the review of income and wealth

Review of Income and Wealth
Series 60, Supplement Issue, November 2014
DOI: 10.1111/roiw.12132

IS MINING FUELLING LONG-RUN GROWTH IN RUSSIA? INDUSTRY PRODUCTIVITY GROWTH TRENDS SINCE 1995

BY MARCEL P. TIMMER*

University of Groningen

AND

ILYA B. VOSKOBOYNIKOV

University of Groningen and National Research University Higher School of Economics

GDP per capita growth rates in Russia have been amongst the highest in the world since the mid-1990s. Previous growth accounting research at the macro-level suggests that this was mainly driven by multi-factor productivity (MFP) growth. In this paper we analyze for the first time the drivers of Russian growth at the level of industries. We derive a proper measure of capital services, instead of using stock measures as in previous research. Using this, we find that aggregate GDP growth is driven as much by capital input as MFP growth. Mining and Retailing industries are growing fast, but have poor MFP performance. In contrast, MFP growth was high in goods-producing industries but their share in GDP declined. MFP growth was highest in those industries that were particularly underdeveloped in the Russian economy in the 1990s.

JEL Codes: L16, O47, P28

Keywords: industrial growth accounting, Russia, structural change

1. Introduction

GDP per capita growth in Russia has been amongst the highest in the world since the mid-1990s, averaging 3.7 percent annually between 1995 and 2012.[1] For this reason it is occasionally clubbed together with other fast growing economies such as Brazil, China, and India into BRIC, and set against the European Union, Japan, and the U.S. where growth is sluggish. As such, Russian economic development today is seen as yet another successful transition from a command to a

Note: This paper benefitted from help, multiple discussions, and long term support of Vladimir Bessonov, Revold Entov, Vladimir Gimpelson, Dale Jorgenson, Rostislav Kapeliushnikov, Andrey Yakovlev, and Evgeniy Yasin. We also thank Reitze Gouma for assistance in practical implementation of EU KLEMS methodology. We thank Robert Inklaar, who kindly provided additional unpublished data of PPPs for investment goods by types of assets for this study. Two referees and the guest editor provided helpful comments. Various versions of this paper were presented at research seminars in Moscow at the Higher School of Economics and the New Economic School/CEFIR; at the 32nd IARIW Conference in Boston; at the 2nd World KLEMS Conference in Boston; at the WIIW in Vienna; at the University of Graz; and at the BOFIT research seminar in Helsinki. This project was supported by the Basic Research Program of the National Research University Higher School of Economics as well as the visiting research program of BOFIT.

*Correspondence to: Marcel Timmer, PO Box 800, Faculty of Economics and Business, GEM, University of Groningen, the Netherlands (m.p.timmer@rug.nl).

[1]The Conference Board Total Economy Database™, January 2013, http://www.conference-board.org/data/economydatabase/

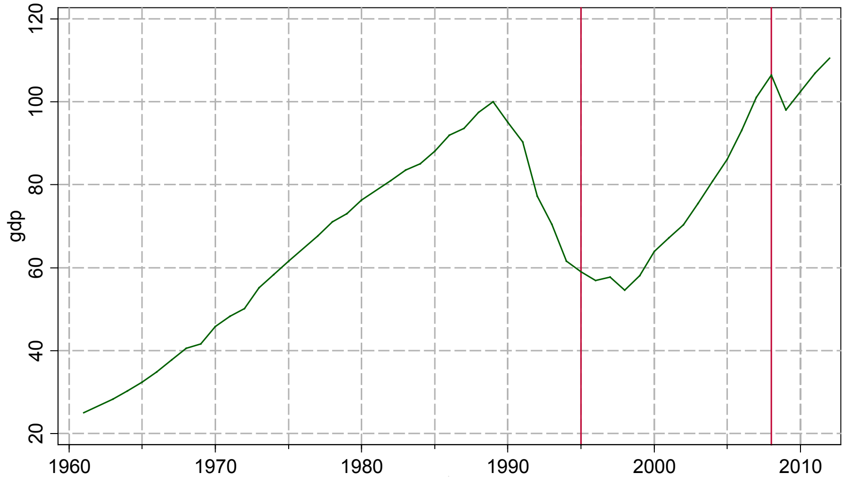


Figure 1. Long Run Growth of the Russian Economy in 1961–2012 (1989 = 100)
Source: 1961–90: Ponomarenko (2002); 1991–2012: the Russian statistical office (Rosstat).

market economy. This is a dramatic change of fortune. In the past Soviet economic performance was highlighted as a typical example of extensive growth, driven by high investment and labor input growth, with little improvements 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 multiple price distortions of the planned economy, a better allocation of inputs among industries, and increasing incentives for firms to diminish real costs of production, productivity should become the main driver of growth (Campos and Coricelli, 2002). These benefits were not realized immediately, and as is well known 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 from the market economy seem to be finally realized, akin to the success of various other formerly planned economies in Eastern Europe (Fernandes, 2009; Havlik *et al.*, 2012) and China.

Recent growth accounting studies of Russia confirm this view and find 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 labor and capital inputs. Entov and Lugovoy (2013), Jorgenson and Vu (2010), and Kuboniwa (2011) all find that MFP growth was (much) higher than input growth in the period from about 1995 to 2008. Izyumov and Vahaly (2008) find that input growth is even negative in this period, and all output growth is due 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 set of developed and developing countries, Russian MFP growth of around 5 percent annually since the mid-1990s appeared to be amongst the highest in the world (Jorgenson and Vu, 2010). This supports the view that Russia managed to switch from an extensive input-driven to an intensive productivity-driven growth trajectory.

There is another strand of the literature however, that emphasizes the important role of tradable natural resources in Russian growth. It suggests that Russian growth is mainly driven by the windfall profits made through 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 investments and GDP and maintain that Russian growth is still extensive, rather than driven by productivity improvements.

In this paper we aim to contribute to this debate and analyze 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 34 industries for the period 1995 to 2008, taking into account revisions in the National Accounts Statistics, changes of industrial classifications, measurement issues of labor and capital, and estimates of factor shares in value added. We pay particular attention to deriving a proper measure of capital services in the tradition of Jorgenson *et al.* (1987), instead of using stock measures that dominate previous research, and discuss the importance of properly accounting for depreciation and rental prices. We show that the of the capital services concept is not only theoretically to be preferred, but also empirically matters, 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 he showed that a proper accounting for quantity and quality of inputs leads to considerably lower estimates of MFP growth compared to analysis based on raw unadjusted series. Our second contribution is that we trace the slow productivity performance to a limited set of industries, namely Mining and Retailing where growth was particularly driven by capital inputs. These industries increased shares in GDP, and the Mining sector accounted for a quarter of GDP in 2008. On the other hand, intensive growth took place in many manufacturing industries, but their share in GDP declined. Russian high-tech production was well developed before transition, but did not survive the competition from high-quality imported products, while low-tech manufacturing suffered from low-cost competition from Asia. Various modern market services expanded in Russia and showed high MFP growth. These sectors were particularly underdeveloped in the 1990s, and much of this growth was through catching-up.

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 when attempting a growth account based on official Russian statistics. We highlight deficiencies in the official data and how we dealt with those. Comparisons with previous studies are also made. Growth accounting results at the aggregate and industry levels are discussed in Section 4. Section 5 concludes.

[2]See, e.g., Connolly (2012).

2. Growth Accounting Method

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

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

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

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

$$\Delta \ln A_j \equiv \Delta \ln Z_j - \bar{v}^Z_{K,j} \Delta \ln K_j - \bar{v}^Z_{L,j} \Delta \ln L_j \tag{2}$$

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

$$v^Z_{K,j} = \frac{p^K_j K_j}{p^Z_j Z_j}; \quad v^Z_{L,j} = \frac{p^L_j L_j}{p^Z_j Z_j} \tag{3}$$

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

$$\Delta \ln Z_j = \bar{v}^Z_{K,j} \Delta \ln K_j + \bar{v}^Z_{L,j} \Delta \ln L_j + \Delta \ln A_j. \tag{4}$$

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

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

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

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

This equation allows decomposition of GDP growth rates by contributions of factors and multifactor productivity growth in industries.

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 a 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 as

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

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

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

such that the sum of shares over all capital types add to 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 for a one-year lease in the rental market. In the absence of taxation the familiar cost-of-capital equation is given by:

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

with $i_{j,t}$ representing 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 how to measure the rate of return, on both 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 *et al.*, 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 is the same for all assets in an industry, but is allowed to vary across industries, and is derived as a residual as follows:

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

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 labor.

[3]Ideally taxes should be included to account for differences in tax treatment of the 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.

The theoretical basis for the Jorgenson-type implementation of user cost is fairly restrictive though, relying amongst others on perfect foresight of investment returns. Balk (2010) provides a defense of the ex-ante approach which is considered to be independent of neo-classical theory. Oulton (2007) argues that the ex-post approach, which assumes a single appropriate rate of return for all assets, does not do full justice to a world with many assets.[4] For a proper empirical implementation of the ex-post approach, all assets in the economy have to be covered and capital income should be accurately measured. Measurement error in any of these will in part show up in variation of the internal rate of return, and hence impact MFP measures.[5] The main reason to opt for an ex-post rate of return nevertheless is that it provides a method to take into account changes in capital utilization rates, which is of particular importance for an analysis of Russian growth from 1995 to 2008 which was a typical boom period. In 1995, Russia was at the trough of a severe crisis (see Figure 1) and obviously utilization rates increased rapidly afterwards. This increase should be accounted for in our input measures as we are interested in MFP as a measure of technological change,[6] 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 through 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 in the approach outlined above, which would make a separate adjustment to the capital input measure superfluous. Hulten (1986) elucidated this theoretical result and highlights 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 (partially) include 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 of real value added, labor, and capital for 34 industries for the period 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 labor than available both in the literature and in the official statistics. Detailed data of output for industries in an international industrial classification, which cover the total economy, have become

[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 Mattey (1998) or Basu and Fernald (2001).

available in official publications of the Russian statistical office (Rosstat)[8] only recently, whereas detailed series of labor and capital have never been issued. In comparison with the extant literature, our measures of capital and labor are more detailed, cover a longer period, and have a better theoretical foundation. In this section we discuss our choices for the data sources and methods, and compare those with the previous growth accounting literature on Russia. In Section 3.1 we discuss sources for value added and labor input, and in Section 3.2 capital input. In Section 4 we will show how the various choices have an impact on the final growth accounting result. In general, our choices lead to higher estimates of the contribution of capital to growth and consequently lower estimates of MFP than the extant literature.

Although we use this new database for a growth accounting exercise, it serves many other applications of economic analysis, in particular when used in conjunction with comparable data for other countries, such as found in the EU KLEMS project (O'Mahony and Timmer, 2009). The data have been posted on the World KLEMS website (www.worldklems.net).

3.1. *Output and Labor 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 labor 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 case of Russia some of these elements are not consistent with each other, whereas others have only recently existed in the official statistics. SNA was introduced in Russia in the early 1990s, substituting for the old Soviet national income accounting called the Material Product System (MPS).[10] But this process was slow and even now some rudiments of MPS have survived in the system of national statistics. This coexistence creates conceptual inconsistencies between different blocks of the Russian statistical system.[11] In contrast with the National Accounting Statistics (NAS), such primary sources as regular firms and households surveys in many aspects are well developed and have been collected for decades. Detailed data of primary sources in many cases are published and may be used to fill gaps in NAS statistics, improving official data for the purpose of detailed industrial growth accounting. The industrial classification was changed in 2003. The old industrial classification was introduced in the period of planned economy and made up within MPS, and inconsistent with any interna-

[8]For convenience all sources published by the Russian statistical office are referenced as *Rosstat* in spite of the fact that the official name of the Russian/Soviet statistical office has been changing over time.

[9]Schreyer (2001) and Jorgenson *et al*. (2005).

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

[11]Ivanov (1987, 2009), Ivanov *et al*. (1993), and Masakova (2006). See also Entov and Lugovoy (2013) for a discussion in the context of growth accounting.

tional classification (Masakova, 2006). It was supplanted by a new classification in 2003, but Rosstat did not revise industry-level series in NAS back before 2002 in the new classification. We briefly discuss how we dealt with three major data hurdles—linking of industries across the old and new classification; measuring labor input; and measuring the labor share in value added issues—and refer interested readers to Voskoboynikov (2012) for more details.

To construct real value added series we had to bridge the change in industrial classification. For years before 2003 the NAS industrial data has only been available in the old Soviet industrial classification,[12] which is inconsistent with the new one,[13] or any other international classification. Nominal gross output values by industries in the new classification before 2003 were obtained from Rosstat and were created within the Russia KLEMS feasibility study project (Bessonov *et al.*, 2008). This dataset is an unpublished backcast estimation, which is based on the detailed bridge between the old classification and the new one. The bridge was compiled by Rosstat for 2003–04, when primary data were collected in the two classifications at the same time.[14] To obtain nominal value added in industries we multiply the gross output of an industry to the corresponding value-added–gross-output ratio. These ratios were calculated for the industries in the old classification, which were the closest counterparts of the industries in the new classification with published data. The volume indices of gross output until 2002 are based on output volume indices for detailed products with nominal gross output weights fixed in the new classification. The volume indices of value added until 2002 are assumed to be equal to the volume indices of 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 the indices of gross output. The only difference between official gross output and value added volume indices is in a different set of product weights.

Labor input is measured as hours worked.[15] For this we use series from the *Balance of Labor 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 down to a finer industry detail and backcast the series before 2005 we rely on a combination of data from the *Balance of Labor Force*[17] (BLF) and reports of organizations of "*the Full Circle*" (FC),[18] which include large, medium,

[12]The all-union classification of industries of the national economy, OKONKh (*Obshchesoiuznyĭ klassifikator "Otrasli narodnogo khoziaĭstva"*; Rosstat, 1976). From now on the OKONKh classification will be referred to as "the Old classification."

[13]The new industrial classification, OKVED (*Obshcherossiĭskiĭ klassifikator vidov ėkonomicheskoĭ deiatel'nosti*) coincides with NACE 1.0 to the four-digit level. OKVED/NACE 1.0 is referred to as "the New industrial classification."

[14]Corresponding methodology was developed by Eduard Baranov and Vladimir Bessonov and implemented for backcast estimations of industrial output for the Ministry of Economic Development of the Russian Federation (Bessonov *et al.*, 2008). A detailed description of this methodology is available in Bessonov (2005).

[15]Preferably an adjustment for labor quality was made as well, but this data is not readily available at the industry level. Thus the labor composition effect will be covered in measured MFP.

[16]In Russian—*Balans zatrat truda.* Its description and methodology are available in Rosstat (2006).

[17]In Russian—*Balans trudovykh resursov.*

[18]In Russian—*Polnyĭ krug organizatsiĭ*. Its comprehensive definition and description are available in Vishnevskaya *et al.* (2002).

and small firms as well as various public administration organizations. The BLF is the oldest system of labor accounts and used to be part of the MPS. It is based on FC with additional estimations for the 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 Labor Inputs. Before 2003, trends in BLF and FC at the corresponding industries were applied. BLF and FC measure number of employees, and we have to assume that employee growth proxies for growth in hours. Details on the construction of labor series can be found in Voskoboynikov (2012, section 4).

Previous studies use estimations of the number of workers from BLF. But before 2003, the BLF is inconsistent with the NAS as it does not cover self-employment in agricultural husbandries. This mostly informal activity in Agriculture is about one fifth of the total amount of FTE jobs in the Russian economy. An imputation for value added made in the NAS GDP such that any measure of aggregate productivity based on official statistics, is biased. Following Poletayev (2003), we assume zero 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.[19]

The shares of labor and capital in value added are used as weights in the growth accounting methodology and reflect the output elasticity of the inputs. The labor share should reflect the total cost of labor from the perspective of the employer, and hence include wages but also non-wage benefits for employees and an imputed wage for self-employed workers. In Russia there is a longstanding tradition of non-wage payments. This is well known, and Rosstat makes estimates which are included in the total economy series of the NAS, but not in the industry statistics. This is why the industry-level NAS series on labor compensation underestimate cost shares for labor. For the total economy in 1995–2008 this underestimation is substantial and varies between 11 and 17 percent (Voskoboynikov, 2012, A.T11). Bessonov (2004) argued that given the low accuracy of official imputations of hidden wages, using these shares would not make growth accounting estimations more precise. Previous studies therefore resorted to an alternative share, mostly taking a fixed 0.6 or 0.7 as the labor share, which is assumed to be typical for developed economies (Gollin, 2002), or getting them from econometric estimations (Kuboniwa, 2011). Instead we develop new measures of labor compensation at a detailed industry level by using official imputations on shadow wages and value added made by Rosstat. These are added to official labor compensation of employees and value added from the NAS. For 2002 and consecutive years the overall amount of hidden wages at the overall economy level has been allocated among industries in proportion to the industry value added share of shadow activities taken from official imputations.[20] For years before 2002 the hidden wages were allocated in proportion to the industry distribution of shadow value added of 2002. Finally our estimate of labor income of the self-employed is

[19]A detailed description of the model is available in the appendix of Voskoboynikov (2012). Kapeliushnikov (2006) suggested an alternative approach for imputations of labor costs in non-market households for years before 1999 on the basis of changes of the area of plowing.

[20]Data are available in official publications—see Rosstat (2010, tables 2.3.46–2.3.53).

added. For all industries except Agriculture it was assumed that the hourly earnings of the self-employed are the same as those of 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 Russia Longitudinal Monitoring Survey.[21] Further details can be found in Voskoboynikov (2012, section 6).

3.2. *Capital Input Series*

One of the most difficult problems in doing growth accounting for economies that were formerly centrally planned 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 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 by eight asset types to measure capital input based on the perpetual inventory method (PIM): computing equipment, communication equipment, software, residential structures, non-residential structures, machinery and equipment, transport, and other assets.[22] For each individual asset, stocks have been estimated on the basis of investment series using the perpetual inventory method (PIM) with geometric depreciation profiles. According to the 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:

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

with $S_{k,T}$ the capital stock (for a particular 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 we get $\partial_{k,t} = (1 - \delta_k)^{t-1}$, and:

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

If it is assumed that the flow of capital services from each asset type k (K_k) is proportional to the average of the stock available at the end of the current and the

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

[22]In Russian: *vychislitel'naia tekhnika; informatsionnye mashiny, ne vkliuchaia vychislitel'nuiu tekhniku; nematerial'nye aktivy; zhilishcha; zdaniia, sooruzheniia i peredatochnye ustroĭstva; transportnye sredstva; silovye i rabochie mashiny;* and *prochie aktivy.*

prior period ($S_{k,T}$ 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 the average shares of each asset 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 and but becoming idle after transition due to the changing patterns of production and consumption. This stock has no market value anymore but is however still present in official capital stock statistics. Related to this is the question whether and how capital input measures should be adjusted for changes in capital utilization 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, a proper choice of alternative investment deflators needs to be made.

There are two main sources for official data on investment and capital stock in constant prices in Russia. The first is the Balance of Fixed Assets (BFA),[23] which covers the total economy (Bratanova, 2003). This provides capital stocks based on direct observations of firm balance sheets in the current year—previous year stocks plus new acquisitions minus discards. Imputations for firms without a balance sheet are also made. 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 prefer to build up their own estimates through the perpetual inventory method and use the stock estimate only as a benchmark estimate for the initial year of the series. Investments series are taken from the series of gross fixed capital formation (GFCF) from the NAS, which are available in current and constant prices. This is the approach followed by Kuboniwa (2011) and Izyumov and Vahaly (2008), both using aggregate investment data with a depreciation rate of 1.8 and 5 percent, 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 about 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 however 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 1991–96, prices on investment goods grew much faster than the overall level of

[23]In Russian: *balans osnovnykh fondov po polnoĭ stoimosti v postoiannykh tsenakh*. The Russian statistics also develop the Net Balance of Fixed Assets (*balans osnovnykh fondov po ostatochnoĭ stoimosti v tekushchikh tsenakh*), which includes net capital stocks and depreciation. However, data on net capital stocks in constant prices are not available.

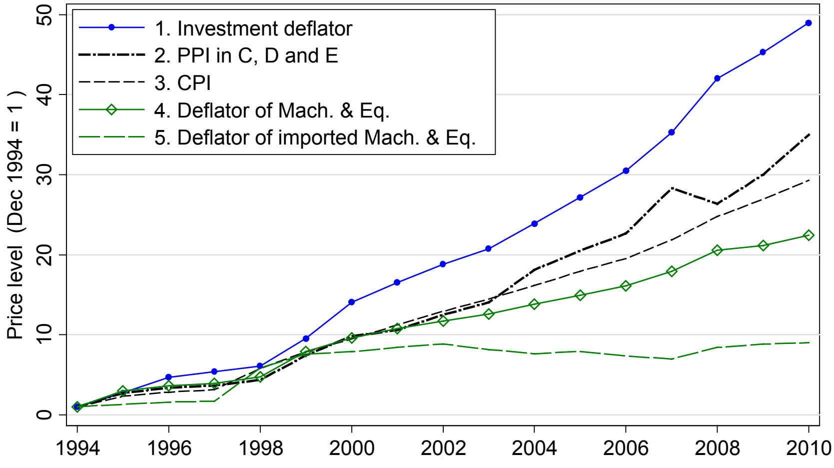


Figure 2. Alternative Investment Deflators

Notes: Price level measured by investments deflator from NAS (1); producer price index in manufacturing (2); consumer price index (3); price index on machinery and equipment from BFA (4); price index on imported machinery and equipment (5). The price index on imported machinery and equipment captures price changes on imported machinery from the perspective of a Russian domestic purchaser. It has been 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 VĖD Rossii; Mashiny i oborudovanie*) available in Rosstat (2012), producer price index on machinery and equipment of the U.S. Bureau of Labor Statistics (BLS, 2012) and yearly averaged exchange rates of U.S. dollars to Russian rubles of the Central Bank of Russia. This approach is based on the assumption that prices on imported equipment in a foreign currency change in the same way as corresponding prices in the U.S.

Source: 1–4: *Rosstat* (see details in Section 3); 5: own calculations.

prices in the economy. However, this is very unlikely because typically investment price indices are falling relative to the overall price levels (Greenwood *et al*., 1997). Furthermore, Bratanova (2003, 4.40) has pointed out the overestimation of prices on investment in Russian statistics. This is clearly shown in Figure 2 which provides the developments of a number of Russian price series. As prices changes are overestimated, real investments are underestimated, and likewise the growth rate of capital stocks.

Our solution to deal with these problems is to build up stocks from 1995 with a PIM using new investment deflators and asset-specific deprecation 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.[24] 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 called "Form F11," which is part of the

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

BFA.[25] 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.[26] We use the price index of construction works for deflation of investment in residential and non-residential structures; and the index on machinery and equipment, and the overall investment price index for the remaining types of assets (Rosstat, 2002, 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 on prices of imported equipment and vary for different types of assets. 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).[27] The transformation of initial stocks and investment series from the Old to the New classification was accomplished with the detailed official (unpublished) bridge for investments.

While popular with many researchers, the use of capacity utilization rates to correct for capital utilization 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 on the basis of the value of output for 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 Barometer[28] survey (about 500 manufacturing firms), used in Kuboniwa (2011). Two other similar surveys are from the Institute of Economic Policy and the Centre for Economic Analysis (both cover around 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* utilization as opposed to measures of *capital* utilization. Also it is doubtful that they also include utilization rates of "communist capital," and likely refer only to the capital that is potentially useful for production.[29] Our solution to deal with the capacity utilization problem is through the implementation of internal ex-post rates of return in calculations of capital services (see previous section). This way increases in capital utilization are reflected in an increasing internal rate of return rather than through an adjustment of the physical capital stock measures.

[25]Detailed data of survey F11 are issued by Rosstat in yearly internal publications *Otchet o nalichii i dvizhenii osnovnykh sredstv i drugikh 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). A detailed description of the survey in Russian statistics of capital in English is given by Bratanova (2003).

[26]Russian terms: *indeks tsen proizvoditeleĭ v stroitel'stve; indeks tsen na stroitel'no-montazhnye raboty; indeks tsen na mashiny i oborudovanie v sostave investitsiĭ v osnovnoĭ kapital*.

[27]However, for sensitivity analysis we also used rates on the basis of a survey of services lives, provided by Rosstat in 2008. Results of the growth accounts appear to be barely affected.

[28]http://www.ecsoc.ru/en/reb/

[29]See Beaulieu and Mattey (1998) for an overview of various approaches to measuring capital utilization.

TABLE 1

Value Added Decomposition for Market Economy in Case in 1995–2008 (various alternatives)

	1	2	3	4	5	6	7
Labor share of value added (%)	70.0	70.0	70.0	52.3	52.3	52.3	63.9
Growth rates							
Value added	4.82	4.82	4.82	4.82	4.82	4.82	4.82
Labor	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 and 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
Contributions to value added							
Value added	4.82	4.82	4.82	4.82	4.82	4.82	4.82
Labor	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 and 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 labor 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 labor 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.
7 As 5 but capital services with external rate of return.

Source: Authors' calculations based on value added and labor from Voskoboynikov (2012); official capital stock from Rosstat (http://cbsd.gks.ru/; accessed May 31, 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).

4. Growth Accounting Results

In this section we describe the main results from the industry-level growth accounting using the constructed dataset discussed above. Before we do that we first discuss how aggregate economy estimates of MFP growth in Russia depend on the various assumptions made in the literature compared to our choices. This will illustrate the empirical relevance of our new measures of capital input and labor shares.

4.1. *Aggregate Economy Growth Accounting Alternatives*

In Table 1 we provide various alternative ways for a decomposition of value added growth in the Russian market economy for the period 1995 to 2008.[30] Value added growth and labor input growth are kept the same in all alternatives in order to focus on the impact of alternative estimates for capital input and labor shares in

[30]The market economy is defined as all sectors excluding public administration, education, and health and social work. This collection of industries we call the market sector, which does not necessarily mean that all activities in this set are fully market based, nor that all activities in the excluded sectors are non-market. But it is a useful way of grouping industries, particularly since we know that in the "non-market" sectors output and hence productivity measurement is difficult (see Schreyer, 2012).

value added. We start with a decomposition in which capital input growth is based on the official net capital stocks from Rosstat and assuming a labor share of 70 percent, as in the bulk of the growth accounting literature for the Russian economy.[31] In this alternative, MFP growth explains 3.6 percentage points out of 4.8 percent growth in value added, which supports the idea that Russian growth has been mainly productivity-based since the mid-1990s.

A second alternative is provided in the second column of Table 1. Here capital input growth is based on a combination of the official capital stock in 1995 and a PIM method for the years after using real investment from the NAS and a 5 percent 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 growing too fast, and consequently, capital stocks are growing too slow. Indeed, in this alternative there is barely growth in aggregate capital stock (0.2 percent), and the stock of non-residential buildings even declined by 1.7 percent annually. In Jorgenson and Vu (2010, table 2), capital input is even declining over this period. As a result, estimated MFP is even higher than in the first alternative (3.9 percent).

If we use alternative deflators that seem more in line with other price developments in the Russian economy, capital stocks are growing for all asset types and capital input growth is estimated at 2.9 percent annually. In this third alternative, MFP growth is lower than in the previous ones at 3.1 percent (see Table 1). As discussed above, the assumption of a labor share of 0.7 is common for developed economies, but not necessarily valid for a transition economy like Russia. In alternative 4 we use a labor 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 labor is much lower and at 52 percent of value added. Hence the output elasticity of capital is estimated to be higher, and given that capital input is growing faster than labor input, estimated MFP is falling to 2.6 percent.

Further improvements to the data can be made. In alternative 5, we replace the common 5 percent depreciation rates on all assets by asset specific rates from Fraumeni (1997). For buildings this rate will be lower than five, while for machinery and especially ICT it will be much higher. Consequently, the growth rates of buildings stock should go up and of machinery should go down, as shown in column 5. The impact on aggregate capital stock growth is minor however and estimated MFP is 2.7 percent. 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 greater 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 percent annually, explaining 53 percent of value added growth in the market

[31]De Broeck and Koen (2000), Dolinskaya (2001), Bessonov (2004), Rapacki and Próchniak (2009), Jorgenson and Vu (2010), and Entov and Lugovoy (2013).

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
High-skill intensive	3.6	3.6	3.92
Low-skill intensive	22.0	14.8	2.72
Services	40.4	41.0	5.82
High-skill intensive	5.1	11.2	10.70
Low-skill intensive	35.3	29.8	4.60
Non-market services	13.9	16.0	3.41

Source: Authors' calculations, see main text.

economy over the period 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 (see last column in Table 1). 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 investment flows are opaque, this data is neither readily available, nor easy to interpret. We therefore choose a real rate of return of 4 percent and recalculate the labor 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 percent.

4.2. *Changing Structure of the Russian Economy*

The literature that deals with structural change of the Russian economy typically explores a traditional division of activities into agriculture, industry, and services. This partition of the economy is useful for analyzing structural change in developing economies where the majority of workers are still in primary industries, but is unsuited for studies of Russian development. Russia passed the first stage of industrialization in the first half of the twentieth century and had a sizeable 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 based on the skill-intensity of production, distinguishing between high-skilled and low-skilled goods production and services, and we follow this. 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

TABLE 3
Average Growth Rates of Inputs and MFP in 1995–2008

	Annual Real Growth Rates (%)			Contribution to Total (percentage points)		
	Labor Input	Capital Input	MFP	Labor 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
High-skill intensive	–2.54	–0.18	5.57	–0.11	–0.01	0.23
Low-skill intensive	–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
High-skill intensive	1.20	2.78	8.97	0.11	0.27	0.86
Low-skill intensive	1.85	4.20	1.69	0.71	1.61	0.65
Non-market services	2.67	3.35	0.84	0.70	0.88	0.22

Sources: Authors' calculations, see main text.

system in the industry Mining, but also in some sub-industries of Wholesale Trade, Inland Transport, and Fuel. For example, the World Bank (2005) report and Gurvich (2004) 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 grouping together mining and wholesale distribution[32] and find that its share has been growing from around one fifth of total GDP in 1995 to almost a quarter in 2008.

Production of goods other than mining products declined rapidly in importance from 26 to 18 percent in 2008. While high-skill intensive manufacturing industries such as chemicals and electrical equipment remained relatively stable but small (4 percent), value added in agriculture, textiles, metal, and plastics declined rapidly. The share of market services remained more or less constant at 40 percent of GDP, but structural change within this sector was high. 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 percent in 2008. This is a reflection of the catching up process of 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).

4.3. *Sectoral Contribution to Aggregate Input and Productivity Growth*

The productivity performance of the various sectors of the Russian economy has been quite diverse. In Table 3 (left hand side) we provide the annual growth

[32]This will overestimate the size of the energy sector, as it also includes wholesaling activities that are not related to energy.

rates of labor and capital input and MFP growth for the main sectors in Russia from 1995 to 2008. MFP is calculated by subtracting weighted input growth from value added growth as shown in equation (4). Capital input has been 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 industries, in particular in finance and business services. While their labor and capital inputs grew at rates comparable to the market economy as a whole, MFP growth for skill-intensive services was almost 9 percent per year, which is more than 6 percentage points higher than the economy as a whole. This is a remarkable rate 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 (Fernandes, 2009).[34] Using industry specific purchasing power parities (PPPs) it is possible to compare the level of productivity in Russia with other countries in 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 percent 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 with Germany is still 49 percent, leaving plenty of room for further catching-up.

MFP growth was also fast for high-skilled manufacturing, at 5.6 percent annually, and this could potentially be a major source of growth for Russia. But it appeared that MFP growth was mainly due to a severe rationalization of the sector in the wake of increased competition from advanced nations as Russia opened up to international trade in high-tech in the 1990s. Capital input growth was negative, and especially labor declined rapidly, so this sector is now less than 4 percent GDP and has ceased to be an important source of growth.

In contrast, labor and in particular capital inputs gravitated toward low-skill intensive services and the mining sector. Together these two sectors more than fully "explain" aggregate labor input growth, and are responsible for 2.5 percentage points out of 2.9 percent growth in aggregate capital input. But while input growth rates were high, MFP growth rates were far below average. In low-skill intensive services average MFP growth was 1.7 percent, and in Mining only 0.8 percent, such that they are together responsible for only 0.9 percentage points out of 2.6 percent aggregate MFP growth.

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

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

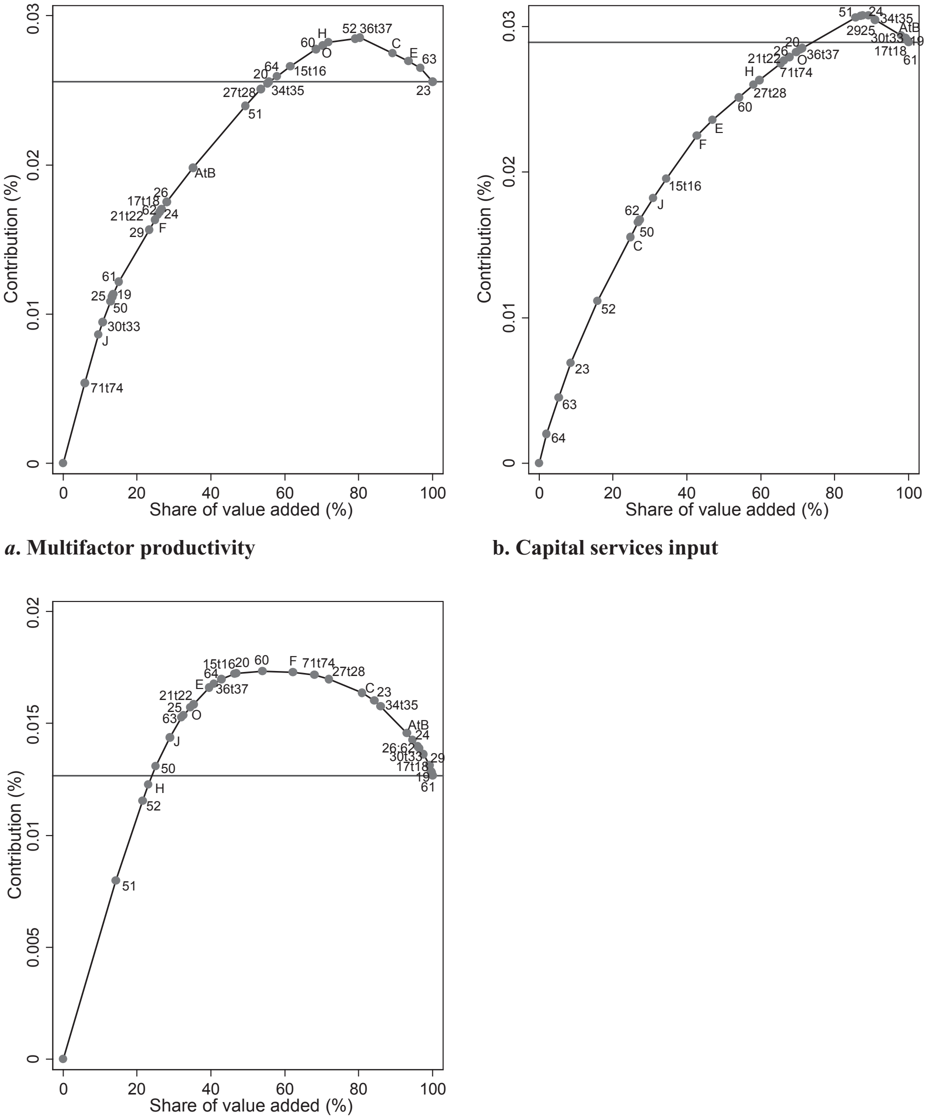
[34]For Russia the underdevelopment of trade, banking, and insurance industries, given its level of GDP per capita, is discussed in Gregory and Stuart (2001, p. 368).

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 the-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: 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 summed share of value added of all industries which demonstrate 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, with the value being lower when the growth pattern is more broad-based and observed in many industries. On the other hand, if growth is more concentrated in few industries, the value will be higher.

The Harberger diagrams are given in Figure 3 for MFP, capital, and labor input growth. For capital input we find that the value added share of industries with positive growth rates is 89.2 percent 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, together contributing half of the aggregate growth. Negative growth rates are found in industries of material production such as textiles, and electrical and transport equipment, and in particular for Agriculture. Growth in labor input is much less widespread in the economy. The value added share of industries with positive labor input growth is just above half. And the curvature is much higher than for capital at 0.54. Labor 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 widely spread across industries than capital input growth. The value added share of industries with positive growth rates is 80.3 percent 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 in skill-intensive manufacturing from Germany and other EU countries that were building up widely dispersed production chains across Europe. This was an important driver of productivity growth in the Czech Republic, Hungary, and the Slovak Republic (Havlik *et al.*, 2012), for example.

Retailing is one of the industries that are growing fast in terms of inputs, but its MFP growth 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 labor-intensive, mostly informal,



a. **Multifactor productivity**

b. Capital services input

c. Labour input

Figure 3. Harberger Diagrams of Input and Productivity Growth in 1995–2008

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

retail shops run by families. The retail sector in the Soviet Union was lagging for a long time. Starting from the middle of 1990s, Russia has experienced an explosive growth of modern retail centers, and in 2009 they had captured 35 percent of total retail sales (McKinsey, 2009, p. 65), both through FDI and expansion of domestic retail chains. But this expansion has not yet lead to increased MFP.

5. Concluding Remarks

GDP per capita growth rates in Russia have been amongst the highest in the world since the mid-1990s. In contrast to previous growth accounting studies, we do not find that this is mainly driven by MFP growth. Rather, labor and capital input growth explain about as much of the value added growth during the period 1995–2008 as 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 labor and capital inputs, but had only poor 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 were the only industries that performed well in terms of MFP growth and were expanding. But as their MFP levels were extremely low in the mid-1990s, much of this growth is of some 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 provide hopeful signs for future economic development.

Although we believe that the dataset developed for this paper is of a higher quality than what is currently available from official sources or otherwise, there is still much to be improved upon. 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 with 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 that is currently underway is expected to be helpful in that respect (the most recent one is of 1995), as is the development of new price deflators that take quality change into account. With respect to capital, investment price indices that properly account for imported equipment and quality changes (e.g., for ICT capital) would be helpful. As shown, some of these indices are used by Rosstat in deflation of capital stocks, but not for investment series. Better measurement of labor costs and profits by industry (where activities of large vertically integrated firms are allocated to the various industries) would also be useful for analysis of changes in industrial structure.

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 for the case of Russia where market competition is still limited. Furthermore, the issue of how to deal with capital utilization variation cannot be complete 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 into the sources of growth in Russia, relying on other non-parametric or parametric approaches.

Appendix: List of Sectors and Industries

NACE 1.0 Code	Name of Sector/Industry Used in the Paper
	Total economy
	Market economy
	Goods
	High skill-intensive
24	Chemicals and chemical products
29	Machinery, nec
30t33	Electrical and optical equipment
	Low skill-intensive
AtB	Agriculture, hunting, forestry, and fishing
15t16	Food, beverages, and tobacco
17t18	Textiles and textile products
19	Leather, leather, and footwear
20	Wood and products of wood and cork
21t22	Pulp, paper, paper, printing, and publishing
25	Rubber and plastics
26	Other non-metallic mineral
27t28	Basic metals and fabricated metal
34t35	Transport equipment
36t37	Manufacturing, nec; recycling
	Market services
	High skill-intensive
J	Financial intermediation
71t74	Renting of machinery and equipment and other business activities
	Low skill-intensive
E	Electricity, gas, and water supply
F	Construction
H	Hotels and restaurants
50	Sale, maintenance and repair of motor vehicles and motorcycles; retail
52	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods
60t63	Transport and transport services
64	Post and telecommunications
O	Other community, social and personal services
	Extended mining
23	Fuel
C	Mining and quarrying
51	Wholesale trade
	Non-market economy
70	Real estate activities
L	Public administration and defense; compulsory social security
M	Education
N	Health and social work

References

Balk, B. M., "An Assumption-Free Framework for Measuring Productivity Change," *Review of Income and Wealth*, 56, S224–56, 2010.

Basu, S. and J. Fernald, "Why is Productivity Procyclical? Why do we Care?" in C. R. Hulten, E. R. Dean, and M. J. Harper (eds), *New Developments in Productivity Analysis*, University of Chicago Press, Chicago and London, 225–301, 2001.

Beaulieu, J. J. and J. Mattey, "The Workweek of Capital and Capital Utilization in Manufacturing," *Journal of Productivity Analysis*, 10, 199–223, 1998.

Berndt, E. R. and M. A. Fuss, "Productivity Measurement with Adjustments for Variations in Capacity Utilization and Other Forms of Temporary Equilibrium," *Journal of Econometrics*, 33(1–2), 7–29, 1986.

Bessonov, V. A., "O Dinamike Sovokupnoĭ Faktornoĭ proizvoditel'nosti v Rossiĭskoĭ Perekhodnoĭ Ėkonomike [on Dynamics of Total Factor Productivity in the Russian Economy in Transition]," *HSE Economic Journal*, 8, 542–87, 2004.

———, *Problemy Analiza Rossiĭskoĭ Makroėkonomicheskoĭ Dinamiki Perekhodnogo Perioda [Problems of the Analysis of Macroeconomic Dynamics of the Russian Economy in Transition]*, Institut Ėkonomiki Perekhodnogo Perioda, Moscow, 2005.

Bessonov, V. A. and I. B. Voskoboynikov, "Fixed Capital and Investment Trends in the Russian Economy in Transition," *Problems of Economic Transition*, 51(4), 6–48, 2008.

Bessonov, V. A., I. B. Voskoboynikov, E. V. Dryabina, I. A. Kim, and A. N. Ponomarenko, "On Findings of Preliminary Study of RU-KLEMS," Background Paper for the RU KLEMS Workshop in Higher School of Economics, Moscow, March 31, 2008.

BLS, "Producer Price Index Commodity Data. Group 11. Item 11. Machinery and Equipment," Bureau of Labor Statistics (http://www.bls.gov/data/#prices), 2012.

Bratanova, L., "Measurement of Capital Stock in Transition Economies", Occasional Paper 2003/1, United Nations Economic Commission for Europe, Statistical Division, 2003.

Campos, N. F. and F. Coricelli, "Growth in Transition: What We Know, What We Don't, and What We Should," *Journal of Economic Literature*, 40, 793–836, 2002.

Connolly, R., "Climbing the Ladder? High-Technology Export Performance in Emerging Europe," *Eurasian Geography and Economics*, 53, 356–79, 2012.

De Broeck, M. and V. Koen, "The Great Contradictions in Russia, the Baltics and the Other Countries of the Former Soviet Union: A View from the Supply Side," IMF Working Paper, WP/00/32, 2000.

Diewert, W. E., "What is to be Done for Better Productivity Measurement," *International Productivity Monitor*, 16, 40–52, 2008.

Dolinskaya, I., "Explaining Russia's Output Collapse: Aggregate Sources and Regional Evidence," IMF Working Paper, WP/01/16, 2001.

Entov, R. M. and O. V. Lugovoy, "Growth Trends in Russia After 1998," in M. Alexeev and S. Weber (eds), *The Oxford Handbook of the Russian Economy*, Oxford University Press, Oxford, 132–60, 2013.

Fernandes, A. M., "Structure and Performance of the Service Sector in Transition Economies," *Economics of Transition*, 17, 467–501, 2009.

Fraumeni, B., "The Measurement of Depreciation in the U.S. National Income and Product Accounts," *Survey of Current Business*, July, 7–23, 1997.

Gollin, D., "Getting Income Shares Right," *Journal of Political Economy*, 110, 458–74, 2002.

Greenwood, J., Z. Hercowitz, and P. Krusell, "Long-Run Implications of Investment-Specific Technological Change," *American Economic Review*, 87, 342–62, 1997.

Gregory, P. R. and R. C. Stuart, *Russian and Soviet Economic Performance and Structure*, 7th edn, Addison-Wesley, Boston, MA, 2001.

Gurvich, E., "Makroėkonomicheskaia Otsenka Roli Rossiĭskogo Neftegazovogo Kompleksa [Macroeconomic Role of Russia's Oil and Gas Sector]," *Voprosy Ėkonomiki*, 10, 4–31, 2004.

Harberger, A. C., "A Vision of the Growth Process," *American Economic Review*, 88, 1–32, 1998.

Havlik, P., S. Leitner, and R. Stehrer, "Growth Resurgence, Productivity Catching-Up and Labor Demand in Central and Eastern European Countries," in M. Mas and R. Stehrer (eds), *Industrial Productivity in Europe. Growth and Crisis*, 219–63, 2012.

Hulten, C. R., "Productivity Change, Capacity Utilization and the Sources of Efficiency Growth," *Journal of Econometrics*, 33, 31–50, 1986.

Inklaar, R. and M. P. Timmer, "Of Yeast and Mushrooms: Patterns of Industry-Level Productivity Growth," *German Economic Review*, 8, 174–87, 2007.

———, "The Relative Price of Services," *Review of Income and Wealth* (doi: 10.1111/roiw.12012), 2012.

Iradian, G., "Rapid Growth in Transition Economies: Growth-Accounting Approach," IMF Working Paper, WP/07/164, 2007.

Ivanov, Y., "Possibilities and Problems of Reconciliation of the SNA and the MPS," *Review of Income and Wealth*, 33, 1–18, 1987.

———, "Experiences and Problems of the CIS Countries in Transition from the MPS to the SNA," *Review of Income and Wealth*, 55, 466–84, 2009.

Ivanov, Y., B. Rjabushkin, and T. Homenko, "Introduction of the SNA into the Official Statistics of the Commonwealth of Independent States," *Review of Income and Wealth*, 39, 279–94, 1993.

Izyumov, A. and J. Vahaly, "Old Capital vs. New Investment in Post-Soviet Economies: Conceptual Issues and Estimates," *Comparative Economic Studies*, 50, 111–57, 2008.

Jorgenson, D. W. and K. M. Vu, "Potential Growth of the World Economy," *Journal of Policy Modeling*, 32, 615–31, 2010.

Jorgenson, D. W. and M. P. Timmer, "Structural Change in Advanced Nations: A New Set of Stylised Facts," *Scandinavian Journal of Economics*, 113, 1–29, 2011.
Jorgenson, D. W., F. M. Gollop, and B. Fraumeni, *Productivity and U.S. Economic Growth*, North-Holland, Amsterdam, 1987.
Jorgenson, D. W., M. S. Ho, and K. J. Stiroh, *Information Technology and the American Growth Resurgence*. *Productivity*, Vol. 3, MIT Press, Cambridge, MA, 2005.
Kapeliushnikov, R. I., "Zaniatost' v Domashnikh Khoziaĭstvakh Naseleniia [Employment in Households]," in V. E. Gimpelson and R. I. Kapeliushnikov (eds), *Nestandartnaia Zaniatost' v Rossiĭskoĭ Ėkonomike [Atypical Employment in the Russian Economy]*, Gosudarstvennyĭ universitet—Vysshaia shkola ėkonomiki, Moscow, 224–80, 2006.
Krugman, P., "The Myth of Asia's Miracle," *Foreign Affairs*, 73(6), 62–78, 1994.
Kuboniwa, M., "The Russian Growth Path and TFP Changes in Light of Estimation of the Production Function using Quarterly Data," *Post-Communist Economies*, 23, 311–25, 2011.
Masakova, I. D., "Recalculation of the Russian GDP Series in Connection with the Transition to New Classifications," Joint UNECE/Eurostat/OECD/ Meeting on National Accounts and Update of SNA, 8th Meeting, April 25–28, ECE/CES/GE.20/2006/3 (http://www.unece.org/fileadmin/DAM/stats/documents/ece/ces/ge.20/2006/mtg2/3.e.pdf), 2006.
McKinsey, *Lean Russia: Sustaining Economic Growth through Improved Productivity*, McKinsey Global Institute, 2009.
McMillan, M. and D. Rodrik, "Globalization, Structural Change, and Productivity Growth," NBER Working Paper Series 17143, 2011.
Ofer, G., "Soviet Economic Growth: 1928–1985," *Journal of Economic Literature*, 25, 1767–833, 1987.
O'Mahony, M. and B. van Ark, *EU Productivity and Competitiveness: An Industry Perspective*, European Commission, 2003.
O'Mahony, M. and M. P. Timmer, "Output, Input and Productivity Measures at the Industry Level: The EU KLEMS Database," *Economic Journal*, 119(538), F374–403, 2009.
Oomes, N. and O. Dynnikova, "The Utilization-Adjusted Output Gap: Is the Russian Economy Overheating?" IMF Working Paper, WP/06/68, 2006.
Oulton, N., "Ex Post Versus Ex Ante Measures of the User Cost of Capital," *Review of Income & Wealth*, 53, 295–317, 2007.
Poletayev, A. V., "Ėffektivnost' Funktsionirovaniia Rossiĭskogo Rynka Truda [Efficiency of Labor Market in Russia]," HSE Working Paper, WP3/2003/06, 2003.
Ponomarenko, A. N., *Retrospektivnye Natsional'Nye Scheta Rossii: 1961–1990 [Retrospective Russian National Accounts in 1961–1990]*, Finansy i statistika, Moscow, 2002.
Rapacki, R. and M. Próchniak, "Economic Growth Accounting in Twenty-Seven Transition Countries, 1990–2003," *Eastern European Economics*, 47(2), 69–112, 2009.
Rosstat, *Otraslevaia Klassifikatsiia Otrasleĭ Narodnogo Khoziaĭstva [Statistical Classification of Industries of the National Economy]*, Gosudarstvennyĭ komitet SSSR po statistike, Moscow, 1976.
———, *Metodicheskie Polozheniia Po Statistike. Vyp. 1 [Methodological Regulations on Statistics, Vol. 1]*, Gosudarstvennyĭ komitet Rossiĭskoĭ Federatsii po statistike, Moscow, 1996.
———, *Metodicheskie Rekomendatsii Po Nabliudeniiu Za Tsenami Proizvoditeleĭ v Stroitel'Stve [Manual for Measurement of Producer's Prices in Construction]*, Gosudarstvennyĭ komitet Rossiĭskoĭ Federatsii po statistike, Moscow, 2002.
———, *Metodicheskie Polozheniia Po Statistike. Vyp. 4 [Methodological Regulations on Statistics, Vol. 4]*, Gosudarstvennyĭ komitet Rossiĭskoĭ Federatsii po statistike, Moscow, 2003.
———, *Metodicheskie Polozheniia Po Statistike. Vyp. 5 [Methodological Regulations on Statistics, Vol. 5]*, Federal'naia sluzhba gosudarstvennoĭ statistiki, Moscow, 2006.
———, *Investitsii v Rossii 2009 [Investments in Russia 2009*, Federal'naia sluzhba gosudarstvennoĭ statistiki, Moscow, 2009.
———, *Natsional'nye Scheta Rossii v 2002–2009 Godakh [National Accounts of Russia in 2002–2009]*, Federal'naia sluzhba gosudarstvennoĭ statistiki, Moscow, 2010.
———, "Tsentral'naia Baza Statisticheskikh Dannykh [the Central Database of Statistical Data]," Federal'naia sluzhba gosudarstvennoĭ statistiki (http://www.gks.ru/dbscripts/Cbsd/DBInet.cgi; accessed January 26, 2012), 2012.
Schreyer, P., *OECD Productivity Manual: A Guide to the Measurement of Industry-Level and Aggregate Productivity Growth*, OECD, Paris, 2001.
———, *Measuring Capital. OECD Manual. Measurement of Capital Stock, Consumption of Fixed Capital and Capital Services*, 2nd edn, OECD, Paris, 2009.
———, "Output, Outcome, and Quality Adjustment in Measuring Health and Education Services," *Review of Income and Wealth*, 58, 257–78, 2012.

Vishnevskaya, N. T., V. E. Gimpelson, S. V. Zaharov, R. I. Kapeliushnikov, T. I. Korshunova, P. M. Kudiukin, T. M. Maleva, and A. V. Poletayev, *Obzor Zaniatosti v Rossii. Vyp. 1 (1991–2000 Gg.) [Employment Survey in Russia, Issue 1, 1991–2000]*, TEIS, Moscow, 2002.
Voskoboynikov, I. B., "New Measures of Output, Labor and Capital in Industries of the Russian Economy," GGDC Research Memorandum GD-123, 2012.
Voskoboynikov, I. B. and E. V. Dryabina, "Otraslevaia Istoricheskaia Statistika Osnovnykh Fondov Rossiĭskoĭ Promyshlennosti (1970–2004). Dannye i Istochniki [Historical Time Series Data of Fixed Capital of the Russian Economy. Manufacturing (1970–2004). Data and Sources]," HSE Working Paper, WP2/2009/03, 2009.
World Bank, "Russian Federation: From Transition to Development", a Country Economic Memorandum for the Russian Federation, March 2005.
Young, A., "The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience," *Quarterly Journal of Economics*, 110, 641–80, 1995.
———, "Gold into Base Metals: Productivity Growth in the People's Republic of China during the Reform Period," *Journal of Political Economy*, 111, 1220–61, 2003.