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Structural Change in Russia: How Gas Burns Productivity

Ilya B. Voskoboynikov

For additional information please contact:

Name: Ilya B. Voskoboynikov
Affiliation: University of Groningen

Email Address: I.Voskoboynikov@rug.nl

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Ilya B. Voskoboynikov[1] *(University of Groningen)*

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Summary

Outstanding growth of the Russian economy in the last decade is widely explained in the literature by oil and gas export, but not efficiency. However, another strand of the literature points out productivity as the main source of Russian growth. The objective of the present project is to resolve this debate with a newly developed detailed dataset of output, labour, capital and productivity. The dataset covers 34 industries for the period 1995-2009, providing an opportunity to represent aggregate growth rates as a sum of contributions of labor, capital and multifactor productivity both for the total economy and for industries (industrial growth accounting). As a result we found that two most important sources of growth are capital in *Oil and Gas* as well as multifactor productivity in *Financial Intermediation* and *Business Services*. We also report that being least productive *Oil and Gas* is expanding and slow down aggregate productivity growth.

JEL: O47; P28; L16.

Key words: industrial growth accounting, aggregate productivity, structural change, Russia, natural resources

[1] Corresponding author; e-mail: i.voskoboynikov@rug.nl

1. Introduction

Transformation from a command to a market economy is also the transition from inputs-driven (extensive) to a productivity-driven (intensive) growth (Campos and Coricelli 2002). Indeed, in last decades before transition the economy of the Soviet Union and its East-European partners were mainly extensive (Ofer 1987; Krugman 1994). Increasing productivity contribution after transition was caused by the elimination of multiple price distortions of planned economy; better allocation of inputs among industries and increasing motivation of firms to diminish real costs of production.

However, this shift from extensive to intensive growth is not necessary the case applicable to the Russian economy after transition. Russia differs from East-European transition economies in such aspects as a more advanced industrial sector before transition, abundance of tradable natural resources, large territory, and remoteness from the European Union (EU). Moreover, since many former socialist countries have become members of EU, the gap in development of institutions seems to be also substantial.

The extant literature does not clarify this issue. One strand of the literature explains Russian growth by high oil and gas prices[2]. Growth could be fueled by investments, which are available from windfall profits. The indirect evidence of this is the substantial contribution of the *Oil and Gas* sector to GDP growth and the share of this sector in total investments[3]. However, if the link between windfall profits and total growth rates exists, it should be identified in the decomposition of output growth rates into contributions of labor, capital and multifactor productivity (*growth accounting*) in the form of a substantial capital contribution. However, according to the growth accounting literature the main source of growth in Russia is multifactor productivity[4].

The neoclassical growth accounting framework provides decomposition of growth rates both by sectors and by factors of production (Jorgenson, Gollop, and Fraumeni 1987; Jorgenson, Ho, and Stiroh

[2] (Ahrend 2006; Beutin, Veugelers, and de Souza 2007; Gaddy and Ickes 2010; Connolly 2011)
[3] (Gurvich 2004; Kuboniwa, Tabata, and Ustinova 2005; World Bank 2005)
[4] (De Broeck and Koen 2000; Dolinskaya 2002; Voskoboynikov 2003; Bessonov 2004; Iradian 2007; Izyumov and Vahaly 2008; Rapacki and Próchniak 2009; Kvintradze 2010; Kuboniwa 2011)

2005). It is an efficient instrument for the analysis of supply side sources of growth. For example, industrial growth accounting has been successfully implemented to explain the increase of productivity gap between US and EU after 1995 (van Ark, O'Mahony, and Timmer 2008; Timmer and others 2010) and to study performance of economies in transition (Fernandes 2009; Havlik, Leitner, and Stehrer 2012). However, until recently the industrial growth accounting examination for the Russian economy has been impossible because of data unavailability. It demands the set of time series on output, labor and capital by industries and types of factors, which are not available in the official statistics for the whole period in question. As a result, existing growth accounting literature for the Russian economy has been focused mostly on the level of the total economy[5].

In contrast with the extant literature, this study uses the newly developed detailed dataset of real value added, labor, capital and productivity for 34 industries in 1995-2009, being compiled in the international classification NACE 1.0 (Voskoboynikov 2012). This dataset covers a longer period and provides more sophisticated indicators than in the literature and in the official statistics. For example, industrial output time series in official statistics in NACE 1.0 are available from 2003 only; industrial data on labor costs consistent with the System of National Accounts – from 2003. Finally, the new dataset includes industrial series of capital services, whereas they are not available in official statistics until now.

The aim of the present study is to consider supply-side sources of economic growth within the industrial growth accounting framework. If the link between high oil prices and growth of the Russian economy is explained by the transformation of windfall money to capital services, it should appear in the growth accounting decomposition in the form of a substantial contribution of capital services. Further, low efficiency of Russian oil and gas sector is expected to be found as low or negative MFP growth rates of corresponding industries. Finally, the oil and gas sector provides higher factors' compensation. Its share in value added is extending in time, which leads to the slowdown of aggregate MFP productivity growth rates.

[5] Papers of Dolinskaya (2002) and Bessonov (2004) are exceptions which consider aggregate sectors in the Old industrial classification OKONKh for the period before 2002, using official data on labor, capital and capacity utilization.

This story is partially presented in the literature. For example, evidence of inefficiency of oil and gas sector is considered by Ahrend and Thompson (McKinsey 1999; Ahrend and Tompson 2004) The influence of labor reallocation on productivity at the micro level has been discussed by Brown and Earl (2003), Gimpelson, Kapeliushnikov and Lukiyanova (2010) have pointed out inefficiency of labor allocation in Russian Manufacturing. Ahrend, de Rosa and Tompson (2006) as well as and Connolly (2011) concluded that capital reallocates to *Oil and Gas sector* which provides the highest level of rates of returns.

However, In comparison with the extant literature, our measures of labor and capital are more detailed, cover a longer period, and have a better theoretical foundation. In particular, in case of labor we operate with the number of FTE jobs within SNA production frontiers, taking into account substantial informal employment in *Agriculture*[6] not only after 2003, as it has been done in official statistics, but also in 1995-2002. In case of capital we use the concept of capital services (Jorgenson 1963), which is superior to the concept of capital stocks adjusted on capacity utilization in recent literature[7]. In contrast with capital stocks, capital services take into account variations in productivity of different types of assets. For example, one ruble of investment in buildings generates much less capital services per year, than the same ruble invested in software, because buildings are in operation for decades, whereas software is in active use for say at most five years.

Our paper contributes to the literature on economies in transition, suggesting the explanation of Russian growth on the basis of better measures of inputs, as it was proposed by Campos and Coricelli (2002). In addition it adds value to the link between the abundance of tradable natural resources and economic development in case of a diversified economy (van der Ploeg 2011). Finally, this study is a step forward in putting of the development pattern of the Russian economy into the context of international

[6] Informal activity in *Agriculture* is about one fifth of total amount of FTE jobs in the Russian economy. It is taken into account in GDP but skipped in the Balance of Labor Force that is why any measures of productivity of the total economy within SNA before 2003, which are based on official statistics, are biased. See more on this problem in (Poletayev 2003; Kapeliushnikov 2006)

[7] See e.g. (Iradian 2007; Rapacki and Próchniak 2009; Kuboniwa 2011) See also (OECD 2009) about comparisons of different concepts of capital.

comparisons at the level of industries, which is the mainstream of new development economics (Lin 2010; McMillan and Rodrik 2011).

The second section of the paper introduces the industrial growth accounting framework and the approach to the direct aggregation of industrial production functions. The third section discusses results of growth accounting for the aggregate economy, identifies sources of growth in sectors in industries and, finally, shows that aggregate multifactor productivity slowdowns because of the extension of the *Oil and Gas* sector.

2. Data and approach

This study is based on a newly developed detailed dataset of real value added, labor, capital and productivity for 34 industries in 1995-2009 in the international classification NACE 1.0 (Voskoboynikov 2012). The dataset includes longer and more detailed time series of industrial output and labor, than available both in the literature and in the official statistics.

The growth accounting methodology allows the 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) and Jorgenson, Gollop and Fraumeni (1987). We use this approach for building a consistent set of inputs, output and productivity measures for the Russian economy in 1995-2009. It follows the representation of value added-based industrial growth accounting of Jorgenson, Ho and Stiroh (2005, ch. 8) and Timmer and others (2010, pp. 54-7).

The quantity of value added Z_j in industry j may be represented as the function of capital services, labor services and technology as

(1) $Z_j = g_j\ K_j, L_j, T\ .$

Under the assumptions of competitive factor markets, full input utilization and constant returns to scale the multifactor productivity A_j is defined as

(2) $\Delta \ln A_j \equiv \Delta \ln Z_j - v_{K,j}^Z \Delta \ln K_j - v_{L,j}^Z \Delta \ln L_j$

where $v_{\circ,j}^Z$ is the period-average share of the input in nominal value added. The value shares of capital and labor are defined as follows.

(3) $v_{K,j}^Z = \frac{p_j^K K_j}{p_j^Z Z_j}; \quad v_{L,j}^Z = \frac{p_j^L L_j}{p_j^Z Z_j}$

such that they sum to unity.

Growth rates of value added are defined in two different ways in case of single or double deflation. For single deflation growth rates of real value added is a weighted average of gross output growth rates of corresponding sub-industries weighted with nominal value added. For double deflation the quantity of value added is defined implicitly from a Törnqvist expression for gross output:

(4) $\Delta \ln Z_j = \frac{1}{v_{Z,j}^Y} \Delta \ln Y_j - \left(1 - v_{Z,j}^Y\right) \cdot \Delta \ln X_j$,

where Y - gross output, X - intermediate inputs, $v_{Z,j}^Y$ is the period-average share of value added in gross output. The corresponding price index for value added is defined implicitly to make the following value identities hold:

(5) $p_j^Z Z_j = p_j^K K_j + p_j^L L_j = p_j^Y Y_j - p_j^X X_j.$

Rearranging equation (2), industry value added growth can be decomposed into the contribution of capital, labor and multifactor productivity (MFP):

(6) $\Delta \ln Z_j = v_{K,j}^Z \Delta \ln K_j + v_{L,j}^Z \Delta \ln L_j + \Delta \ln A_j,$

Where $v_{\circ,j}^Z$ is the period average share of factor compensation in value added of industry j.

The volume growth of GDP is defined as a Törnqvist weighted average of value added growth in industries as follows

(7) $\Delta \ln Z \equiv \quad {}_j v_{Z,j}^{GDP} \cdot \Delta \ln Z_j =$

$$= \quad {}_j v_{Z,j}^{GDP} \cdot v_{K,j}^Z \cdot \Delta \ln K_j + \quad {}_j v_{Z,j}^{GDP} \cdot v_{L,j}^Z \cdot \Delta \ln L_j + \quad {}_j v_{Z,j}^{GDP} \cdot \Delta \ln A_j,$$

where $v_{Z,j}^{GDP}$ is the average share of value added of industry j in GDP. Equation (7) shows that the GDP growth rates are based on direct aggregation across industries. It allows decomposition of value added growth rates by contributions of factors and a multifactor productivity in industries.

If the value added share of industries with low MFP growth rates extend, total MFP contribution will go down. This effect may be represented as

$$(8)\quad {}_j v_{Z,j}^{GDP} \cdot \Delta \ln A_j \equiv \frac{1}{2}\ {}_j\ v_{Z,j,t-1}^{GDP} + v_{Z,j,t}^{GDP}\ \cdot \Delta \ln A_j =$$

$$= \frac{1}{2}\ {}_j\ v_{Z,j,t-1}^{GDP} + \ v_{Z,j,t}^{GDP} - v_{Z,j,t-1}^{GDP}\ + v_{Z,j,t-1}^{GDP}\ \cdot \Delta \ln A_j =$$

$$= \frac{1}{2}\ {}_j\ 2 \cdot v_{Z,j,t-1}^{GDP} + \Delta v_{Z,j}^{GDP}\ \cdot \Delta \ln A_j =$$

$$= \ {}_j\ v_{Z,j,t-1}^{GDP} \Delta \ln A_j + \frac{1}{2}\ {}_j\ \Delta v_{Z,j}^{GDP} \Delta \ln A_j .$$

The first term on the right hand side of (8) represents the contribution of industries with the assumption that the value added shares remain the same as in year t-1, whereas the second term indicates the effect of industries shares changes. It is the second term that captures the effect of stagnant sectors extension. Indeed, the impact of shrinking ($\Delta v_j < 0$) of progressive industries with high MFP growth rates becomes negative. In the same time the role of extending ($\Delta v_j > 0$) stagnant sectors with low or negative MFP growth rates becomes more substantial.

A number of important limitations should be considered of the models outlined above. We only considered models of value added. Value-added - based growth accounting is more restrictive than the gross output-based model.

The second type of limitations is related to the assumptions of perfect competition and equilibrium in the neoclassical growth accounting framework. These might not hold for the Russian economy, in particular in earlier years of transition. However, there are arguments why this approach is useful. First, growth accounting is a standard framework for international comparison of productivity not only among developed economies, but also among developing economies and economies in transition. It has been implemented in the literature even for planned economies (Ofer 1987; Krugman 1994). So, it may be used for comparisons with the existing analyses in the literature. Second, it could be

considered as the benchmark for alternative calculations based on different set of assumptions such as non-constant economies of scale and mark-ups (Barro 1999; Basu and Fernald 2001).

The third type of limitations of doing growth accounting for the Russian economy has to do with the accuracy and drawbacks of data available in NAS. The following subsections of this chapter deal with this problem, transforming the official data of NAS to the form suitable for the growth accounting exercise.

3. Results and discussion

3.1. Total economy perspective

Soviet economic performance used to be the textbook example of extensive inputs-based growth (Ofer 1987; Krugman 1994). Deep fall of the Russian economy in 1990-s and outstanding recovery after the crisis of 1998 (Fig. 1) have also been discussed in detail and finally explained by credit market imperfections and disorganization (Blanchard and Kremer 1997; Roland and Verdier 1999). However, the explanations of the recovery period after 1998 are still contradictory. One strand of the literature attributes it to growing world oil prices[8]. In the same time, there is no clear understanding of the link between the inflow of oil price money and high growth rates after 1999. If economic performance of the Russian economy depends on oil prices and is based on the transformation of the rainfall money into investments, why does another strand of the literature[9] report such a small contribution of capital to growth?

FIG. 1. GDP of the Russian economy in 1970-2010.

To answer the question we compiled two datasets, a replication and an improved one. The replication dataset is based on assumptions widely used in the literature. It adopts the concept of net capital stock as a capital input. Following the bulk of the literature[10] it explores official investment

[8] (Ahrend 2006; Beutin, Veugelers, and de Souza 2007; Gaddy and Ickes 2010; Connolly 2011)
[9] E.g. (Rapacki and Próchniak 2009). Voskoboynikov (2012) provides a comprehensive survey of growth accounting literature for the Russian economy.
[10] See the survey in Voskoboynikov (2012)

deflators with no distinction by types of assets and fixed depreciation rates 5 % per year which do not vary across types of assets and industries. It also uses fixed factors' shares, which are 0.3 for labor and 0.7 for capital. However, labor series of the replication dataset are improved in comparison with the literature[11], but these developments are heavily based on concepts of the official statistics, and are added up mostly to disaggregation of official time series.

The improved dataset employs advantages of more detailed primary statistics better theoretical foundations. Instead of official investment deflators, which overestimate inflation substantially, a more relevant set of investment price indices was adapted. This set called *Production price indices in construction* is also available in the official statistics. It is used by statisticians for deflation of capital stocks, more consistent with such indicators of inflation as CPI and PPI, explicitly takes into account changes on prices of imported equipment and varies for different types of assets. Another improvement is adaptation of the concept of capital services instead of capital stocks. In contrast with capital stocks, capital services capture differences of capital input of eight types of assets. For example, in case of stocks one ruble of investments into a building provides the same capital input as one ruble invested in software. However, in case of services software contributes much more because its service life is shorter than of a building. Finally, factors' shares were evaluated taking into account variations among industries, wages of self-employed and differences in wages of workers in market economy and persons engaged in households which produce for own consumption (Voskoboynikov 2012).

Tab. 1. Growth accounting of Market economy in 1995-2009. Direct aggregation

[11] See (Voskoboynikov 2012, section 4) for details.

Table 1 gives results of growth accounting with the replication[12] and improved datasets. As can be seen, the former confirms that the MFP contribution explains growth, while the latter shows that capital is at list as much important for growth as MFP. Moreover, the link between high inflow of oil profits and economic growth becomes clear. These profits make investments available, that is why of 3.7 p.p. 1.8 p.p. is contributed by capital. Moreover, because of strengthening of ruble after 1998 import of machinery and equipment has dramatically increased and the contribution of 0.8 p.p. of Machinery and Equipment is also substantial.

Our calculations of capital servicers are based on the assumption of full capacity utilization. However, variations in capacity utilization were huge. For example, in industry they change from 85.7 % in 1990 to 45.5 % in 1998 (Bessonov 2004, tab. 3). Previous studies have reported that the initial fall of output and the following recovery of the Russian economy were partially explained by variations in capital capacity utilization with no new capital put into operation[13]. Following this logic, once capacity utilization has converged to the maximum level, the recovery growth had to slow down, as it happened with the Soviet economy in the middle of 1920-s (Gaidar 2003). However, this story had not happened in 2000-s. On the contrary, average growth rates in the post-crisis decade in 1999-2008 exceeded 7 per cent a year (tab. 2).

Tab. 2. Contributions of labor productivity and MFP in case of external and internal rate of return (p.p.)

Although the role of capacity utilization variations in the post-crisis recovery is, probably, overvalued in the literature in comparison with the contribution of new capital, it is important to understand how

[12] In most cases dealing with the Russian economy the growth accounting literature considers the total economy level and uses the aggregate production function approach, which differs from direct aggregation because of the effects of reallocation of labor and capital across industries (Jorgenson, Ho, and Stiroh 2005, ch. 8). However, as shown in (Voskoboynikov 2012) on the same dataset, these effects are relatively small and do not influence the domination of MFP contribution.

[13] (Dolinskaya 2002; Bessonov 2004; World Bank 2008; Kvintradze 2010; Kuboniwa 2011)

sensitive our results are to the assumption of full capacity utilization (Berndt and Fuss 1986). Hulten (1986) has illustrated this problem, asking of the level of capacity utilization of a factory which works eight hours a day. It is true that machines of the factory work only a part of the day. However, the rest of time they are in a safe dry place, connected to power supply and communications and ready for service. It is impossible to use facilities for other purposes. The level of capacity utilization of this factory is probably not related to hours that machines work.

There is an approach of taking into account capacity utilization consistent with the neoclassical growth accounting framework, which is the implementation of the internal rate of return (IRR). If facilities are idle, their rental prices equal null and they do not contribute into the flow of capital services. Growth accounting for the market economy on the basis of IRR is presented on Table 2(b). The table shows that correction on capacity utilization does not change main conclusion of the previous table that factors are at least as much important for growth as MFP.

The IRR-based approach has certain limitations. Inklaar (2010) has demonstrated that its accuracy depends on the completeness of asset types, which are taken into account. Since such essential types of assets as land are not covered by Russian assets statistics, this measure could be weak. Another weak point is the possibility of negative rental prices. Although in theory they have sense, they break the industrial growth accounting system. To avoid this problem, we assume that in such cases rental prices equal zero which, in turn, makes our estimations less accurate. To sum up, following Inklaar (2010) we prefer the dataset which is based on the external rate of return.

Aggregate growth accounting on the basis of the improved dataset unveils the substantial contribution of capital. In the same time, three more questions remain. First, if the story of transformation of oil and gas profits into investments is correct, the oil and gas sector itself should be substantially fueled by capital input. Second, the contribution of MFP is still substantial. What sectors, being efficient, provide the most substantial contribution to productivity? Finally, what is the trend of factors reallocation between industries? It is important for the analysis of long run perspectives of

growth. For example, if factors flow from more productive to less productive sectors, the productivity slowdown is expected.

3.2. Sectoral contribution of factors and productivity

We start sectoral analysis of sources of growth with the introduction of a relevant sectoral structure. Then the section discusses what sectors provide the most substantial contribution to aggregate growth rates of productivity, capital and labor.

3.2.1. Sectoral structure of the economy

The literature which deals with structural change of the Russian economy alone or in comparison with other economies in transition explores a traditional three-sectoral approach which considers Agriculture, Industry and Services[14] for two reasons. First, transformation from plan to market could be also defined as the process of resources reallocation on the basis of market incentive. Using patterns of market economies with similar level of development for comparisons, it is possible to identify to what extend transition of a certain economy leads to the industrial structure, which is consistent with relative prices. (Campos and Coricelli 2002). This grouping is convenient in terms of the stylized facts of development, which have been broadly discussed in the literature starting from pioneering research of Kaldor (1961), Baumol (1967), Kuznets (1971) and Maddison (1980). Especially it is helpful for comparisons of economies in transition a broad range of development stages, from the below-average level of Kyrgyzstan with GDP per capita in 2005 equals 1930 U.S. dollars to the above average level of Slovakia with 23279 U.S. dollars[15]. Second, for many countries in transition the three-sectoral approach is the only possible because of data availability.

From this perspective the Russian economy with GDP per capita equal to 12357 dollars[16] is a typical economy in transition of the above average level of development with reallocation of output and labor from *Agriculture* and *Industry* to *Services* (Lazarev and Gregory 2007; World Bank 2008) with the latter demonstrating the highest labor productivity growth rates. This reallocation pattern has been explained

[14] See e.g. (Lazarev and Gregory 2007; World Bank 2008).
[15] Penn World Tables 7.0, PPP Converted GDP per capita, Geary Khamis, at current prices
[16] Penn World Tables 7.0, PPP Converted GDP per capita, Geary Khamis, at current prices

in the literature both by over-industrialization of planned economies with underdevelopment of services before transition and a general shift of development to services.

However, the three-sectoral approach seems to be misleading and restrictive if we shift focus from across-countries comparisons to the intertemporal structural changes of the Russian economy. To begin with, once detailed data is available data availability restriction may be weakened. It allows us to exclude *Non-market services*, for which productivity measures are of poor quality. Next, the influence of structural change from *Agriculture* to *Industry* on productivity should be not substantial for Russia, which passed the stage of industrialization in the first half of 20th century. Consequently, the sectoral structure of post-industrial economies seems more relevant for the Russian economy.

As it has been shown by O'Machoney and van Ark (2003) for EU and US, there is substantial heterogeneity in productivity growth rates among industries with different skills intensity. This effect is explained by importance of skills in efficient adaptation of new technologies, which is essential for MFP growth. Further, the sector of *Market Services* should be considered in more detail because of potential heterogeneity among its sub-industries. This heterogeneity has been documented for developed economies by O'Mahony and van Ark (2003) as well as Jorgenson and Timmer (2011) for years starting from 1980. Fernandes (2009) also reported substantial differences in labor productivity growth rates among East European economies in transition – new members of EU. Both papers highlight significant variations in productivity between high-skill and low-skill intensive sub-industries of *Market Services*. Finally, the three-sectoral approach does not take into account the specific role of industries, which are engaged in production, supply and export of oil and gas, in performance of the Russian economy.

The share of *Extended Oil and Gas sector (Gas)* is around one fifth of the Russian economy[17]. It consists of *Mining*, some sub-industries of *Wholesale Trade*, *Inland Transport* and *Fuel*. The World Bank report (2005), Gurvich (2004) as well as Kuboniwa and Ustinova (2005) pointed out that performance of each of these industries on the basis of SNA data, being considered separately is confusing because of the dominance of huge vertically integrated holdings, such as *Gazprom*. If such a company has

[17] See e.g. (World Bank 2005)

establishments both in, say, *Mining* and in *Wholesale Trade*, prices of transactions between the establishments are not market and may be adjusted to reallocate value added to the establishment in *Wholesale Trade* and to avoid taxes on natural resources production. If a part of *Gas* belongs to one sector (as *Mining* within Industry in the three-sectoral division) and another one is in another sector (as *Wholesale Trade* in *Services*), sectoral productivity would depend on *transfer pricing* between establishments of large energy holdings. The influence of transfer pricing on value added allocation between industries is expected to be substantial. (World Bank 2005) pointed out that transfer pricing was used by these holdings to minimize tax payments using both legal and illegal approaches[18].

Accordingly, the first sector of our preferred sectoral structure is *Gas*. Along with *Gas* we split the *Market economy* into *Goods* (*Agriculture* and sub-industries of *Manufacturing*) and *Market Services*. In this manner we take into account potential differences in labor productivity growth in industries which produce goods and services. As Baumol (1967) pointed out, if opportunities for the substitution of labor with capital are limited, which takes place in some industries in *Services* (e.g. *Social work*), labor productivity in these industries will grow slower. Moreover, labor will reallocate to these industries from other sectors, slowing down total productivity growth rate. This effect is called the Baumol disease.

Next, following the literature (Fernandes 2009; Jorgenson, Timmer 2011) we take into account potential differences in productivity between low-skills intensive and high-skills intensive sectors. In addition to the literature, there is one more argument for this grouping. It is convenience of mapping of Russia in the global economy. As it stands, comparative advantages of the Russian economy are concentrated now in *Gas*. However, taking into account that historically Russia has a sophisticated industrial structure, there are two potential development trends for its economy. The first is related with growth of low skills-intensive sectors and competition with China, whereas the second is developing of high skill-intensive industries in line with U.S. and EU, which provide substantial contribution to MFP growth of developed economies.

[18] One of these illegal approaches is transfers to short-life firms specially created for tax evasion. On the basis of the banking transactions database of the Central Bank Mironov (Mironov 2006) reported that in 2003-4 the leaders of this type of tax evasion were government-controlled companies, of which *Gasprom* was the largest evader, transferring around 1.9 bn. US dollars.

The sectoral structure consists of five sectors which are *Gas*, *High*- and *Low-skill intensive Goods*, as well as *High and Low Skill-intensive Services*. Detailed allocation of industries by sectors is available in the Appendix. Table 3 shows value added shares of these sectors. As can be seen from the table, economic activity is reallocating from *Goods* to *Services* and *Gas.* If in 1995 the share of Goods was almost one third, in 2009 it fell to one fifth. In the same time the most dynamic sector is High Skill-intensive Services, which extended from 6 % in 1995 to 15% in 2009.

[Tab. 3. Sectoral shares of value added of Market economy]

3.2.2. Multifactor productivity

The literature considers MFP as the most important source of growth for the Russian economy. Although its role is more modest in our data, it is still responsible for 1.6 of 3.7 p.p., or more than two fifth of total growth rates (Tab. 1). It is important to identify sectors, which accelerate and slowdown the aggregate productivity growth.

The most essential contribution to total MFP is provided by high skill-intensive sub-sectors of goods and services, which is presented on Tab. 4. They show higher MFP growth rates and contribute three fifth of aggregate MFP growth rates (0.98 of 1.62 p.p.) in total, with high skill-intensive services being dominate. *Low skill-intensive goods* also contribute to MFP. Being less efficient they have a higher value added share and surpass high skill-intensive goods in contribution to total MFP. In the same time, *Low Skill-Intensive services* and *Gas* are stagnant.

[Tab. 4. Growth of MFP in 1995-2009]

Accuracy of measurement of MFP contribution critically depends on precision of value added growth rates. In contrast with growth output and intermediate inputs, for which prices and quantities may be obtained by direct observation, real value added should be imputed with the implementation of the double deflation procedure. However, this approach demands detailed and accurate data on intermediate inputs, which is often not available. That is why many statistical offices implement simplified methods such as single deflation of nominal value added with gross output price indices or assume that real value added growth rates are equal to weighted average of corresponding gross output volume indices. Once prices on intermediate inputs and final products move in a similar way, it does not lead to serious problems. However if prices on final products grow faster than prices on intermediate goods, the simplified approach overestimates real value added growth of a corresponding industry. In particular, there is evidence in the literature[19] that adjustment on price change of intermediate goods may lead to a substantial revision of industrial real value added growth rates and corresponding productivity measures. Since double deflation has not been introduced in Russian official statistics, errors in official estimations of real value added growth rates may also be substantial.

In case of Russia there are two potential sources for this type of error, which are transfer pricing within *Gas* and discrepancy between the world (export) and domestic prices on energy products (Fig. 2). Export prices are set by the world market, while domestic prices are partially under control of the government, which considers them as a tool for regulation of the economy. For example, the World Bank (2005) reports that in the crisis of 1998 and first years of recovery the government hold domestic energy prices low stimulating growth.

[Fig. 2. Domestic and export prices on oil, oil products and gas in 1998-2003]

[19] (Griliches 1994; Triplett 1996; Fremdling, De Jong, and Timmer 2007)

Using SUT's time series available in the WIOD database[20] we implement the double deflation approach for estimation of alternative time series of real value added. In such a way we control the influence of possible errors in official real value added on our results. Comparison of MFP growth rates on the basis of official double deflated (Tab. 4) real value added show that after the implementation of double deflation performance of energy-intensive industries[21] falls. For example, *Gas* dropped from -0.05 p.p. to -0.20 p.p. In the same time, most productive *High Skill-intensive Services* provide the highest contribution to MFP both in case of single and double deflation.

In the same time, taking into account low quality of imputed SUTs and sensitivity of the double deflation procedure to the quality of SUT's data, double deflated real value added time series should be treated with care.

3.2.3. Capital and labor

Aggregate growth accounting decomposition on table 1 has unveiled that capital is the most important source of growth. Of 3.7 p.p. of aggregate GDP growth it provides 1.8 p.p., or almost half.

Detailed decomposition of capital growth rates and contributions by sectors is presented on table 5. Capital growth rates in *Services* (4.3 p.p.) are the highest in comparison with other sectors and over perform not only traditional manufacturing industries in *Goods* (0.8 p.p.), but also *Gas* (3.6 p.p.). However, if we take into account the average value added share of *Services* (49.8 %; tab. 3), we get 0.96 p.p., which is close to the corresponding value of *Gas* (0.67 p.p.).

[Tab. 5. Growth of capital services in 1995-2009]

[20] http://www.wiod.org/

[21] Energy intensive industries may be identified with the Use table on the basis of the ratio of energy intermediate inputs to value added.

As it has been expected, the contribution of capital in *Gas* is substantial and provides one third (0.7 of 1.8 p.p.) of the contribution to growth rates of the total economy. However, capital input contribution of *Low Skills-intensive Services* (0.8 p.p.) is even higher than of *Gas*.

Comparing capital growth rates in *Goods* (0.1 p.p.) and *Services* (1.0 p.p.) we observe the process of elimination of planned economy disproportions. Relatively low contribution of traditional industries in *Goods* may be explained by overinvestment in *Manufacturing* and *Agriculture* in preceding decades of planned economy, whereas capital performance in *Services* is a reaction on underinvestment in the past. Explosive growth of capital in such sub industries as *Retail* and *Telecom* (7.0 and 10.6 p.p. of capital growth per year) just reflects the process of catching up of lagging sectors of planned economy.

On the whole, the contribution of capital input of *Gas* and *Low Skills-intensive Services* accounts for more than four fifth of total capital contribution (1.5 of 1.8 p.p.). It confirms the hypothesis of the link between oil and gas revenues and capital inflow as an essential source of economic growth. In the same time, partially this extensive component of growth removes structural imbalances between sectors of *Goods* and *Services* inherited form planned economy.

[Tab 6. Growth of labour services in 1995-2009]

Labour contribution to growth is modest and equal to 0.35 of 3.7 p.p. (Tab. 1). It has two components which reflect the process of labor reallocation from *Goods* to *Low Skilled Services* and *Gas*. According to Table 6, *Low Skills-intensive Services* and *Gas* (mainly Wholesale Trade) gain labor, providing 0.6 p.p. (Tab. 6), whereas *Goods* loose it with growth rates -0.3 p.p.

3.3. Patterns of productivity growth

In the previous section aggregate growth accounting has shown that major sources of growth are capital and productivity. However, this aggregate level approach overlooks possible heterogeneity among industries. Alternatively, if we focus on separate sectors, as it has been done in the previous section, the link between industrial and aggregate performance may be not clear. An efficient perspective for further analysis has been suggested by Harberger (1998) and is known as Harberger diagrams.

The Harberger diagram provides intuitive way of identification whether aggregate growth rates of any measure are contributed by few industries or growth is widespread[22]. This diagram is a graphical representation of the industrial growth pattern with Y-axis showing growth contributions and X-axis – the cumulative value added shares. The industries are ranked by growth rates, so the fastest growing industry is to be found near the origin. The growth pattern is yeasty if it is broad-based and observed in many industries. Contrary, if growth is concentrated in few industries, the pattern is mushroom-like.

Inklaar and Timmer (2007) have suggested three useful descriptive indices for these diagrams, which are the aggregate growth, the cumulative share of growth with positive contributions and curvature. The aggregate growth is the sum of industry contributions, whereas the other two measures indicate pervasiveness of growth. The cumulative share is the average share of value added of industries which demonstrate positive growth rates. Finally the curvature is defined as the ration of the area between the diagram and the diagonal line, and the total area beneath the diagram. The curvature lies between 0 and 1, with the value being null when all industries have the same growth. Thus if all industries grow with the same rates the curvature equals one.

[Fig. 3. Harberger diagrams of productivity growth in 1995-2009]

[22] \ This representation of the Harberger diagram approach is based on Timmer (2010, pp. 178-83)

Fig. 3 shows the labor productivity Harberger diagram for the period 1995-2009 for the Market economy. As can be seen, this is the yeasty growth with relatively high aggregate growth rates of 2.9 p.p. per year, the percentage of industries with positive value added almost 90 %, and the curvature 0.34. The diagram confirms the homogenous labor productivity growth pattern reported earlier for the period until 2002 by the World Bank (2005). Next, substantial contributions are provided by *High Skills-Intensive Services* (Finance and Business Services) as well as *Gas* (Fuel, Mining, and Wholesale Trade). However, the labor productivity Harberger diagram is not helpful for understanding to what extent this homogenous productivity growth is explained by increasing efficiency or capital intensity. For this we need the MFP Harberger diagram. Accordingly, MFP growth is concentrated in a limited number of industries.

Comparing these two diagrams it is interesting to identify industries which contribute to aggregate labor productivity growth but diminish MFP. Major industries of this group are Mining and Fuel from *Gas* and Retail from *Low Skills-intensive Services*. The value added share of these three industries is 19%, which explains the difference in 22 p.p. between percentages of industries with positive growth rates of labor productivity and MFP almost completely.

As may be seen in Fig. 3(b), in contrast with labor productivity MFP growth pattern is mushroom-like. Aggregate MFP growth rates equal 1.6, which is lower than of labor productivity; the positive value added share for MFP growth rates is lower by 23 p.p. than for labor productivity and equal 66 %; and the curvature 0.49 is closer to one.

For these industries high capital intensity goes hand in hand with inefficiency[23]. In case of Mining[24] and Fuel inefficiency could be explained by outdated technologies and monopolistic power. As to Retail, this industry consists of two sub-sectors. The first is capital intensive and represented by new modern

[23] As has been seen in the previous section, if we take into account differences between domestic and export energy prices, MFP growth of Mining and Fuel could be even lower.
[24] (McKinsey 1999; Ahrend and Tompson 2004)

supermarkets with up-to-date retail technologies[25], whereas the second is labor-intensive inefficient mostly informal retail, which accumulates low quality labor from other sectors. The Harberger diagram of MFP in case of double deflation (Fig. 3(c)) is more contrast in reflection of the negative contribution of Gas and Retail. It is even more mushroom-like than the diagram in case of single deflation.

The analysis of the Harberger diagrams reveals that Gas and Retail slowdown productivity of the Russian economy. The next step is to get a clue if the economy becomes more extensive in time because of the extension of these industries.

3.4. Structural change and productivity growth

Aggregate MFP growth rates slowdowns if factors compensation of low productive industries expends. In this case the value added share of stagnant sectors goes up, whereas the contribution of dynamic sectors shrinks. Formally this idea is represented by decomposition (8) in section 2.

$$(8) \qquad {}_j v_{Z,j}^{GDP} \cdot \Delta \ln A_j = \quad {}_j v_{Z,j,t-1}^{GDP} \Delta \ln A_j + \frac{1}{2} \quad {}_j \Delta v_{Z,j}^{GDP} \Delta \ln A_j$$

Directly aggregated MFP growth rates is a sum of a weighted average of MFP growth rates in industries with fixed weights of the initial year (fixed shares effect) and the component, which captures the change in shares of industrial value added (cross effect). If stagnant sectors with negative MFP growth rates expand or dynamic sectors with high MFP growth rates shrink, corresponding components of the second term in (8) are negative.

[Tab. 7. Growth rates, contributions and factors compensation for labor]

[25] Retail sector in the Soviet Union was laggard, so starting from the middle of 1990-s Russia has experienced the explosive growth of the number of modern retail centers. If in 1999 McKinsey (1999, p. 5) reported that such modern high productivity formats as supermarkets were almost entirely absent with less than 1% of market share, in 2009 they achieve, according to McKinsey (2009, p. 65), 35% being three times more productive than old forms.

For example negative cross effect of *Gas* is explained by the growing share and negative productivity growth rates. It provides the most substantial negative cross-effect both for single and double deflation cases. To be more specific, in case of single deflation the sectorial extension leads to a modest negative contribution of -0.08 p.p. of 1. 62 p.p. in total. However, in case of double deflation the impact is -0.13 of 0.98 p.p. in total. In other words, if the share of *Gas* remains the same the total economy growth would be more than ten per cent higher. Negative cross effect -0.03 and -0.06 p.p. is also provided by *Low Skills-intensive* services mainly because of *Construction* and *Retail*. In contrast, *High Skills-intensive Services* contribute positively both because of high MFP growth rates and substantial GDP extension.

To sum up, our data provides evidence of negative influence of high oil prices on long run productivity growth of the economy. Windfall money creates opportunities for domestic *Gas* sector to attract more labor and capital providing higher level of returns to factors. However, these factors become not as much productive as they could be in other industries and, eventually, diminish total performance. The effect is more substantial if case of double deflation.

Another interesting conclusion is the long run outcome of the government policy after the crisis 1998. In late 1990-s – early 2000 stimulating the after-crisis recovery the government kept energy prices low in comparison with the world prices, (Fig. 2 and Tab. 7). However, in fact this policy supported energy intensive sectors (e.g. Fuel in Gas or Utilities in *Low Skills-intensive Services*) more than the rest of the economy, providing opportunities for the former to engage more factors instead of diminishing real costs. This may explain the mushroom-like multifactor productivity growth pattern with energy intensive industries on the right (Fig. 3).

Another explanation of negative cross effects follows from the hypothesis suggested in (World Bank 2005) is that low domestic energy prices created incentive in the economy to use less energy efficient and cheaper equipment. In the short run such investment decisions diminish costs, but in the long run with the convergence of domestic and world energy prices the decisions lead to fall in MFP growth, being more harmful in energy intensive sectors.

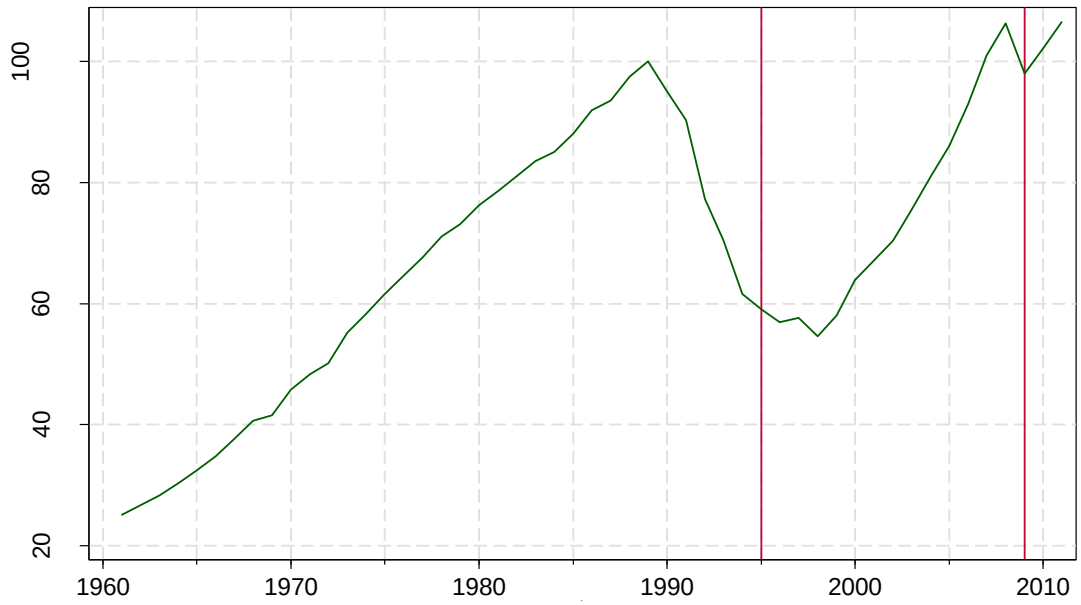
4. Conclusion

Performance of the Russian economy in last two decades has been determined by the export of energy resources, terms of trade and the transition from plan to market. The first two factors provide the inflow of export profits, which are transformed into investments and bolster economic growth. This dependence of Russian growth on world oil prices is a commonplace in the literature. However, until recently quantitative studies of supply-side sources of economic growth have pointed out productivity as main source of growth and fixed that the contribution of capital was not substantial. Using a more detailed newly developed dataset and a more advanced approach to growth accounting, this study has shown that capital contributes almost half of annual output growth rates, mainly due to capital growth in the *Extended Oil and Gas sector* and *Low Skill-intensive services*.

In turn, transition from plan to market should also stimulate growth. Elimination of multiple price distortions of planned economy leads to a more efficient allocation of resources and a more homogeneous performance throughout sectors. However, it might be not the case of Russia. As it follows from the mushroom-like industrial pattern of multifactor productivity (MFP) growth, along with such efficient industries as *Finance* and *Business Services* there are industries with negative MFP growth such as *Fuel* and *Utilities*. A possible explanation of this substantial heterogeneity is remaining price distortions, which are the government regulation of domestic energy prices and transfer pricing between establishments of such large energy-related holdings as *Gazprom*. The results of this study indicate that such low-productive sectors as *Gas* and *Low Skilled-services* have been extended during transition because of higher returns to factors, which leads to the extension of the value added share of low-productive industries and slowdowns multifactor productivity growth.

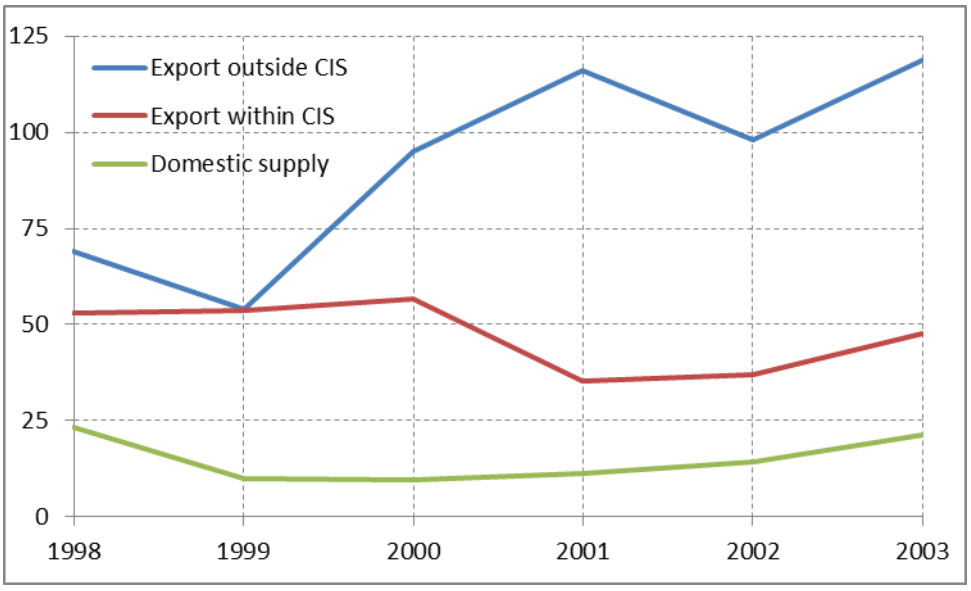
Graphs

Fig. 1. Long run growth of the Russian economy (1961-2011)



Source: 1961-1990 - (2002); 1991-2011 – the Russian statistical office (*Rosstat*).

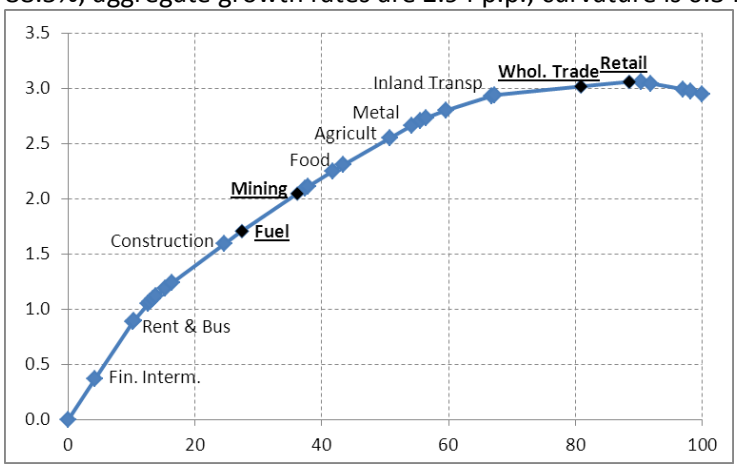
Fig. 2. Domestic and export prices on gas in 1998-2003



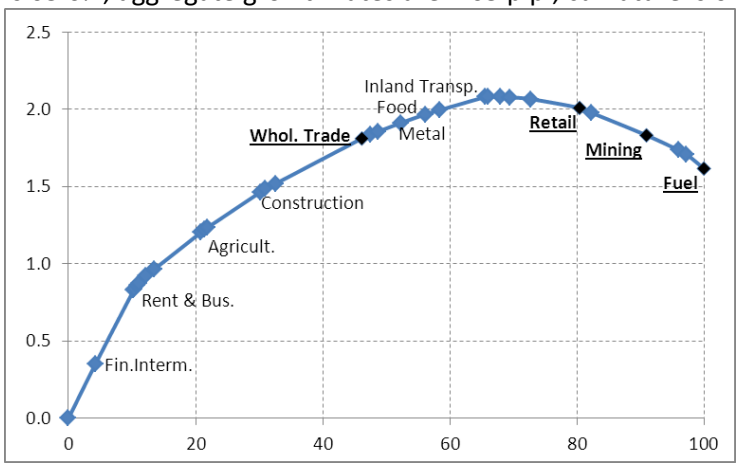
NOTE: Average prices on gas in 1998-2003 (USD per thousand cubic meters of natural gas)
SOURCE: (Gurvich 2004, tab. 3)

Fig. 3. Harberger diagrams of productivity growth in 1995-2009

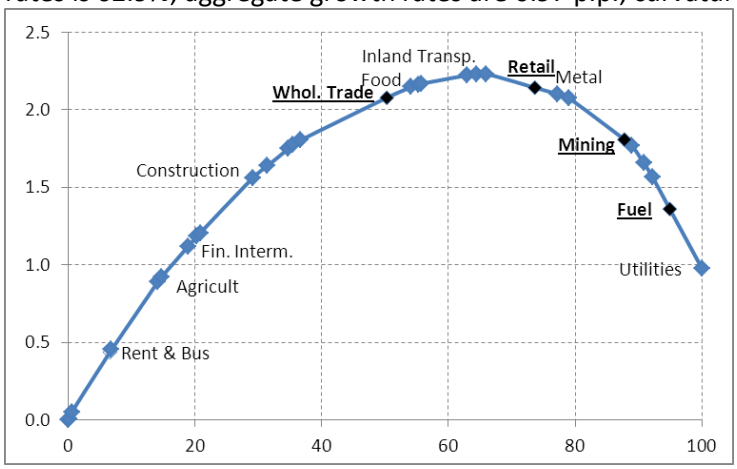
a. Labor productivity in case of single deflation. Percentage of industries with positive growth rates is 88.5%; aggregate growth rates are 2.94 p.p.; curvature is 0.34.



b. Multifactor productivity in case of single deflation. Percentage of industries with positive growth rates is 65.6%; aggregate growth rates are 1.63 p.p.; curvature is 0.49.



c. Multifactor productivity in case of double deflation. Percentage of industries with positive growth rates is 62.9%; aggregate growth rates are 0.97 p.p.; curvature is 0.70.



Tables

Tab. 1. Growth accounting in Market economy in 1995-2009. Direct aggregation

	Replication data		Improved data	
	Volume growth rate (p.p.)	Contribution to growth in value added (p.p.)	Volume growth rate (p.p.)	Contribution to growth in value added (p.p.)
Value added	3.73	3.73	3.73	3.73
Labor input	0.79	0.55	0.79	0.35
Capital input	0.35	0.11	3.26	1.77
ICT	11.40	0.11	10.70	0.28
Non-ICT	-0.02	-0.01	2.84	1.49
Mach. And Equipment	4.52	0.23	6.17	0.81
Non-res. buildings	-1.49	-0.30	1.87	0.58
Other assets	1.62	0.06	0.94	0.10
MFP	3.08	3.08	1.62	1.62

Source: own calculations

Note:

Standard data: official investment deflators; depreciation is 5% and fixed across industries; capital input is net stocks and labor share 0.7 being fixed across industries.

Improved data: PPI in construction as investment deflators; depreciation data is based on (Fraumeni 1997); capital input is capital services and labor shares vary across industries.

Tab. 2. Contributions of labor productivity and MFP (p.p.)

(a) External rate of return

	1995-2009	1995-1998	1999-2008
Value added	3.73	-2.68	7.09
Labor input	0.35	-1.11	0.92
Capital input	1.77	-0.79	2.91
ICT	0.28	0.24	0.37
Non-ICT	1.49	-1.03	2.53
Mach. And Equipment	0.81	-0.30	1.41
Non-res. buildings	0.58	0.09	0.74
Other assets	0.10	-0.82	0.38
MFP	1.62	-0.78	3.26

Source: own calculations

(b) Internal rate of return

	1995-2009	1995-1998	1999-2008
Value added	3.73	-2.68	7.09
Labor input	0.35	-1.11	0.92
Capital input	1.51	-0.14	2.33
ICT	0.15	0.10	0.22
Non-ICT	1.36	-0.24	2.12
Mach. And Equipment	0.37	-0.08	0.82
Non-res. buildings	0.90	0.16	1.06
Other assets	0.08	-0.32	0.24
MFP	1.87	-1.43	3.83

Source: own calculations

Tab. 3. Sectoral shares of value added of Market economy (%)

	1995	2009	Average
Total	100.0	100.0	100.0
Goods	29.7	20.5	25.1
High Skills-intensive	4.2	3.5	3.8
Low Skills-intensive	25.6	17.0	21.3
Services	46.9	52.8	49.8
High Skills-intensive	6.4	15.4	10.9
Low Skills-intensive	40.5	37.4	38.9
Gas	23.4	26.8	25.1

Source: own calculations

Tab. 4. Growth of MFP in 1995-2009

	Approach to real VA deflation	
	Single	Double
Annual growth rates (p.p.)		
Total	1.62	0.98
Goods	1.99	1.79
High Skills-intensive	3.19	-0.25
Low Skills-intensive	1.77	2.15
Services	2.14	1.46
High Skills-intensive	7.85	5.63
Low Skills-intensive	0.56	0.31
Gas	0.21	-0.81
Contributions (p.p.)		
Total	1.62	0.98
Goods	0.50	0.45
High Skills-intensive	0.12	-0.01
Low Skills-intensive	0.38	0.46
Services	1.07	0.73
High Skills-intensive	0.86	0.61
Low Skills-intensive	0.22	0.12
Gas	0.05	-0.20

Source: own calculations

Tab. 5. Growth of capital services in 1995-2009

	Annual growth rates (p.p.)	Contributions (p.p.)
Total	3.26	1.77
Goods	0.83	0.14
High Skills-intensive	0.03	0.00
Low Skills-intensive	0.97	0.14
Services	4.34	0.96
High Skills-intensive	3.09	0.14
Low Skills-intensive	4.68	0.82
Gas	3.56	0.67

Source: own calculations

Tab. 6. Growth of labor services in 1995-2009

	Annual growth rates (p.p.)	Contributions (p.p.)
Total	0.79	0.35
Goods	-1.56	-0.30
High Skills-intensive	-3.32	-0.09
Low Skills-intensive	-1.25	-0.21
Services	1.38	0.33
High Skills-intensive	0.89	0.03
Low Skills-intensive	1.51	0.30
Gas	1.97	0.31

Source: own calculations

Tab. 7. Growth rates, contributions and factors compensation for labor (p.p.)

	Total	Fixed VA shares	Change in VA shares
Single deflation			
Total	1.62	1.44	0.19
Goods	0.50	0.57	-0.07
High Skills-intensive	0.12	0.13	-0.01
Low Skills-intensive	0.38	0.44	-0.06
Services	1.07	0.74	0.34
High Skills-intensive	0.86	0.49	0.36
Low Skills-intensive	0.22	0.25	-0.03
Gas	0.05	0.13	-0.08
Double deflation			
Total	0.98	0.97	0.01
Goods	0.45	0.50	-0.05
High Skills-intensive	-0.01	-0.02	0.01
Low Skills-intensive	0.46	0.52	-0.06
Services	0.73	0.54	0.19
High Skills-intensive	0.61	0.36	0.25
Low Skills-intensive	0.12	0.18	-0.06
Gas	-0.20	-0.08	-0.13

Source: own calculations

Appendix. List of sectors and industries

NACE 1.0 Code	Name of a sector/industry used in the paper
	TOTAL ECONOMY
	Market Economy
	Goods
	High Skills-intensive
24	Chemicals
29	Other Machinery
30t33	Electr. Equip.
	Low Skills-intensive
AtB	Agriculture
15t16	Food & Bev.
17t18	Textiles
19	Footwear
20	Wood products
21t22	Paper & Publish.
25	Rubber & plastics
26	Non-Met. Miner.
27t28	Metal
34t35	Transp. Equip.
36t37	Oth. Manuf.
	Market Services
	High Skills-intensive
J	Fin. Intermed.
62	Air trnsp.
71t74	Rent. & bus.act.
	Low Skills-intensive
E	Utilities
F	Construction
H	Hotels and Rest.
50	Automotive trade
51	Retail Trade
61	Water trnsp.
60	Inland transport
63	Oth. Trnsp. serv.
64	Post & Telecom
O	Soc. & Pers. Serv.
	Gas (Extended Gas and Oil)
23	Fuel
C	Mining
51	Wholesale trade
	Non-Market Economy
L	Public Adm.
M	Education
N	Health and Social Work
P	Private households

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