	2.15	1.98	0.17	3.19	3.06	0.12

Notes: Calculations are based on equation (12) and estimation results from Table 4. Contribution to logarithmic growth (100*dy*) is in percentage points.TFP stands for overall total factor productivity, which comes from technology and ToT shocks, and ToT means terms of trade. The results for 2008 and 2009 are missing for the Czech Republic, Hungary and Poland due to the switch to NACE 2 and the subsequent lack of NACE 1.1 data on capital stocks for those years.

Based on our industry TFP growth estimations we can also trace the results over time.[13] Overall TFP growth showed notable ups and downs in many countries in the late 1990s, with sometimes negative TFP growth in the mid-1990s in the Czech Republic and Romania. The years 2000–2007 were characterised by particularly strong TFP growth in all countries. The 2008–2009 crisis left its traces also in terms of lower or sometimes negative TFP growth. These fluctuations may partly reflect a methodological weakness in the given industry-specific TFP estimations[14], but there are also economic arguments for a weaker technological progress in an uncertain and unfavourable economic environment. Both financial means and incentives to

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[13] These results are reported in Appendix C.

[14] Our approach to estimate industry-specific TFP growth rates in country-year panels and separately for each industry may come at the cost of not being able to purge the residual from all cyclical factors. This potential caveat can arise as individual countries differ and we are not able to take out individual business cycles fully.

improve the existing technologies may be impaired in times of economic distress. However, again, individual countries differ in their time path of TFP growth rates. Thus, in 2000–2007, most countries, Estonia, Latvia, Lithuania and Slovenia among them (named in decreasing order), showed huge technological progress, ranging between 4.9% and 2.7% in annual terms on average over the period. By contrast, Poland recorded high TFP growth between 1995 and 2000 and considerably weaker improvements since. As mentioned before, TFP growth in Hungary started to decline from relatively high levels as early as 2005 and became almost zero or negative even in the years prior to the crisis.

Unfortunately, due to data constraints, we cannot analyse the years 2008 and 2009 for all countries.[15] We observe a decline in TFP growth in most countries in 2008, in Latvia and Slovakia even one year earlier. In comparison with 2007, Slovenia and Romania showed an increase in TFP growth in 2008, but a sharp drop into negative territory was recorded in 2009. By contrast, TFP growth in Slovakia and Estonia remained in the positive zone even in 2009.

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[15] The Czech Republic, Hungary and Poland switched their national accounts classification to NACE 2 with the reporting year 2008, thus we could not obtain comparable data on capital stocks for the last two years in the sample herein.

CONCLUSIONS

According to the endogenous growth theory, technological progress plays a vital role in assuring economic growth. In this paper we calculate TFP growth using a novel approach. We start by calculating TFP at the most detailed industry level in order to take account of different production technologies in different activities. This allows us to overcome a major shortcoming of previous production function approaches to measuring TFP growth in the CESEE region, which rely on one-sector model of the economy. Our framework is flexible enough to incorporate non-constant returns to scale and variations in the utilisation of input factors.

Being constrained by a short time dimension, which is typical for our country sample, we estimate TFP separately for each industry, thus pooling the data across all 40 countries available in the database. We employ instrumental variable estimation to control for endogeneity between factor growth, utilisation and TFP, and we include country-fixed effects. Our results point to constant returns to scale in most industries. Only mining, energy, trade and repair, public administration, and manufacture of transport equipment show decreasing returns to scale; the estimated returns to scale are insignificant and close to zero in agriculture, health and social work, and education. These results seem plausible from the economic point of view.

After this careful estimation of industry-specific TFP growth, we aggregate TFP growth from the industry level using information from national input-output tables and following the methodology proposed by Basu et al. (2010). This procedure entails a number of crucial assumptions and decisions, in particular concerning the choice between the product-specific and industry-specific technology assumption. We work with the theoretically recommended product technology assumption. All our calculations are based on WIOD, which provides the input-output tables that are harmonised across countries and interpolated over time. This gives us a rich panel data set suitable for comparison across countries and over the period of 1996–2009.

On average, we find rather large differences in TFP growth between individual CESEE countries. The Baltic States and Slovakia exhibit the highest TFP growth over this period of time, while the most advanced countries (e.g. Poland and Hungary) range at the lower end. This implies also technological convergence among these countries and with respect to the international technological frontier. While technological progress in goods producing industries contributed most strongly to overall value added growth in Poland, the Czech Republic, Slovenia and Slovakia, efficiency gains in services sector were of greater importance in Bulgaria, Hungary and Lithuania.

We further considered the contribution of TFP to the growth of individual final use components. Productivity gains in the exports sector emerged as being of particular importance in most economies. While TFP growth in exports also played an important role in Estonia, Bulgaria and Romania, its contribution was even higher in the production of investment goods in these three countries. This suggest that technological progress in outward oriented industries was particularly fast, possibly fuelled by foreign direct investment in the export sector. However, these developments also imply that export-led growth can be a viable option for the recovery of these countries, provided that they are able to orient their export production towards fast-growing import markets.

While technology improvements play by far the most important role for the growth of individual GDP components, some countries also exhibit a non-negligible contribution from ToT changes, especially so in the investment sector. However, ToT changes may exert both a positive and negative influence on overall growth depending on whether the price effect or the substitution effect of real appreciation dominates. While a positive price effect clearly dominates in Bulgaria, Estonia, Lithuania and Romania, this was not the case of Slovakia and Hungary. The negative ToT effect on the production of consumption and investment goods in these countries may be related to the fact that while correcting for non-price factors (improvements in quality, etc.), these countries hardly experienced real appreciation over the observation period. Nevertheless, technological progress in domestic industries by far offset this effect in all three countries. Over time, we observe that the boom period (2000–2007) was accompanied by strong TFP growth in the region, whereas the reaction to the crisis differed substantially across countries. While in general TFP growth receded in 2008 (in Latvia and Slovakia as early as 2007, and in Slovenia and Romania only in 2009), it remained positive and fairly strong in Estonia and Slovakia.

This novel approach to growth accounting gives interesting insights into the drivers of economic growth and the details concerning the sectoral origin of technological growth in economy. With this methodology we can further assess the importance of domestic as well as international linkages within and between economies. We find that not only the growth contribution of productivity gains differs greatly between CESEEs, but also ToT changes affect individual economies in the region in radically different ways. This effect depends on the degree of real appreciation in individual countries and as such is related to the specific combination of price and non-price developments affecting international competitiveness.

In general, the fact that in most CESEE countries the contribution of TFP growth was highest in the production of export and investment goods is quite encouraging. In contrast to it, low TFP growth, especially in recent years and already prior to the global economic crisis, e.g. in Hungary, deserves more attention and comprehensive analysis of the underlying causes.

Appendix A. Correspondence between industries (NACE) and products (CPA)

Merged industries (28)		**Industries (35)**		**Products (59)**	
Name	**NACE**	**Name**	**NACE**	**Name**	**CPA**
Agriculture, hunting, forestry and fishing	A–B	Agriculture, hunting, forestry and fishing	A–B	Products of agriculture, hunting and related services	1
				Products of forestry, logging and related services	2
				Fish and other fishing products; services incidental of fishing	5
Mining and quarrying	C	Mining and quarrying	C	Coal and lignite; peat	10
				Crude petroleum and natural gas; services incidental to oil and gas extraction excluding surveying	11
				Uranium and thorium ores	12
				Metal ores	13
				Other mining and quarrying products	14
Manufacture of food products, beverages and tobacco	15–16	Manufacture of food products, beverages and tobacco	15–16	Food products and beverages	15
				Tobacco products	16
Manufacture of textiles and textile products	17–18	Manufacture of textiles and textile products	17–18	Textiles	17
				Wearing apparel; furs	18
Manufacture of leather and leather products	19	Manufacture of leather and leather products	19	Leather and leather products	19
Manufacture of wood and wood products	20	Manufacture of wood and wood products	20	Wood and products of wood and cork (except furniture); articles of straw and plaiting materials	20
Manufacture of pulp, paper and paper products; publishing and printing	21–22	Manufacture of pulp, paper and paper products; publishing and printing	21–22	Pulp, paper and paper products	21
				Printed matter and recorded media	22
Manufacture of coke, refined petroleum products and nuclear fuel; chemicals and chemical products	23–24	Manufacture of coke, refined petroleum products and nuclear fuel	23	Coke, refined petroleum products and nuclear fuels	23
		Manufacture of chemicals and chemical products	24	Chemicals, chemical products and man-made fibres	24
Manufacture of rubber and plastic products	25	Manufacture of rubber and plastic products	25	Rubber and plastic products	25
Manufacture of other non-metallic mineral products	26	Manufacture of other non-metallic mineral products	26	Other non-metallic mineral products	26
Manufacture of basic metals and fabricated metal products	27–28	Manufacture of basic metals and fabricated metal products	27–28	Basic metals	27
				Fabricated metal products, except machinery and equipment	28
Manufacture of machinery and equipment n.e.c.	29	Manufacture of machinery and equipment n.e.c.	29	Machinery and equipment n.e.c.	29
Manufacture of electrical and optical equipment	30–33	Manufacture of electrical and optical equipment	30–33	Office machinery and computers	30
				Electrical machinery and apparatus n.e.c.	31
				Radio, television and communication equipment and apparatus	32
				Medical, precision and optical instruments, watches and clocks	33
Manufacture of transport equipment	34–35	Manufacture of transport equipment	34–35	Motor vehicles, trailers and semi-trailers	34
				Other transport equipment	35
Manufacturing n.e.c.	36–37	Manufacturing n.e.c.	36–37	Furniture; other manufactured goods n.e.c.	36

Merged industries (28)		**Industries (35)**		**Products (59)**	
Name	**NACE**	**Name**	**NACE**	**Name**	**CPA**
				Secondary raw materials	37
Electricity, gas and water supply	E	Electricity, gas and water supply	E	Electrical energy, gas, steam and hot water	40
				Collected and purified water, distribution services of water	41
Construction	F	Construction	F	Construction work	45
Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods	G	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	50	Trade, maintenance and repair services of motor vehicles and motorcycles; retail sale of automotive fuel	50
		Wholesale trade and commission trade, except of motor vehicles and motorcycles	51	Wholesale trade and commission trade services, except of motor vehicles and motorcycles	51
		Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	52	Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods	52
Hotels and restaurants	H	Hotels and restaurants	H	Hotel and restaurant services	55
Transport	60–63	Land transport; transport via pipelines	60	Land transport; transport via pipeline services	60
		Water transport	61	Water transport services	61
		Air transport	62	Air transport services	62
		Supporting and auxiliary transport activities; activities of travel agencies	63	Supporting and auxiliary transport services; travel agency services	63
Post and telecommunications	64	Post and telecommunications	64	Post and telecommunication services	64
Financial intermediation	J	Financial intermediation	J	Financial intermediation services, except insurance and pension funding services	65
				Insurance and pension funding services, except compulsory social security services	66
				Services auxiliary to financial intermediation	67
Real estate activities	70	Real estate activities	70	Real estate services	70
Renting of machinery and equipment; other business activities	71–74	Renting of machinery and equipment; other business activities	71–74	Renting services of machinery and equipment without operator and of personal and household goods	71
				Computer and related services	72
				Research and development services	73
				Other business services	74
Public administration and defence; compulsory social security	L	Public administration and defence; compulsory social security	L	Public administration and defence services; compulsory social security services	75
Education	M	Education	M	Education services	80
Health and social work	N	Health and social work	N	Health and social work services	85
Other community, social and personal services; activities of households	O–P	Other community, social and personal service activities	O	Sewage and refuse disposal services, sanitation and similar services	90
				Membership organisation services n.e.c.	91

Merged industries (28)		**Industries (35)**		**Products (59)**	
Name	**NACE**	**Name**	**NACE**	**Name**	**CPA**
				Recreational, cultural and sporting services	92
				Other services	93
		Activities of households	P	Private households with employed persons	95

Appendix B. Correlation of TFP growth with changes in output

Industry	**Solow residual**	**TFP adjusted for varying utilisation**
Agriculture, hunting, forestry and fishing	0.100	0.137
Mining and quarrying	0.206	0.754
Food products, beverages and tobacco	0.149	0.039
Textiles and textile products	0.110	–0.003
Leather and leather products	0.284	–0.147
Wood and wood products	0.375	–0.121
Pulp, paper, publishing and printing	0.134	0.009
Petroleum, chemical products	0.058	0.259
Rubber and plastic products	0.247	0.056
Other non-metallic mineral products	0.362	0.004
Basic metals and fabricated metal products	0.076	0.089
Machinery and equipment n.e.c.	0.315	0.070
Electrical and optical equipment	0.248	0.064
Transport equipment	–0.094	–0.302
Manufacturing n.e.c.	0.282	0.134
Electricity, gas and water supply	0.271	0.281
Construction	0.289	0.065
Wholesale and retail trade	0.270	–0.007
Hotels and restaurants	0.280	–0.166
Transport	0.306	0.035
Post and telecommunications	0.386	0.077
Financial intermediation	0.300	0.333
Real estate activities	–0.048	0.037
Other business activities	0.211	0.253
Public administration and defence	0.001	0.119
Education	0.325	0.501
Health and social work	0.311	0.793
Other social and personal services	0.417	–0.061
Overall	0.176	0.085

Notes: Correlation is calculated for within-transformed variables to avoid country-specific differences. TFP adjusted for varying utilisation is calculated using equation (19). The same sample is used for Solow residual and TFP adjusted for varying utilisation. Overall correlation is calculated by stacking together all 28 industries, no weighting is applied.

Appendix C. Contributions of TFP to real value added by year

Table C1

Bulgaria

	Total	**Goods**	**Of which**		**Services**	**Of which**	
			Manufacture	**Construction**		**Trade**	**Transport**
1996	–5.09	–3.61	–3.71	–0.33	–1.47	2.08	–0.22
1997	4.66	2.97	–0.40	0.00	1.70	–0.21	0.04
1998	3.86	0.97	0.24	–0.07	2.89	0.02	0.17
1999	1.46	1.86	2.22	0.16	–0.40	–0.20	–0.03
2000	1.02	0.07	–0.22	–0.03	0.95	–0.31	–0.47
2001	3.07	0.90	–0.02	0.16	2.17	–0.02	0.63
2002	2.15	1.16	–0.08	0.12	0.99	0.39	0.13
2003	2.17	0.66	0.39	–0.01	1.51	0.40	0.20
2004	0.78	–0.14	–0.45	–0.50	0.92	–0.06	–0.05
2005	1.66	0.93	0.56	0.04	0.74	0.15	0.00
2006	0.84	0.13	0.67	0.17	0.71	0.55	0.06
2007	2.50	0.75	0.86	0.76	1.75	1.00	0.73
2008	2.68	2.27	1.14	0.84	0.41	0.43	0.19
2009	–0.74	–1.22	–0.98	0.47	0.48	0.60	0.50
1996–2007	1.59	0.55	0.01	0.04	1.04	0.32	0.10
1996–2009	1.50	0.55	0.02	0.13	0.95	0.34	0.13

Notes: Calculations are based on equation (12) and estimation results from Table 4. Contribution to logarithmic growth (100*dy*) is in percentage points.

Table C2

Czech Republic

	Total	**Goods**	**Of which**		**Services**	**Of which**	
			Manufacture	**Construction**		**Trade**	**Transport**
1996	9.09	3.78	2.36	0.60	5.32	2.08	1.08
1997	–0.74	–0.85	–0.06	–0.09	0.12	1.55	–0.22
1998	–3.32	–1.70	–1.76	–0.09	–1.62	1.17	–0.60
1999	2.72	1.98	2.04	–0.43	0.74	0.44	0.43
2000	2.70	2.78	1.51	0.40	–0.08	0.10	–0.23
2001	3.54	1.10	0.87	0.45	2.44	1.22	0.19
2002	3.93	3.13	3.09	–0.11	0.80	0.23	0.07
2003	1.77	0.38	0.04	0.15	1.40	0.53	–0.06
2004	1.30	1.52	1.19	0.03	–0.22	0.23	0.05
2005	3.23	1.57	1.60	–0.03	1.66	1.30	0.27
2006	0.67	0.31	0.41	0.04	0.36	0.43	0.31
2007	1.04	0.48	0.88	–0.20	0.56	0.89	–0.10
2008	–	–	–	–	–	–	–
2009	–	–	–	–	–	–	–
1996–2007	2.16	1.21	1.02	0.06	0.96	0.85	0.10
1996–2009	–	–	–	–	–	–	–

Notes: Calculations are based on equation (12) and estimation results from Table 4. Contribution to logarithmic growth (100*dy*) is in percentage points. The results for 2008 and 2009 are missing due to the lack of NACE 1.1 data for these years.

Table C3

Estonia

	Total	Goods	Of which		Services	Of which	
			Manufacture	Construction		Trade	Transport
1996	2.74	0.98	0.46	–0.47	1.76	1.22	0.39
1997	5.31	3.24	1.85	0.08	2.07	0.82	–0.09
1998	5.62	3.35	1.21	0.43	2.27	0.95	0.77
1999	–0.36	0.16	–0.30	0.13	–0.52	1.09	–0.70
2000	3.65	2.07	0.35	0.22	1.57	1.51	–0.34
2001	4.26	1.29	–0.43	0.44	2.98	0.29	0.52
2002	5.03	2.98	1.58	0.23	2.05	0.43	0.41
2003	6.72	2.00	0.25	0.42	4.72	2.12	0.94
2004	5.91	1.51	0.65	0.18	4.40	1.71	0.93
2005	1.93	2.41	0.42	0.97	–0.48	0.40	0.69
2006	5.97	2.49	1.20	0.36	3.48	1.04	0.18
2007	5.64	2.16	0.81	0.44	3.48	1.47	0.90
2008	3.27	0.67	0.27	0.09	2.60	0.38	0.39
2009	3.05	1.97	0.94	0.85	1.08	0.70	0.11
1996–2007	4.37	2.05	0.67	0.28	2.31	1.09	0.38
1996–2009	4.20	1.95	0.66	0.31	2.25	1.01	0.36

Notes: Calculations are based on equation (12) and estimation results from Table 4. Contribution to logarithmic growth (100*dy*) is in percentage points.

Table C4

Hungary

	Total	Goods	Of which		Services	Of which	
			Manufacture	Construction		Trade	Transport
1996	–1.01	–0.79	0.43	–0.43	–0.22	0.13	–0.09
1997	–0.55	–1.24	–0.48	–0.31	0.69	0.29	–0.02
1998	0.22	–0.74	–0.75	0.30	0.96	0.10	–0.02
1999	–0.58	1.10	1.87	–0.46	–1.68	–0.19	–0.22
2000	4.62	1.35	1.32	0.32	3.27	0.68	0.22
2001	–0.79	–1.17	–0.66	–0.07	0.38	0.46	–0.11
2002	2.12	0.10	0.33	0.12	2.02	0.50	–0.06
2003	2.57	0.58	0.52	–0.09	1.99	1.09	0.13
2004	2.88	1.49	0.63	0.34	1.39	0.95	0.15
2005	0.32	0.38	0.45	0.36	–0.07	–0.19	0.08
2006	–1.06	–1.03	–0.98	0.02	–0.03	1.00	–0.23
2007	1.02	0.25	0.92	–0.37	0.77	0.70	–0.21
2008	–	–	–	–	–	–	–
2009	–	–	–	–	–	–	–
1996–2007	0.81	0.02	0.30	–0.02	0.79	0.46	–0.03
1996–2009	–	–	–	–	–	–	–

Notes: Calculations are based on equation (12) and estimation results from Table 4. Contribution to logarithmic growth (100*dy*) is in percentage points. The results for 2008 and 2009 are missing due to the lack of NACE 1.1 data for these years.

Table C5
Latvia

	Total	Goods	Of which		Services	Of which	
			Manufacture	Construction		Trade	Transport
1996	5.70	2.80	1.95	1.37	2.90	1.05	0.63
1997	0.95	2.68	2.66	0.73	–1.74	–2.06	0.33
1998	1.74	0.72	2.32	–1.50	1.02	1.32	–0.34
1999	0.11	–0.11	–0.24	–0.24	0.22	1.09	0.18
2000	2.18	0.71	0.51	–0.15	1.47	0.73	0.66
2001	0.97	0.56	–0.54	0.70	0.41	0.58	–1.08
2002	0.00	0.59	–0.26	–0.05	–0.59	0.52	0.25
2003	5.66	1.96	1.21	–0.34	3.70	1.39	0.54
2004	5.36	1.97	0.16	0.45	3.38	0.97	0.34
2005	7.14	4.69	0.76	1.48	2.46	0.28	1.21
2006	7.77	2.67	1.04	0.14	5.09	0.98	1.50
2007	3.90	1.26	0.03	0.20	2.64	1.51	0.53
2008	0.21	–0.30	0.77	–1.15	0.51	1.27	0.44
2009	–1.47	0.96	–0.12	0.58	–2.43	–0.62	–0.30
1996–2007	3.46	1.71	0.80	0.23	1.75	0.70	0.40
1996–2009	2.87	1.51	0.73	0.16	1.36	0.64	0.35

Notes: Calculations are based on equation (12) and estimation results from Table 4. Contribution to logarithmic growth (100*dy*) is in percentage points.

Table C6
Lithuania

	Total	Goods	Of which		Services	Of which	
			Manufacture	Construction		Trade	Transport
1996	10.43	1.30	0.53	0.26	9.13	7.86	0.30
1997	–0.10	3.83	1.58	1.11	–3.93	–5.43	0.68
1998	4.92	0.48	0.31	–0.40	4.44	1.36	–0.08
1999	4.73	1.77	1.41	–0.08	2.96	1.34	0.26
2000	–1.03	–0.39	–1.05	–0.15	–0.64	0.46	0.19
2001	1.43	1.25	0.84	0.08	0.18	–0.34	–0.16
2002	1.41	–0.11	–0.04	0.05	1.53	1.68	0.10
2003	6.18	2.44	1.39	–0.26	3.75	2.96	0.03
2004	4.18	1.95	1.38	0.35	2.23	1.42	0.22
2005	2.05	0.67	0.01	0.58	1.37	1.35	0.27
2006	3.72	2.65	1.47	1.02	1.06	1.45	0.02
2007	3.92	0.89	0.53	0.17	3.03	1.34	–0.29
2008	1.55	1.08	0.63	0.47	0.47	0.08	0.66
2009	–1.48	–0.96	–0.62	–0.52	–0.52	0.24	0.18
1996–2007	3.49	1.39	0.70	0.23	2.09	1.29	0.13
1996–2009	2.99	1.20	0.60	0.19	1.79	1.13	0.17

Notes: Calculations are based on equation (12) and estimation results from Table 4. Contribution to logarithmic growth (100*dy*) is in percentage points.

Table C7

Poland

	Total	**Goods**	**Of which**		**Services**	**Of which**	
			Manufacture	**Construction**		**Trade**	**Transport**
1996	4.73	3.81	2.40	0.64	0.92	0.35	0.14
1997	4.03	3.55	2.18	0.36	0.48	0.28	0.24
1998	3.87	2.65	1.74	0.44	1.22	0.53	0.23
1999	0.29	1.62	0.60	0.40	–1.32	–0.38	0.31
2000	–1.70	1.14	0.63	0.44	–2.84	–1.31	0.05
2001	–0.48	–0.32	–0.31	–0.47	–0.16	1.21	–0.22
2002	1.25	0.95	0.71	0.23	0.30	0.22	–0.14
2003	1.88	0.13	–0.03	–0.13	1.75	0.68	–0.11
2004	–0.54	–0.42	–0.92	–0.21	–0.12	0.01	–0.10
2005	1.28	0.76	0.66	–0.21	0.52	0.70	–0.06
2006	1.05	0.40	0.49	–0.17	0.66	0.71	–0.12
2007	0.96	0.96	0.63	0.17	0.00	–0.31	0.03
2008	–	–	–	–	–	–	–
2009	–	–	–	–	–	–	–
1996–2007	1.39	1.27	0.73	0.12	0.12	0.22	0.02
1996–2009	–	–	–	–	–	–	–

Note: Calculations are based on equation (12) and estimation results from Table 4. Contribution to logarithmic growth (100*dy*) is in percentage points. The results for 2008 and 2009 are missing due to the lack of NACE 1.1 data for these years.

Table C8

Romania

	Total	**Goods**	**Of which**		**Services**	**Of which**	
			Manufacture	**Construction**		**Trade**	**Transport**
1996	2.19	1.73	0.50	0.91	0.46	–0.07	–0.38
1997	–2.58	–1.88	–1.59	–0.40	–0.70	–0.44	–0.45
1998	4.50	3.50	2.38	1.07	1.00	0.45	0.49
1999	–8.44	–4.22	–2.73	–0.81	–4.22	–0.85	–1.20
2000	3.26	0.37	1.02	0.20	2.89	1.22	0.83
2001	6.28	3.45	0.75	0.83	2.83	0.49	–0.40
2002	–2.96	–2.49	–1.85	–0.30	–0.48	0.11	0.08
2003	1.80	0.95	1.10	–0.34	0.85	0.09	–0.32
2004	1.64	0.82	0.08	0.16	0.82	0.23	0.01
2005	2.68	1.13	0.93	0.25	1.54	0.63	0.18
2006	0.23	1.06	0.36	0.12	–0.83	0.32	0.10
2007	3.72	1.81	1.69	–0.03	1.91	0.68	0.00
2008	7.77	4.02	2.04	1.15	3.75	0.88	0.43
2009	–3.79	–2.63	–1.47	–0.62	–1.16	0.14	–0.13
1996–2007	1.03	0.52	0.22	0.14	0.51	0.24	–0.09
1996–2009	1.16	0.54	0.23	0.16	0.62	0.28	–0.06

Notes: Calculations are based on equation (12) and estimation results from Table 4. Contribution to logarithmic growth (100*dy*) is in percentage points.

Table C9

Slovakia

	Total	Goods	Of which		Services	Of which	
			Manufacture	Construction		Trade	Transport
1996	4.45	2.37	1.59	–0.58	2.09	1.96	–0.38
1997	4.64	2.00	1.43	0.44	2.65	2.13	0.13
1998	3.61	1.93	0.40	0.27	1.68	0.74	0.01
1999	6.65	4.53	4.52	–0.01	2.12	1.28	0.18
2000	0.76	0.28	–0.24	–0.14	0.48	0.80	–0.50
2001	3.35	2.46	2.47	0.01	0.89	0.16	0.28
2002	2.94	2.88	0.90	0.03	0.06	0.24	–0.01
2003	–0.46	–2.13	–2.00	–0.14	1.67	0.53	0.04
2004	–0.36	–0.04	–0.81	0.52	–0.32	0.55	0.41
2005	6.79	5.42	5.88	–0.13	1.36	–0.19	–0.13
2006	4.20	3.28	1.83	0.46	0.92	0.10	0.10
2007	–0.25	–0.34	–1.40	–0.14	0.09	0.09	0.50
2008	1.98	1.00	0.25	–0.12	0.98	0.19	–0.20
2009	4.73	2.45	1.59	0.66	2.28	0.07	0.48
1996–2007	3.03	1.89	1.22	0.05	1.14	0.70	0.05
1996–2009	3.07	1.86	1.17	0.08	1.21	0.62	0.06

Notes: Calculations are based on equation (12) and estimation results from Table 4. Contribution to logarithmic growth (100*dy*) is in percentage points.

Table C10

Slovenia

	Total	Goods	Of which		Services	Of which	
			Manufacture	Construction		Trade	Transport
1996	2.14	1.85	0.18	–0.19	0.29	0.30	0.13
1997	4.88	2.84	1.02	–0.01	2.04	1.09	0.23
1998	3.27	1.50	–0.08	0.48	1.76	0.99	0.14
1999	2.74	1.59	0.75	0.06	1.15	0.55	0.16
2000	2.85	1.69	1.11	0.12	1.16	1.13	0.07
2001	3.23	1.45	0.80	0.29	1.78	0.53	0.23
2002	1.03	1.21	0.48	0.08	–0.19	0.68	0.04
2003	1.94	1.01	1.06	–0.06	0.93	0.46	–0.06
2004	3.28	2.31	1.57	0.31	0.97	0.54	0.33
2005	4.65	2.90	2.62	–0.11	1.75	0.63	0.16
2006	3.77	2.92	2.35	0.32	0.86	0.55	0.10
2007	1.11	0.65	0.57	–0.15	0.45	–0.26	0.05
2008	3.77	2.06	1.15	–0.01	1.71	0.72	0.30
2009	–6.31	–3.72	–1.43	–0.64	–2.59	–1.86	–0.21
1996–2007	2.91	1.83	1.04	0.10	1.08	0.60	0.13
1996–2009	2.31	1.45	0.87	0.04	0.86	0.43	0.12

Notes: Calculations are based on equation (12) and estimation results from Table 4. Contribution to logarithmic growth (100*dy*) is in percentage points.

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