

Is Mining Fuelling Long-run Growth in Russia? Industry Productivity Growth Trends since 1995

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Abstract

GDP per capita growth rates in Russia have been among the highest in the world since the mid-1990s. Previous growth accounting research suggests that this was mainly driven by multi-factor productivity (MFP) growth. In this paper we analyse for the first time the drivers of Russian growth for thirty-four industries over the period 1995 to 2008. We pay in particular attention to the construction of a proper measure of capital services, to use in place of the stock measures employed in previous research. Based on these new measures, we find that aggregate GDP growth is driven as much by capital input as by MFP growth. Mining and Retailing account for an increasing share of the inputs, but are weak in terms of MFP performance. In contrast, MFP growth was rapid in goods-producing industries, but the sector's GDP share declined. The major drivers of MFP growth were in the high-skilled services industries that were particularly underdeveloped in the Russian economy in the 1990s.

JEL: O47; P28; L16

Key words: industrial growth accounting, structural change, Russia

1. Introduction

GDP per capita growth in Russia has been among the highest in the world since the mid-1990s, averaging 3.7 per cent annually between 1995 and 2012.¹ For this reason it is occasionally clubbed with three other fast growing economies - Brazil, China and India - and said to form the BRIC countries. These are then set against the European Union, Japan and the US, where growth has been sluggish. As such, Russian economic development today is seen as yet another successful transition from command to market economy. This represents a dramatic change of fortune. In the past, Soviet economic performance was cited as a typical example of extensive growth, driven by high investment and labour input growth, with little improvement in technology and efficiency (Ofer 1987; Krugman 1994). But with the introduction of a market economy in early 1990s, it was expected that growth would become intensive, relying on improvements in productivity rather than input growth. Through the elimination of the numerous price distortions of a planned economy, better allocation of inputs among industries, and increasing incentives for firms to reduce the real costs of production, productivity should become the main engine of growth (Campos and Coricelli 2002). These benefits were not realized immediately. It is well known that the Russian transition triggered a deep crisis that finally bottomed out in the mid-1990s (see Figure 1). But since then, the trend in growth has picked up, and the benefits of the market economy seem finally to have reached the stage of realization, akin to the success of various other formerly planned economies in Eastern Europe (Fernandes 2009; Havlik, Leitner, and Stehrer 2012) and China.

Recent growth accounting studies of Russia confirm this view, finding that growth was mainly driven by improvements in the efficiency of input use, as measured by multi-factor productivity (MFP) growth, rather than growth in labour and capital inputs. Entov and Lugovoy (2013), Jorgenson and Vu (2011) and Kuboniwa (2011) all find that the rate of MFP growth was (much) higher than input growth rates in the period from about 1995 to 2008. Izyumov and Vahaly (2008) find that input growth is even negative in this period, and all that output growth is due entirely to MFP growth. These findings are consistent, despite the wide variety of methods and data used (as will be discussed in more detail below). And compared to a large group of developed and developing countries, Russian MFP growth of around 5 per cent annually since the mid 1990s appeared to be among the highest in the world (Jorgenson and Vu 2011). This supports the view that Russia managed to change from extensive input-driven to intensive productivity-driven growth trajectory.

However, there is another strand of the literature that emphasises the important role of tradable natural resources in Russian growth. It suggests that Russian growth is mainly driven by windfall profits due to soaring oil and gas prices in the past 15 years.² These profits fuelled an investment boom in sectors such as mining and ancillary services, which were considered to be neither particularly innovative nor efficient. These more qualitative studies refer to the increasing share of the mining sector in total investment and GDP, and maintain that Russian growth is still extensive, rather than driven by productivity improvements.

¹ “The Conference Board Total Economy Database™, January 2013, <http://www.conference-board.org/data/economydatabase/>”

² See e.g. Connolly (2011).

In this paper we aim to contribute to this debate by analysing for the first time the drivers of Russian growth at a detailed industry-level. We develop a new and consistent set of output and input measures for thirty-four industries for the period 1995 to 2008, taking into account revisions in the National Accounts Statistics, changes in industrial classifications, measurement issues of labour and capital, and estimates of factor shares in value added. We pay particular attention to the construction of a proper measure of capital services in the tradition of Jorgenson, Gollop and Fraumeni (1987), which we use in preference to the stock measures that dominate the previous research. We discuss the importance of properly accounting for depreciation and rental prices and show that the use of the capital services concept is not only theoretically superior but is also empirically useful, as it qualifies the previous growth accounting findings.

Based on these improved input measures, we find that Russian growth since 1995 is driven as much by input growth as by MFP growth. As such, our study is comparable in spirit to the studies by Alwyn Young on East Asia (Young 1995) and on China (Young 2003), where it was shown that proper accounting for quantity and quality of inputs leads to considerably lower estimates of MFP growth compared to analyses based on raw unadjusted series. Our second contribution is that we trace the sluggish productivity performance to a limited set of industries, namely mining and retailing, where growth was mainly driven by capital inputs. These industries increased their GDP shares, the mining sector having accounted for a quarter of GDP in 2008. On the other hand, intensive growth took place in many manufacturing industries, but their GDP shares declined. Russian high-tech production, which was well developed before transition, did not survive the competition from high-quality imported products, whereas low-tech manufacturing suffered from low-cost competition from Asia. Various modern market services expanded in Russia and posted high MFP growth. These sectors were particularly underdeveloped in the 1990s, and much of this growth can be attributed to a catch-up phase.

[FIG. 1. About here]

The rest of the paper is organized as follows. In the next section we briefly outline the growth accounting methodology used in this study and discuss our reasons to opt for an ex post external rate of return approach to capital measurement. In Section 3 we discuss the various data challenges to be faced with exercising growth accounting based on official Russian statistics. We highlight deficiencies in the official data and explain our means of dealing with them. Comparisons are made with previous studies as well. Growth-accounting results at the aggregate and industry levels are discussed in Section 4, and Section 5 concludes.

2. Growth accounting methodology

To analyse the sources of Russian growth we use the standard growth accounting methodology which enables a breakdown of output growth rates into a weighted average of the growth of various inputs and productivity change (see Schreyer (2001) for an overview). We follow the representation of value added-based industrial growth accounting of Jorgenson, Ho and Stiroh (2005, ch. 8).

The quantity of value added (Z_j) by industry j can be represented as a function of capital services, labour services and technology:

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

Assuming a translog production function, competitive markets for inputs and constant returns to scale, the change in multifactor productivity (A_j) is defined as

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

where $\bar{v}_{\cdot,j}^Z$ is the period-average share of the input in the nominal value added of industry j . The value shares of capital and labour are defined as

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

such that they sum to unity. Rearranging equation (2), industry value added growth can be decomposed into the contributions of capital, labour and multifactor productivity (MFP):

$$(4) \Delta \ln Z_j = \bar{v}_{K,j}^Z \Delta \ln K_j + \bar{v}_{L,j}^Z \Delta \ln L_j + \Delta \ln A_j.$$

This decomposition is done at the industry-level, and the aggregate results are obtained by using the direct aggregation across industries approach (Jorgenson, Ho, and Stiroh 2005). Then the volume growth of GDP is defined as a Törnqvist weighted average of value added growth in industries:

$$(5) \Delta \ln Z \equiv \sum_j \bar{v}_{Z,j}^{GDP} \cdot \Delta \ln Z_j$$

where $\bar{v}_{Z,j}^{GDP}$ is the average GDP-share of value added of industry j . Substituting (4) into (5) gives

$$(6) \Delta \ln Z = \sum_j \bar{v}_{Z,j}^{GDP} \cdot \bar{v}_{K,j}^Z \cdot \Delta \ln K_j + \sum_j \bar{v}_{Z,j}^{GDP} \cdot \bar{v}_{L,j}^Z \cdot \Delta \ln L_j + \sum_j \bar{v}_{Z,j}^{GDP} \cdot \Delta \ln A_j$$

This equation enables decomposition of GDP growth rates by contributions of factors and multifactor productivity growth by industry.

In this paper we pay particular attention to the measurement of capital, given the various difficulties and uncertainties in deriving a proper empirical measure in the Russian context. Here we outline our theoretical approach and in the next section the empirical implementation. Following the growth accounting tradition, we measure capital input as the flow of capital services, which takes into account the different marginal productivities of various asset types. Aggregate capital input in industry j (K_j) is defined as a Törnqvist volume index of individual capital assets stocks:

$$(7) \Delta \ln K_j = \sum_k \bar{v}_{k,j}^K \Delta \ln K_{k,j}$$

where $\Delta \ln K_{k,j}$ indicates the volume growth of capital stock of asset k . Assets are weighted by the period average shares of each type in the value of capital compensation, given by

$$(8) v_{k,j}^K = \frac{p_{k,j}^K K_{k,j}}{p_j^K K_j}$$

such that the sum of shares over all capital types is unity. The estimation of the compensation share of each asset is related to the user cost of each asset. The rental price of capital services $p_{k,t}^K$ reflects the price at which the investor is indifferent between buying and renting the capital good via a one-year lease in the rental market. In the absence of taxation the familiar cost-of-capital equation is given by

$$(9) p_{k,j,t}^K = p_{k,j,t-1}^I i_{j,t} + \delta_k p_{k,j,t}^I - (p_{k,j,t}^I - p_{k,j,t-1}^I)$$

where $i_{j,t}$ represents the nominal rate of return in industry j , δ_k the depreciation rate of asset type k , and $p_{k,t}^I$ the investment price of asset type k . This formula shows that the rental fee is determined by the nominal rate of return, the rate of economic depreciation and an asset-specific capital gain.³

The literature is divided on the question of how to measure the rate of return, both on theoretical and empirical grounds. Following the neo-classical theory underlying growth accounting, the nominal rate of return is determined ex-post in the so-called endogenous approach (Jorgenson, Ho, and Stiroh 2005). It is assumed that the total value of capital services for each industry equals its compensation for all assets. This procedure yields an internal rate of return that exhausts capital income and is consistent with constant returns to scale. This nominal rate of return, which is the same for all assets in an industry but varies across industries, is derived as a residual:

$$(10) i_{j,t} = \frac{p_{j,t}^K K_{j,t} + \sum_k (p_{k,j,t}^I - p_{k,j,t-1}^I) K_{k,j,t} - \sum_k p_{k,j,t}^I \delta_{k,j} K_{k,j,t}}{\sum_k p_{k,j,t-1}^I K_{k,j,t}}$$

where the first term $p_{j,t}^K K_{j,t}$ is the capital compensation in industry j , which is derived as value added minus the compensation of labour.

The theoretical basis for the Jorgenson-type implementation of user cost is fairly restrictive in that it assumes perfect foresight as to investment returns. Balk (2010) provides a defence of the ex-ante approach, which is considered to be independent of neo-classical theory. Also Oulton (2007) argues that the ex-post approach, which assumes a single appropriate rate of

³ Ideally taxes should be included to account for differences in tax treatment of different asset types and different legal forms (household, corporate and non-corporate). However, this refinement would require data on capital tax allowances and rates, which is beyond the scope of this paper.

return for all assets, does not do full justice to a world of multiple assets.⁴ For a proper empirical implementation of the ex-post approach all assets in the economy must be included and capital income should be accurately measured. Measurement error in any of these will show up in variations in the internal rate of return, and hence will impact MFP measures.⁵ The main reason to opt for an ex-post rate of return is that it enables one to take account of changes in capital utilization rates, which is of particular importance for analysing Russian growth from 1995 to 2008, a typical boom period. In 1995 Russia was at the trough of a severe crisis (see Figure 1), so that utilization rates increased rapidly afterwards. This increase should be accounted for in our input measures given our interest in MFP as a measure of technological change⁶, and almost all previous growth accounting studies attempt to deal with this one way or the other (see next section).

We opt to deal with this via the ex-post approach. Berndt and Fuss (1986) showed that by treating capital as a quasi-fixed input, the income accruing to it is correctly measured using the approach outlined above, which would make a separate adjustment to the capital input measure superfluous. Hulten (1986) elucidated this theoretical result and highlighted the conceptual problems of defining and measuring capital utilization rates, as opposed to capacity utilization. He also shows that the theoretical result of Berndt and Fuss (1986) was derived under rather strict assumptions which do not necessarily hold in practice. Therefore our MFP measure might still include some of the effects of improved capacity utilization, and only an econometric approach will be able to separate it out; see Hulten (1986) for further discussion.⁷ We therefore also provide some growth accounting results based on an ex-ante approach and show that the main conclusions of this study are not dependent on this choice of method.

3. Data sources and choices

This study is based on a newly developed detailed dataset for real value added, labour and capital in 34 industries for the period from 1995 to 2009 in the international classification NACE 1.0 (Voskoboynikov 2012). The dataset includes longer and more detailed time series of industrial output and labour than are available in the literature or official statistics. Detailed data on output for industries by international industrial classification and covering the whole economy have only recently become available in the official publications of the Russian statistical office (Rosstat)⁸, and detailed series on labour and capital have never been issued. In comparison with the extant literature, our measures of capital and labour are more detailed, cover a longer period, and have a better theoretical foundation. In this section we discuss our choices of data sources and methods, and compare these with the previous growth accounting literature on Russia. In section 3.1 we discuss sources for value added and labour input, and in section 3.2 capital input. In section 4 we show how the various choices affect the final growth accounting result. In

⁴ He ends up advocating a hybrid approach that uses an external rate of return to aggregate across different capital assets and an internal rate of return to determine the overall output elasticity of capital in the calculation of MFP.

⁵ See Diewert (2008) and Schreyer (2009) for a more extensive discussion of these topics.

⁶ Schreyer (2009) notes that if one is interested in MFP as a measure of real cost reduction, improvements in the utilization of capital capacity might be considered part of MFP growth and not capital input growth. An ex-ante approach would fit this interpretation.

⁷ Examples of such work include Beaulieu and Matthey (1998) and Basu and Fernald (2001).

⁸ For convenience all sources published by the Russian statistical office are referenced as *Rosstat*, given that the official name of the Russian/Soviet statistical office has been changed several times.

general, our choices lead to higher estimates of the contribution of capital to growth and consequently lower estimates of MFP than in the extant literature.

Although we use this new database for a growth accounting exercise, it serves many other applications of economic analysis, particularly when used in conjunction with comparable data for other countries. We will post the data on the World KLEMS website (www.worldklems.net) in July, 2013.

3.1 Output and labour input series

A key concern when dealing with statistics from formerly centrally planned economies is the quality of the official data. Canonical prerequisites for industry growth accounting are a set of consistent data on labour and capital inputs and outputs within the System of National Accounts (SNA) framework.⁹ SNA is the international standard of measures of economic activity, which amounts to a coherent and consistent set of macroeconomic accounts of sources and uses of national income. However, in the case of Russia some of these elements are not mutually consistent, whereas others have only recently entered the official statistics. SNA was introduced in Russia in the early 1990s and replaced the old Soviet national income accounting, the Material Product System (MPS).¹⁰ But this process was slow, and even nowadays some rudiments of MPS have survived in the system of national statistics. This creates conceptual inconsistencies between different blocks of the Russian statistical system.¹¹ In contrast to the National Accounting Statistics (NAS), such primary sources as regular surveys of firms and households are in many aspects well developed and have been used for decades. Detailed data from primary sources in many cases is published and may be used to fill gaps in NAS statistics and so improve the official data for the purpose of detailed industrial growth accounting. The old industrial classification¹², forged within the MPS, had been introduced in the period of the planned economy and was not consistent with any international classification schemes (Masakova 2006). It was supplanted by a new classification¹³ in 2003, but Rosstat did not revise pre-2002 industry-level series in the new NAS classification scheme. We briefly discuss how we dealt with three major data hurdles issues and advise interested readers to get more details from Voskoboynikov (2012). These are: linking of industries across the old and new classification; measuring labour input and measuring the labour share in value added.

To construct our real value added series we had to bridge the change in industrial classification. For years before 2003 the NAS industrial data are available only according to the old Soviet industrial classification, which are not consistent with the new classification or any other international one. Nominal gross output values by industry in the new classification before 2003 were obtained from Rosstat and were developed for the Russia KLEMS feasibility study project (Bessonov and others 2008). This dataset is an unpublished backcast estimation, which is

⁹ (Schreyer 2001b; Jorgenson, Ho, and Stiroh 2005)

¹⁰ In Soviet and Russian literature this system is called the Balance of National Economy (*Balans narodnogo khoziaistva*). We use term *the Material Product System* to provide consistency with the bulk of the literature in English.

¹¹ (Ivanov 1987; Ivanov, Rjabushkin, and Homenko 1993; Masakova 2006; Ivanov 2009). See also Entov and Lugovoy (2013) for a discussion in the context of growth accounting.

¹² The all-union classification of industries of the national economy, OKONKh (*Obshchesoiuznyi klassifikator "Otrasli narodnogo khoziaistva"* (Rosstat 1976)). Henceforth the OKONKh classification will be referred to as "the Old classification".

¹³ The new industrial classification, OKVĖD (*Obshcherossiiskii klassifikator vidov ekonomicheskoi deiatel'nosti*) coincides with NACE 1.0 to the four-digit level. OKVĖD/NACE 1.0 is referred to as "the New classification".

based on the detailed bridge between the old and new industrial classifications. The bridge was compiled by Rosstat for 2003-2004, when primary data were collected according to the two classification schemes at the same time.¹⁴ To obtain nominal value added in industries we multiply the gross output of an industry by the corresponding value added-to-gross output ratio. These ratios were calculated for the industries according to the Old classification, which were the closest counterparts to the industries in the new classifications with published data. The volume indices of gross output up to 2002 are based on output volume indices for detailed products with nominal gross output weights fixed in the new classification. The volume indices for value added until 2002 are assumed to be equal to the volume indices for output. This approach is justified by the fact that official volume indices of value added are calculated on the basis of the same set of physical volume indices of products as are the indices for gross output. The only difference between official gross output and value added volume indices is in the different sets of product weights.

Labour input is measured as hours worked.¹⁵ For this we use series from the *Balance of Labour Inputs*¹⁶, which is consistent with the value added numbers from NAS. It is available from 2005 onwards but only at an aggregate 1-digit industry level. To break it down into finer industry detail and backcast the series back to pre-2005 years, we rely on a combination of data from the *Balance of Labour Force*¹⁷ (BLF) and reports of organizations of “*the Full Circle*” (FC)¹⁸, which include large, medium and small firms as well as various public administration organizations. The BLF is the oldest system of labour accounts and was formerly a part of the MPS. It is based on FC with additional estimations for self-employed and workers engaged in commercial production in husbandries (Rosstat 1996; Rosstat 2003). FC contains more detailed data than the BLF. For 2003 and later, detailed industry shares from BLF, and if necessary from FC, were applied to the aggregate series from the Balance of Labour Inputs. Before 2003, trends in BLF and FC at the corresponding industries were applied. BLF and FC give the numbers of employees, and we assume that employee growth proxies for growth in hours. Details on the construction of labour series can be found in Voskoboynikov (2012, Section 4).

Previous studies use estimates of the number of workers from BLF. But for years before 2003, the BLF is not consistent with NAS, as it does not cover self-employment in agricultural husbandries, which produce for own consumption¹⁹. This mostly informal activity in Agriculture amounts to about one fifth of the total amount of FTE jobs in the Russian economy. An imputation for value added made in the NAS GDP, so that any measure of aggregate productivity based on official statistics, is biased. Following Poletayev (2003), we assume zero

¹⁴ Corresponding methodology was developed by Eduard Baranov and Vladimir Bessonov and implemented for backcast estimates of industrial output for the Ministry of Economic Development of the Russian Federation (Bessonov and others 2008). Detailed description of this methodology is available in (Bessonov 2005).

¹⁵ Preferably an adjustment for labour quality was made as well, but this data is not readily available at the industry level.

¹⁶ In Russian – *Balans zatrat truda*. Its description and methodology is available in (Rosstat 2006)

¹⁷ In Russian – *Balans trudovykh resursov*.

¹⁸ In Russian - *Polnyi krug organizatsii*. Its comprehensive definition and description is available in (Vishnevskaya and others 2002)

¹⁹ In Russian: *lichnye podsobnye khoziaistva*

productivity growth rates in non-market households. Since data on output growth rates of non-market households are available, it is possible to impute employment growth.²⁰

The shares of labour and capital in value added are used as weights in the growth accounting and reflect the output elasticity of the inputs. The labour share should reflect the total cost of labour from the perspective of the employer and so include wages but also non-wage employee benefits and an imputed wage for self-employed workers. In Russia there is a long standing tradition of non-wage payments. This is well known, and Rosstat provides estimates that are included in the total economy series of the NAS, but not in the industry statistics. This is why industry-level NAS series on labour compensation in industries underestimate labour-cost shares. For the total economy in 1995-2008 this underestimation is substantial and varies between 11 and 17 per cent (Voskoboynikov 2012, A.T11). Bessonov (2004) argued that given the inaccuracy of official imputations of hidden wages, using these shares would not make growth accounting estimations more precise. Previous studies therefore resorted to alternative share figures, usually a fixed 0.6 or 0.7 for the labour share, which is assumed to be typical for developed economies (Gollin 2002), or obtained them from econometric estimations (Kuboniwa 2011). Instead we develop new measures of labour compensation at a detailed industry level by using official imputations of shadow wages and value added made by Rosstat. These are added to official labour compensation of employees and value added from the NAS. For 2002 and subsequent years, the overall amount of hidden wages at the overall economy level has been allocated among industries in proportion to the industry value added shares of shadow activities according to official imputations²¹. For years before 2002, the hidden wages were allocated in proportion to the industry distribution of shadow value added in 2002. Finally our estimate of labour income of self-employed is added. For all industries except *Agriculture* it was assumed that the hourly earnings of self-employed are the same as for employees. For *Agriculture*, with a high share of low educated workers, we imputed with the total economy average wage for low educated employees based on data from the RLMS survey.²² Further details can be found in Voskoboynikov (2012, Section 6).

3.2 Capital input series

One of the most difficult problems in growth accounting for ex-centrally planned economies is the measurement of capital input. The present paper uses the concept of capital services, which is superior to the concept of capital stocks used in the recent literature for Russia. In contrast to capital stocks, capital services take into account variations in productivity of different types of assets. For example, one rouble of investment in buildings generates much less capital services per year than the same rouble invested in software, because buildings are much longer in operation. For this paper we constructed detailed capital stocks for eight asset types, to measure capital input based on the perpetual inventory method (PIM): computing equipment,

²⁰ Detailed description of the model is available in Appendix of Voskoboynikov (2012). Kapeliushnikov (2006) suggested an alternative approach for imputation of labour costs in non-market households for years before 1999 on the basis of changes in plowing area.

²¹ The data are available in official publications; see (Rosstat 2010, tab. 2.3.46-2.3.53).

²² Qualification of workers was identified in RLMS by International Standard Classification of Occupations ISCO code 88. Workers were considered low qualified if the corresponding code varied between 6000 and 7000. "Russia Longitudinal Monitoring survey, RLMS-HSE", conducted by Higher School of Economics and ZAO "Demoscope" together with Carolina Population Center, University of North Carolina at Chapel Hill and the Institute of Sociology of the Russian Academy of Science.

communication equipment and software, residential structures, non-residential structures, machinery and equipment, transport, and other assets.²³ For each individual asset, stocks were estimated on the basis of investment series using the perpetual inventory method (PIM) with geometric depreciation profiles. According to PIM, the capital stock (S) is defined as a weighted sum of past investments with weights given by the relative efficiencies of capital goods at different ages:

$$(11) \quad S_{k,T} = \sum_{t=0}^{\infty} \partial_{k,t} I_{k,T-t}$$

where $S_{k,T}$ denotes the capital stock (for asset type k) at time T , $\partial_{k,t}$ the efficiency of a capital good k of age t relative to the efficiency of a new capital good, and $I_{k,T-t}$ the investments in period $T-t$. The geometric depreciation pattern δ_k is assumed constant over time, but different for each asset type, so that $\partial_{k,t} = (1 - \delta_k)^{t-1}$ and

$$(12) \quad S_{k,T} = \sum_{t=0}^{\infty} (1 - \delta_k)^{t-1} I_{k,T-t} = S_{k,T-1} (1 - \delta_k) + I_{k,T}$$

If it is assumed that the flow of capital services from asset type k (K_k) is proportional to the average of the stock available at the end of the current and prior periods ($S_{k,T}$ and $S_{k,T-1}$), capital service flows can be aggregated from these asset types as a translog quantity index by weighting growth in the stock of each asset by its average share in the value of capital compensation, as in equation (7) above.

In order to estimate capital stocks in Russia there are three particular issues that need to be addressed. First, the measures have to deal with so-called “communist capital”. The term “communist capital” was suggested by Campos and Coricelli (2002) and refers to equipment and buildings put into operation before transition but becoming idle after transition due to the changing patterns of production and consumption. This stock no longer has any market value but is still present in the official capital stock statistics. Related to this is the question whether and how capital input measures should be adjusted for changes in capital utilisation rates, as Russia experienced some major fluctuations in growth after transition (see Figure 1). And third, given that the official NAS investment deflator appears to be highly overestimated, one will need better investment deflators.

There are two main sources for official data on investment and capital stocks in constant prices in Russia. The first is the Balance of Fixed Assets (BFA)²⁴, which covers the total economy (Bratanova 2003). This provides capital stocks based on direct observations of firm balance sheets in the current year based on previous year stocks plus new acquisitions minus

²³ In Russian: *vychislitel'naia tekhnika; informatsionnye mashiny, ne vkluchaia vychislitel'nuu tekhniku; nematerial'nye aktivy; zhilishcha; zdaniia, sooruzheniia i peredatochnye ustroistva; transportnye sredstva; silovye i rabochie mashiny; and prochie aktivy.*

²⁴ In Russian: *balans osnovnykh fondov po polnoi stoimosti v postoiannykh tsenakh.* The Russian statistics also develops the Net Balance of Fixed Assets (*balans osnovnykh fondov po ostatochnoi stoimosti v tekushchikh tsenakh*), which includes net capital stocks and depreciation. However, data on net capital stocks in constant prices is not available.

discards. Imputations are carried out for firms without balance sheets. It should be noted that this stock measure does not account for depreciation of assets, unless scrapped as reported by firms. Volume indices of capital stocks are also published by deflating nominal stocks with an investment price index (Rosstat 2006, Section 2.1); see below for more on deflation of BFA. Much of the communist capital is likely to be included in this stock measure, and its growth rate is particularly low. Nevertheless, it is used by Entov and Lugovoy (2013).

Most other studies are based on own estimates via the perpetual inventory method and use the stock estimate only as a benchmark estimate for the initial year of a series. Investment series are taken from the series of gross fixed capital formation (GFCF) of NAS, which are available in current and constant prices. This is the approach of Kuboniwa (2011) and Izyumov and Vahaly (2008), both using aggregate investment data, with depreciation rates of 1.8 and 5 per cent respectively. Izyumov and Vahaly (2008) pay particular attention to the communist capital problem and correct for “market quality” of the capital stock in 1991. They estimate that only half of the stock was useful for production after transition and use this to initiate the PIM estimate. The problem with the NAS investment series is that the implicit deflator appears to be highly overestimated. Bessonov and Voskoboynikov (2008) provide a comparison with other price indices and show that especially in the period 1991-1996 prices of investment goods rose much faster than the overall level of prices in the economy. However, this is very unlikely because typically investment price indices fall relative to the overall price levels (Greenwood, Hercowitz, and Krusell 1997). Moreover, Bratanova (2003, 4.40) noted the overestimation of prices for investment in Russian statistics. This is clearly shown in Figure 2, which shows several Russian price series. Because price changes are overestimated, real investments are underestimated, as is the growth rate of capital stocks.

Our way of dealing with these problems is by building up stocks from 1995 with a PIM using new investment deflators and asset-specific depreciation rates. Our approach tries to improve previous estimates by combining NAS investment series with deflators used in the BFA. We start with the GFCF series given in the NAS, which are available by industry but not by asset type for the whole period under consideration.²⁵ For the breakdown by asset type we use shares derived from detailed information on new acquisitions by industry and asset type, from the annual survey of large and medium firms, Form F11, which is part of the BFA.²⁶ Instead of using the NAS investment price indices, we use the underlying asset type deflators used by Rosstat to deflate overall capital stocks in the BFA.²⁷ We use the price index for construction works for deflating investments in residential and non-residential structures; the overall investments price index is used for other assets and the index on machinery and equipment as part of investments in fixed capital for the remaining types of assets (Rosstat 2002; Rosstat 2012; Rosstat 2012). Asset deflators are assumed to be the same for each industry. The trends of these price series appear to be much more plausible (see Figure 2), and they explicitly take into account changes in

²⁵ Formally, Rosstat publishes series of GFCF for total economy only. For industries, only investments in fixed assets are available. However, the official methodology acknowledges that the conceptual difference between the two measures of investments is minor (Rosstat 2009).

²⁶ Detailed data of survey F11 is issued by Rosstat in yearly internal publications *Otchet o nalichii i dvizhenii osnovnykh sredstv i drugih nefinansovykh aktivakh (f. №11)* (Statement of inventories and flows of fixed assets and other non-financial assets (form 11)). The full list of sources for various years is available in (Voskoboynikov and Dryabina 2009). Detailed description of the survey in Russian statistics of capital in English is given by (Bratanova 2003).

²⁷ Russian terms: *indeks tsen proizvoditelei v stroitel'stve*; *indeks tsen na stroitel'no-montazhnye raboty*; *indeks tsen na mashiny i oborudovanie v sostave investitsii v osnovnoi kapital*.

prices of imported equipment and vary over the different asset types. These deflated investment series are used in a PIM building up from the net capital stock estimate in 1995 from the BFA and using asset-specific depreciation rates from Fraumeni (1997).²⁸ Transformation of initial stocks and investment series from the Old to the New classification was accomplished with the detailed official (unpublished) bridge for investments.

[FIG. 2. About here]

While popular with many researchers, the use of capacity utilization rates to correct for capital utilisation is problematic. For Russia, two such measures are available. The first is the official estimation of physical capacity utilization of assets in mining and manufacturing. These series can be used for the calculation of a composite index with weights based on the output values of the corresponding goods, as suggested by Bessonov (2004) and used by Entov and Lugovoy (2013). The problem is that they only refer to production of a few dozen products of mining, manufacturing and energy distribution. Alternatively, there are three unofficial surveys of capacity utilization in Manufacturing, such as the Russian Economic Barometer²⁹ survey (about 500 manufacturing firms), used in Kuboniwa (2011). Two other similar surveys are those of the Institute of Economic Policy and the Centre for Economic Analysis (both cover some 1200-1400 firms and are used in Oomes and Dynnikova (2006) and Iradian (2007)). Apart from the lack of coverage for the total economy, it is not clear, that such indices relate exclusively or even mainly to capital input; they are typically measures of *capacity* utilisation as opposed to *capital* utilisation. And it is doubtful that they would include utilization rates of “communist capital”, and they most likely refer only to the capital that is potentially useful for production.³⁰ Our way of dealing with the capacity utilization problem is through the implementation of internal ex-post rates of return in calculating capital services (see previous section). Thus increases in capital utilization are reflected in an increasing internal rate of return rather than through adjustments in the physical capital stock measures.

4. Growth accounting results

In this section we describe the main results for industry-level growth accounting using the constructed data set discussed above. Before doing that, we describe how aggregate economy estimates of MFP growth in Russia depend on the various assumptions made in the literature compared to ours. This will illustrate the empirical relevance of our new measures of capital input and labour shares.

4.1. Aggregate economy growth accounting alternatives

In Table 1 we provide various alternative ways of measuring capital input growth and its output elasticity. This is shown for a growth decomposition of value added in the Russian market

²⁸ However, for sensitivity analysis we also used rates on the basis of a survey of services lives, provided by Rosstat in 2008. Results for the growth accounts appear to be virtually unaffected.

²⁹ <http://www.ecsoc.ru/en/reb/>

³⁰ See Beaulieu and Matthey (1998) for an overview of various approaches to measuring capital utilisation.

economy³¹ for the period 1995 to 2008. Value added growth and labour input growth are kept the same for all alternatives in order to focus on the impact of alternative estimates of capital input and labour shares in value added. We start with a decomposition in which capital input growth is based on growth in the official net capital stocks from Rosstat, assuming a labour share of 70 per cent, as in the bulk of the growth accounting literature for the Russian economy.³² In this alternative MFP, growth explains 3.6 percentage points of 4.8 per cent growth in value added, which supports the idea that Russian growth has been intensive and productivity based since the mid-1990s.

In the second alternative capital input growth is based on a combination of the official capital stock in 1995 and a PIM method for the subsequent years using real investment from the NAS and a 5 per cent depreciation rate for all assets, as in Iradian (2007) and Izyumov and Vahaly (2008). As discussed above, the official investment deflator from the NAS appears to be rising too fast, so that capital stocks are growing too slowly. Indeed, in this alternative there is hardly any growth in aggregate capital stock (0.2 per cent), and the stock of non-residential buildings even declined by 1.7 per cent annually. In Jorgenson and Vu (2010) capital input is even declining over this period. As a result, estimated MFP is even higher than in the first alternative (3.9 per cent).

If we use alternative deflators that seem more in line with other price developments in the Russian economy, capital stocks grow for all asset types and capital input growth is estimated at 2.9% annually. In this third alternative, MFP growth is lower than in the previous ones, that is 3.1%. As discussed above, the assumption of a labour share of 0.7 is common for developed economies but is not necessarily valid for a transition economy like Russia. In alternative four, we use a labour share in value added in industries calculated as employee wages from the NAS, adjusted for shadow wages from the NAS and our imputation of self-employed and household workers' income (see section 3.1). We find that the share of labour is much lower, at 52 per cent of value added. Hence the output elasticity of capital is estimated to be higher and, given that capital inputs are growing faster than labour input, estimated MFP drops to 2.6%.

But further improvements to the data can be made. In alternative five we replace the common 5% depreciation rates on all assets by asset-specific rates from Fraumeni (1997). For buildings this rate will be less than 5%, while for machinery and especially ICT it will be much higher. Consequently, the growth rates for buildings stock should rise and for machinery decline, as shown in column 5. The impact on aggregate capital stock growth is, however, minor and estimated MFP is 2.7%. Finally, in our preferred approach we calculate capital input growth, not as the growth in aggregate stock, but through capital services. This does not affect the growth in individual asset stocks, but gives larger weight to assets with higher rental prices (such as machinery) in the capital input index. As assets with higher rentals appear to grow faster, aggregate capital input should be higher than in the previous alternative, and this is confirmed by comparing alternative 6 with 5. Our preferred estimate of MFP growth is hence 2.6 per cent annually, explaining 53 per cent of value added growth in the market economy over the period

³¹ The market economy is defined as all sectors excluding public administration, education, and health and social work. This collection of industries is called here the market sector although not all these activities are fully market based, nor are all the excluded activities non-market-based. But it is a useful way of grouping industries, especially since we now that in the “non-market” sectors output and hence productivity measurement is difficult (see (Schreyer 2012)).

³² (De Broeck and Koen 2000; Dolinskaya 2001; Bessonov 2004; Rapacki and Próchniak 2009; Jorgenson and Vu 2011; Entov and Lugovoy 2013).

1995 to 2008. This is still sizeable but much smaller than the results found in the previous studies using cruder alternatives.

As a robustness check to our preferred estimate, we also provide a calculation based on the ex-ante approach to capital measurement. In the ex-ante approach the rate of return is typically estimated through the current cost of financing such as interest rates or bond yields. In a well-functioning market economy, these might well represent the actual cost of access to finance, but in the Russian economy, which is financially underdeveloped and where investment flows are opaque, these data are neither readily available nor easy to interpret. We therefore choose a real rate of return of 4 per cent and recalculate the labour share of value added and the capital input growth rates as cost shares. Capital input growth increases somewhat, but as the capital share declines, the net effect is minimal and the estimated MFP growth is again 2.6 per cent.

[Table 1 about here]

4.2. Changing structure of the Russian economy

The literature which deals with structural change of the Russian economy typically assumes the traditional division of activities into agriculture, industry, and services. This partition of the economy is useful for analysing structural change in developing economies where the majority of workers are still in primary industries, but is unsuited for studies of Russia. Russia passed the first stage of industrialisation already in the first half of 20th century and had a sizable industrial complex at the end of the 1980s (Ofer 1987, Table 4). Market services on the other hand were relatively underdeveloped, and it is useful to distinguish them from non-market services. O'Mahony and van Ark (2003) proposed a classification of industries, which we also use, based on the skill-intensity of production, distinguishing between high-skilled and low-skilled goods production and services. Finally, we separate out the mining industry, which is important for the Russian economy. In Table 2 we show the shares of these sectors in nominal GDP and their real growth rates over the period 1995-2008.

Particular attention should be given to the definition and measurement of the mining industry in Russia. Mining activities are covered in the Russian statistical system in the industry *Mining*, but also in some sub-industries of *Wholesale Trade*, *Inland Transport* and *Fuel*. For example, the World Bank report (2005), Gurvich (2004), and Kuboniwa, Tabata and Ustinova (2005) pointed out that separate performance measures of each of these industries on the basis of SNA data are misleading because of non-market pricing of transactions between establishments of the vertically integrated holdings, such as *Gazprom*. These firms have establishments in various industries and are known to use transfer pricing in order to minimize tax payments. Due to a lack of detailed data, we approximate the size of the mining sector by combining the mining and wholesale distribution industries and find that its share has grown from around one-fifth of total GDP in 1995 to almost a quarter in 2008.

Other goods production, in contrast, declined rapidly in importance from 26 to 18 per cent in 2008. While high-skill intensive manufacturing industries such as chemicals and electrical equipment remained relatively stable but small (4 per cent), value added in agriculture, textiles, metal and plastics declined rapidly. The share of market services remained more or less constant at 40% of GDP, but structural change within this sector was extensive. Low-skill intensive

services such as utilities and construction lost shares, while high-skill intensive services such as financial intermediation and business services increased their share in GDP to over 10 per cent in 2008. This is a reflection of the catching up process in certain services sectors which were underdeveloped in planned economy (Fernandes 2009). Also the share of non-market services (especially public administration and education) increased somewhat but is still much lower than in advanced nations (Jorgenson and Timmer 2011).

[Table 2 about here]

4.3. Sectoral contribution to aggregate input and productivity growth

The productivity performance of the various sectors has been quite diverse. In Table 3 we provide the annual growth rates of labour and capital input and MFP growth for the main sectors in Russia from 1995-2008. This is shown in the left-hand side of the table. MFP is calculated by subtracting weighted input growth from value added growth, as shown in equation (4). Capital input is measured by our preferred method, the ex-post approach.³³ In the right hand side of the table the contribution of each sector to aggregate growth in inputs and MFP is shown. This is derived by weighting industry growth by its share in value added, as in equation (6). The contributions of all industries add up to aggregate market economy growth by definition.

The fastest MFP growth rates are found in the skill-intensive series, in particular in finance and business services. While labour and capital input grew at rates comparable to the market economy as a whole, MFP growth was almost 9 per cent annually, which is more than 6 per cent higher than the aggregate. This is a remarkable high level of improvement compared to what has been found for advanced countries, but much of this is catch-up growth, as the level of development of these services was particularly low before and during transition, as suggested by Fernandes (2009). Using industry-specific purchasing power parities (PPPs) it is possible to compare the level of productivity in Russia with other countries for the same industries. Based on the industry output PPPs for 2005 derived from expenditure PPPs as described in Inklaar and Timmer (2012), we find that MFP in high-skilled services in Russia in 1995 was only about 12 per cent of the level in Germany. This was by far the lowest relative level of all sectors considered here, confirming the retarded state of these sectors. Even after the period of rapid growth, in 2007 the gap versus Germany is still 49 per cent, leaving plenty of room for further catching-up.

MFP growth was also fast for high-skilled manufacturing, that is 5.6 per cent annually, and this is a potential major source of growth for Russia. But it appeared that MFP growth was mainly due to an extensive rationalisation of the sector in the wake of increased competition from advanced nations, as Russia gradually opened up to international trade in high-tech in the 1990s. Capital input growth was negative and especially labour declined rapidly such that this sector is now less than 4 per cent GDP and ceased to be an important source of growth.

In contrast, labour and in particular capital inputs gravitated towards low-skill intensive services and the mining sector. Together these two sectors more than fully “explain” aggregate labour input growth, and are responsible for 2.5 percentage points of the 2.9% growth in aggregate capital input. But although input growth rates were high, MFP growth rates were far below average. In low-skill intensive services, average MFP growth was 1.7 per cent, and in mining only 0.8 per cent, so that combined they account for only 0.9 percentage points of 2.6 per cent aggregate MFP growth.

³³ Results based on the ex-ante approach are qualitatively similar and available upon request from the authors.

To illustrate the industry concentration of Russian growth in more detail, we turn to the detailed growth account results for the 31 detailed industries listed in the Appendix and present the diagrams suggested by Harberger (1998), known as Harberger diagrams. These diagrams provide an intuitive way of identifying whether an aggregate growth rate is caused by a few industries or whether growth is widespread. This diagram is a graphical representation of the industrial growth pattern with the 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. Inklaar and Timmer (2007) have suggested three useful descriptive indices for these diagrams: aggregate growth, 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 summed share of value added of all industries, which indicates positive growth rates. The curvature is defined as the ratio of the area between the diagram and the diagonal line, and the total area beneath the diagram. The value of curvature lies between 0 and 1, such that the value is lower when the growth is more broad-based and observed in many industries or higher if growth is more concentrated in a few industries.

The Harberger diagrams are shown in Figure 3 for MFP, capital and labour input growth. For capital input we find that the value added share of industries with positive growth rates is 89.2% with a curvature of 0.33. The five industries with the fastest growth in capital inputs are telecom, transport services, fuel refining, retailing and mining, and these together contribute one-half of the aggregate growth. Negative growth rates are found in industries of material production such as textile, electrical and transport equipment, and in particular in Agriculture. Growth in labour input is much less widespread in the economy. The value added share of industries with positive labour input growth is just above one-half. And the curvature is much higher than for capital, that is 0.54. Labour input was growing in services (wholesale and retail trade, hotels, financial intermediation and supporting transport activities) but declined rapidly in industries of material production such as agriculture, machinery, transport equipment and mining.

MFP growth is also more mushroom-like than capital input growth. The value added share of industries with positive growth rates is 80.3% and the curvature is 0.39. The fastest growing industries are business services, finance, electrical machinery and automotive trade. But there is also a tail of industries with negative MFP growth such as mining, utilities, water transport, fuel refining, textiles, footwear and wearing apparel manufacturing, and transport equipment manufacturing. In contrast to other formerly planned economies in Europe, Russia did not benefit from the fast growing FDI from Germany and other EU countries in skill-intensive manufacturing, building up widespread production chains across Europe. This has been an important driver of productivity growth in, for example, the Czech Republic, Hungary and the Slovak Republic (Havlik, Leitner, and Stehrer 2012).

Retailing is one of the industries that are growing fast in terms of inputs, but MFP growth there is slow. The retail sector in Russia has a strong dual nature. One part is represented by new modern capital-intensive supermarkets with up-to-date retail technologies, whereas the other part is labour-intensive, mostly informal, retail shops run by families. The retail sector in the Soviet Union was lagging for a long time and in 1999 McKinsey (1999, p. 5), reported that modern high-productivity formats were almost entirely absent, with less than 1% of market share. Starting from the middle of 1990-s Russia has experienced an explosive growth of modern retail

centres, which in 2009 captured 35 % of total retail sales (McKinsey 2009, p.65) via both FDI and expansion of domestic retail chains. But this expansion has not yet led to increased MFP.

[Table 3 about here]

[Fig. 3 about here]

5. Concluding remarks

GDP per capita growth rates in Russia have been among the highest in the world since the mid-1990s. In contrast to previous growth accounting studies we do not find that this to be mainly driven by multi-factor productivity (MFP) growth. Rather labour and capital input growth explain about as much of the value added growth during the period 1995-2008 as does MFP. The greater measured contribution of capital input is due to the fact that we derived a proper measure of capital services input that distinguishes various capital types with asset-specific depreciation and investment deflators. Using the new industry-level dataset on inputs and outputs, we also found that the (extended) mining sector was not a driver of growth. Together with wholesale and retail trade, the mining sector absorbed an increasing share of labour and capital inputs, but was poor in terms of MFP performance. The mining sector expanded to a quarter of GDP in 2008, up from one fifth in 1995. MFP growth was high in goods industries, but this sector's GDP share declined as it could not cope with increased foreign competition. Finance and business services industries expanded and were the only industries that performed well in terms of MFP growth. But as their MFP levels were extremely low in the mid-1990s, much of this growth is of a basic catching-up character, rather than an indication of dynamism and innovativeness. Given that the reallocation of inputs to more productive activities is a hallmark of growth in successful economies (McMillan and Rodrik 2011), these trends in Russia do not bode well for future economic development.

Although we believe that the data set developed for this paper is of a higher quality than what is currently available from official sources or otherwise, there is still much room for improvement. This includes the development of better price indices for value added in the NAS. Many of the value-added volume series in the NAS are still based on gross output quantity indicators (weighted by value added) and should be gradually replaced by properly (double) deflated value added series. The development of a new supply and use table for 2011, which is currently in progress, should be helpful in that respect (the most recent one is for 1995), as is the development of new price deflators that take quality change into account. With respect to capital, new investment price indices should be used in the NAS that properly account for imported equipment and quality changes (e.g. for ICT capital). As shown, some of these indices are used by Rosstat for deflating capital stocks, but not for investment series. Better measurement of labour costs and profits by industry, in which activities of large vertically integrated firms are allocated to the various industries, would also be useful for any analysis of changes in industrial structures.

As a final note, we would like to stress that the growth accounting based on index numbers used in this study relies on stringent neo-classical assumptions that are likely to be violated in the case of Russia, where market competition is still limited. Also the issue of how to deal with

capital utilisation variation cannot be completely resolved within this neo-classical non-parametric framework. We hope that the database developed for this study will be a fertile breeding ground for other studies of the sources of growth in Russia, relying on other non-parametric or parametric approaches.

Table 1. Value added decomposition for market economy, 1995-2008
(various alternatives)

	1	2	3	4	5	6	7
Labour share of value added (%)	70.0	70.0	70.0	52.3	52.3	52.3	63.9
<i>Growth rates</i>							
Value added	4.82	4.82	4.82	4.82	4.82	4.82	4.82
Labour	1.27	1.27	1.27	1.27	1.27	1.27	1.27
Capital	1.08	0.21	2.86	2.86	2.55	2.89	3.24
ICT capital	n.a.	11.56	16.09	16.09	11.31	10.23	11.02
Machinery & Equipment	n.a.	3.30	6.48	6.48	4.24	4.24	4.23
Non-residential buildings	n.a.	-1.70	0.36	0.36	1.66	1.76	1.64
<i>Contributions to Value added</i>							
Value added	4.82	4.82	4.82	4.82	4.82	4.82	4.82
Labour	0.89	0.89	0.89	0.59	0.59	0.59	1.18
Capital	0.32	0.06	0.86	1.66	1.52	1.67	1.08
ICT capital	n.a.	0.11	0.17	0.29	0.14	0.22	0.19
Machinery & Equipment	n.a.	0.29	0.62	1.05	0.58	0.72	0.58
Non-residential buildings	n.a.	-0.34	0.07	0.33	0.80	0.74	0.31
MFP	3.61	3.87	3.08	2.56	2.71	2.56	2.56

Notes:

- 1 Official capital stock growth (for total economy) and fixed labour share 0.7
- 2 PIM capital stocks, depreciation at 5% a year and official investment deflators
- 3 as 2 but alternative investment deflators which vary by types of assets
- 4 as 3 but labour shares vary over industries
- 5 as 4 but depreciation rates by asset from Fraumeni (1997)
- 6 as 5 but capital services with internal rate of return
- 6 as 5 but capital services with external rate of return

Sources: Authors' calculations based on value added and labour from Voskoboynikov (2012); official capital stock from Rosstat (<http://cbsd.gks.ru/>; loaded 31 May 2013); nominal investment and physical volumes of investments from (Rosstat 2009) and issues of this yearbook for previous years; alternative official deflators from (Rosstat 2012); depreciation rates from Fraumeni (1997);

Table 2 . Sectoral shares of value added and contribution to real growth, %, 1995-2008

	Value added share (current prices)		Annual real growth rates (%)
	1995	2008	
Total economy	100.0	100.0	4.61
Mining and distribution	20.1	24.7	4.87
Goods	25.6	18.3	2.92
<i>High-skill intensive</i>	3.6	3.6	3.92
<i>Low-skill intensive</i>	22.0	14.8	2.72
Services	40.4	41.0	5.82
<i>High-skill intensive</i>	5.1	11.2	10.70
<i>Low-skill intensive</i>	35.3	29.8	4.60
Non-market services	13.9	16.0	3.41

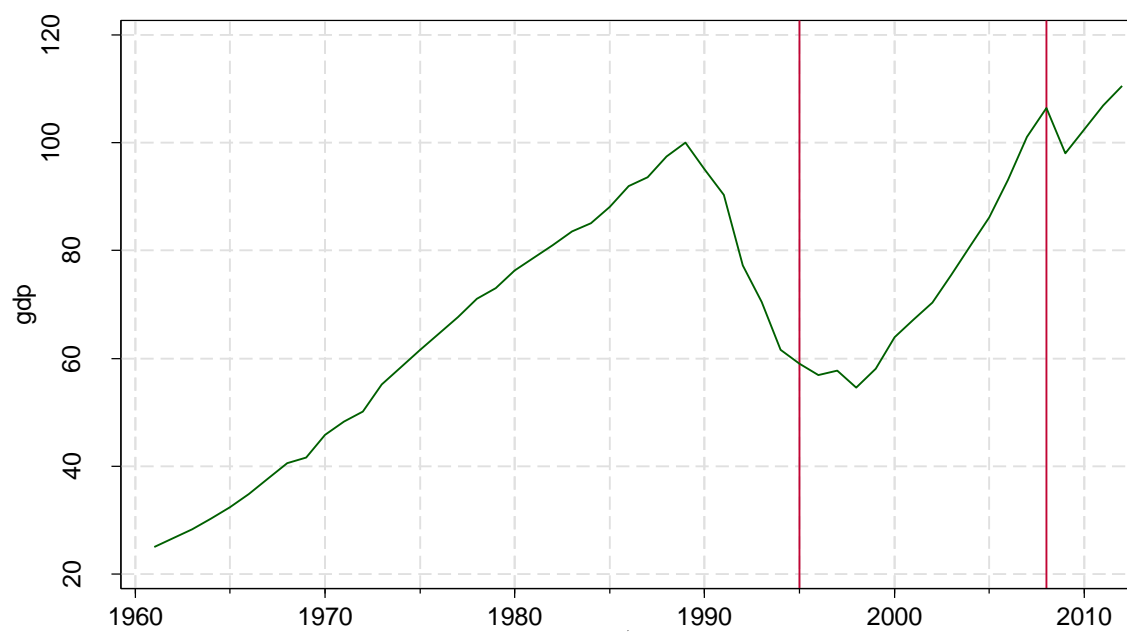
Sources: Authors' calculations, see main text.

Table. 3. Average growth rates of inputs and MFP, 1995-2008

	Annual real growth rates (%)			Contribution to total (percentage points)		
	Labour input	Capital input	MFP	Labour input	Capital input	MFP
Market economy	1.27	2.89	2.56	1.27	2.89	2.56
Goods	-1.01	0.51	3.23	-0.26	0.13	0.83
<i>High Skill-Intensive</i>	-2.54	-0.18	5.57	-0.11	-0.01	0.23
<i>Low Skill-Intensive</i>	-0.71	0.64	2.78	-0.15	0.14	0.60
Services	1.72	3.92	3.14	0.82	1.87	1.50
<i>High Skill-Intensive</i>	1.20	2.78	8.97	0.11	0.27	0.86
<i>Low Skill-Intensive</i>	1.85	4.20	1.69	0.71	1.61	0.65
Mining and distribution	2.67	3.35	0.84	0.70	0.88	0.22

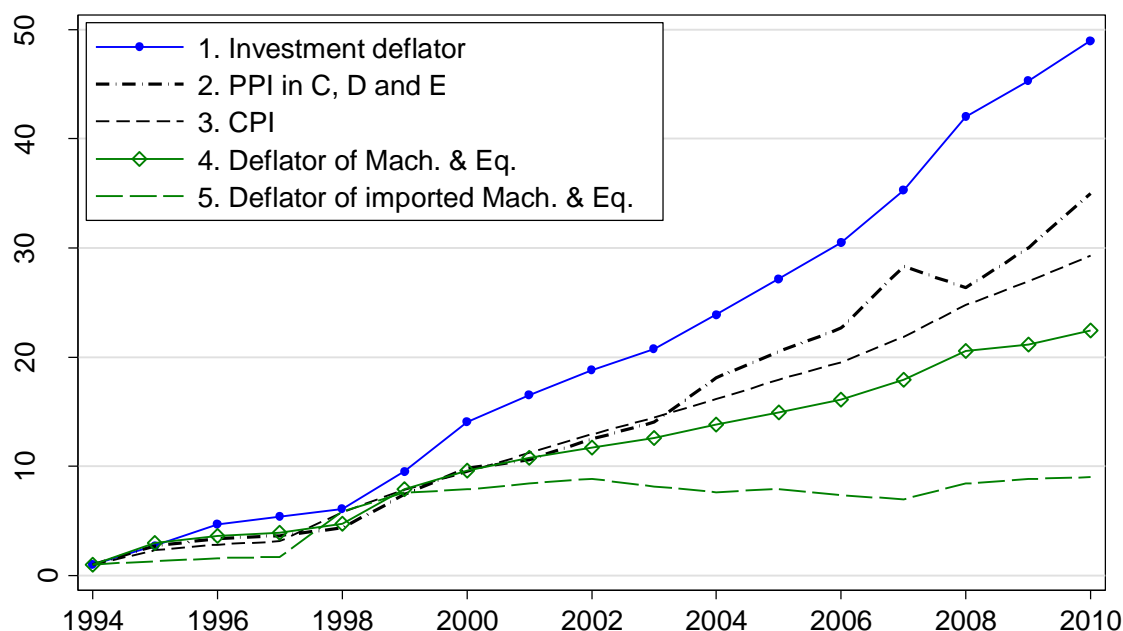
Sources: Authors' calculations, see main text.

Figure 1. Long run growth of the Russian economy, 1961-2012 (1989 = 100)



Source: 1961-1990: (Ponomarenko 2002); 1991-2012: Russian statistical office (*Rosstat*).

Figure 2 Alternative investment deflators

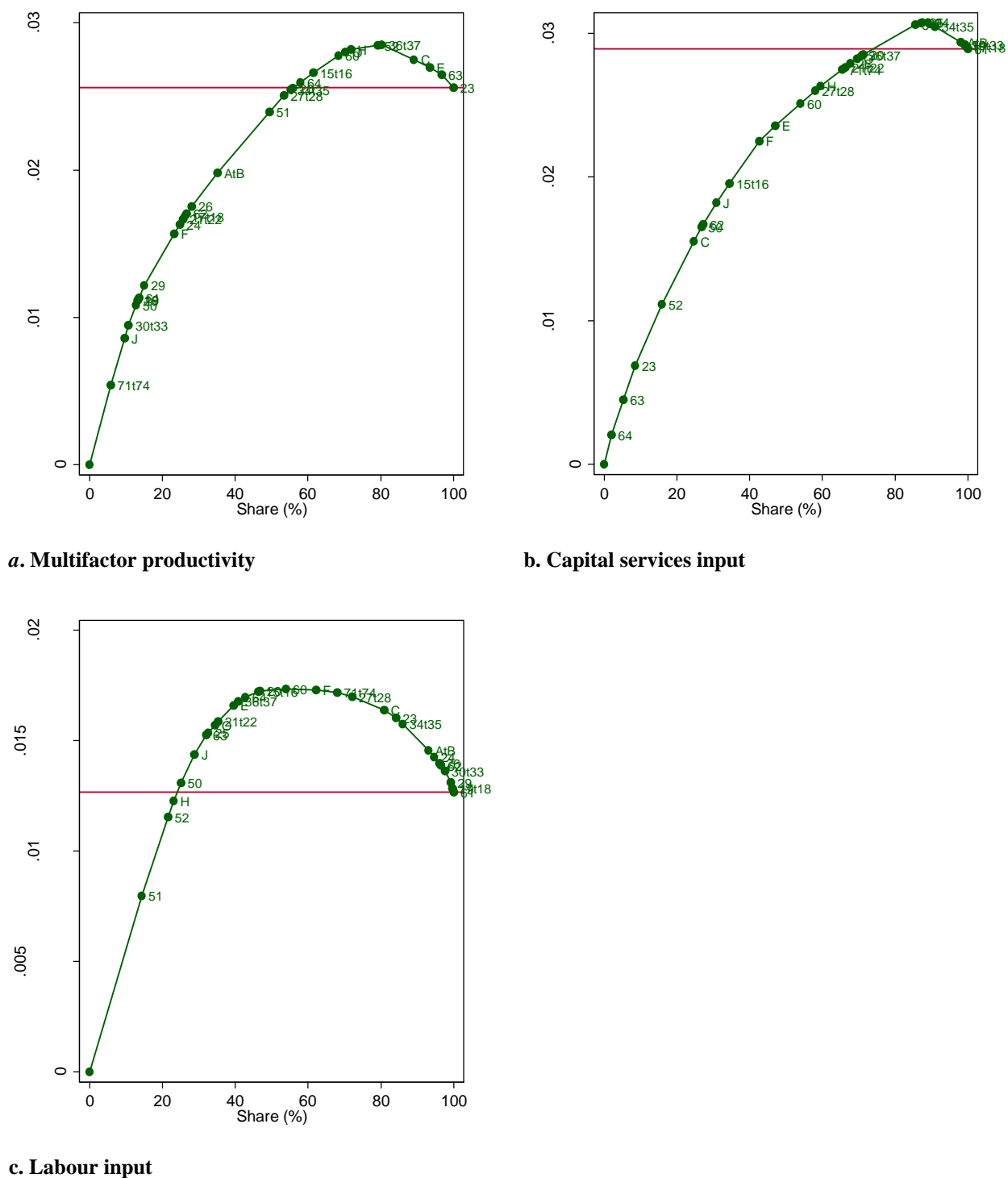


Sources: a.1-4 – Rosstat (see details in Section 3); a.5 - own calculations.

Note: Price level measured by investment deflator from NAS (1); producer price index for manufacturing (2); consumer price index (3); price index for machinery and equipment from BFA (4); price index for imported machinery and equipment (5)*.

*) The price index for imported machinery and equipment captures price changes in imported machinery from the perspective of a Russian domestic purchaser. It was calculated on the basis of the series of imported machinery and equipment in U.S. dollars (*Import po tovaram i tovarnym gruppam v razreze TN VED Rossii; Mashiny i oborudovanie*) available in (Rosstat 2012), producer price index for machinery and equipment of the U.S. Bureau of Labor Statistics (BLS 2012) and yearly average exchange rates of U.S. dollar vs Russian ruble by the Central Bank of Russia. This approach is based on the assumption that prices of imported equipment in a foreign currency change in the same way as corresponding prices in the U.S.

Figure 3. Harberger diagrams for input and productivity growth, 1995-2008



Sources: Authors' calculation; see main text. Industries are denoted by NACE 1.0 codes, which are available in the Appendix.

Appendix. List of sectors and industries

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

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