Intermediate goods and Russian growth in 2003-2018

Eduard Baranov, Dmitri Piontkovski, Aleksandr Roskin, Anton Tolokonnikov, Ilya Voskoboynikov

All – HSE University

15 September 2022

Paper in progress

Abstract

Although sources of Russian growth have been widely discussed in the literature, the role of intermediate inputs remains uncertain. The present paper has attempted to fill this gap. It has shown the increasing role of materials in Russian growth, especially after 2014. Accounting for the shift in relative prices with double deflation changes TFP trends in industries substantially, which highlights importance of inputs for understanding Russian growth. Finally, integration of intermediate inputs into Russia KLEMS framework does not change general observation on TFP slowdown in 2010-s in comparison with the previous decade.

JEL: O47

1. Introduction

VA-based industry growth accounting is a conventional and powerful tool for understanding the origins of global productivity slowdown (Esfahani, Fernald, and Hobijn 2020). This framework indicates this slowdown in Russia as well, which started before the global financial crisis of 2008 (Voskoboynikov 2017). At the same time, intermediate inputs can also shed some light on the role of intermediate inputs in growth performance. What is the role if intermediate inputs in this stagnation in stagnation of the Russian economy in 2010-s, considering its dependence on oil and gas?

Productivity growth in a certain economy is driven by global and country-specific factors. In case of Russia, in early transition country-specific drivers dominated. Starting from early 2000-s the role of global factors increased. Indeed, the initial transformational recession, caused mostly by disorganization (Ickes 2018), led to the fall of productivity. In 2000-s newly established market economy institutions, as well as increasing integration to the global economy started playing a role. These are, among others, access to global financial markets, FDI inflow, increasing role of Russian firms in global value chains, positive impact of ICT revolution, and convergence of some sectors with the initial low productivity level.

The literature considers various factors of Russian growth pattern since early 1990-s. These are productivity and disorganization (Blanchard 1997), the role of labor, capital, labor quality and labor reallocation in Russian industries (Timmer and Voskoboynikov 2014) and the Russian economy in the comparative perspective with OECD economies and BRIC (Vries et al. 2012). TFP slowdown started in mid-2000-s (Voskoboynikov 2017). Taking into account the large share of value added (20-25% of market economy), the role of productivity fall in oil and gas contributes to aggregate productivity growth substantially.

In this context, little is known about the role of intermediate inputs. The present paper aims to fill this gap, introducing newly developed series of intermediate inputs for the Russian economy in NACE 1 (1995-2016) and NACE 2 (2011-2019). Using conventional Jorgensonian (Jorgenson, Gollop, and Fraumeni 1987) approach to growth accounting, the paper shows that the role of materials increased after 2008, the VA-based growth accounting decomposition, widely used in the literature, seems to be sensitive to the double deflation procedure. However, productivity slowdown in 2010-s remains substantial, which highlights the important role of drivers of global productivity slowdown for the explanation of Russia's growth pattern.

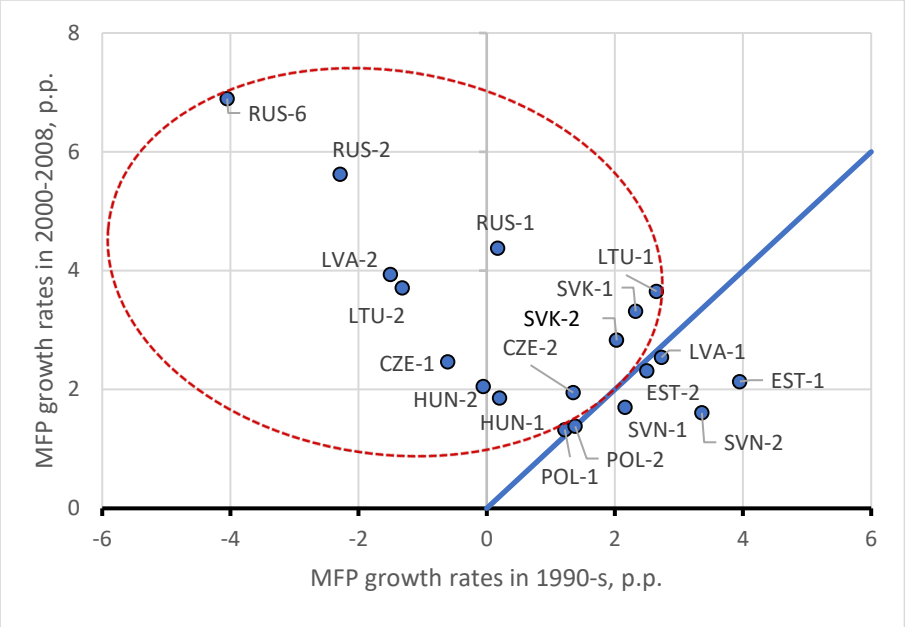
The paper starts from some backgrounds, which provide the long run view on productivity trends in Russia in comparison with other economies in transition in 2000-s – 2010-s. The third section suggests data and methodology approach. The fourth section discusses results for total economy, using

VA-based growth accounting, and for some industries, comparing GO and VA-based growth accounting decompositions. Conclusion summarizes results and highlights directions for the ongoing research.

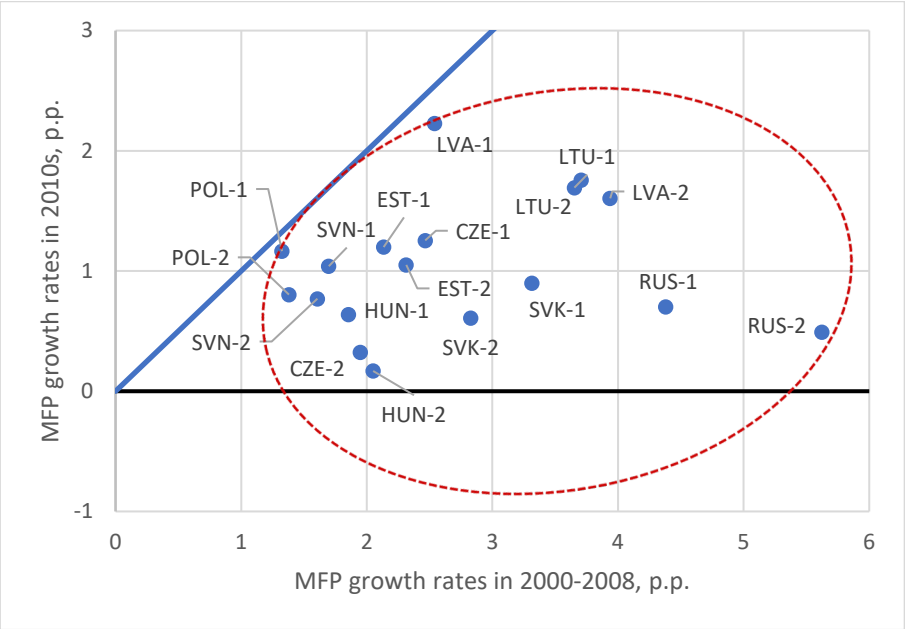
2. Backgrounds

Figure 1 reports three episodes of TFP acceleration and deceleration in East European economies, which are the productivity fall in years of the transformational recession in the 1990s compared to the 1980s (Figure 1a), the last decade before the collapse of the Soviet Union; the post-transition recovery of the 2000s compared to the 1990s (1b); and the productivity slowdown of the 2010s compared to the 2000s (1c). The horizontal axis of the figure represents the TFP growth rates of the first period, and the vertical, the second. Each country is represented as a point with the reference to the data source. For example, if a country appears on the plot above the bisecting line (in blue), it experienced MFP acceleration; if below, it experienced deceleration. For example, according to Penn World Tables 10 (source 1) the annual average MFP growth of Hungary in the 1980s was 1.37 pp; in the 1990s it was just 0.20 pp One can find the corresponding point on the graph 1a, labelled HUN-1, below the bisecting line.

Figure 1. Productivity accelerations and decelerations of East European economies in the 1990s–2010s



a. Early transition and post-transition recovery. 1990–1999 vs. 2000–2008[1]



b. Post-transition recovery and global productivity slowdown. 2000-2008[1] vs. 2010-2019

Sources: Each country code is followed by a number, which refers to a data source: Penn World Tables 10 (1), Total Economy Database™ (2), de Broeck, Koen 2001 (3), (de Broeck, Koen 2000) (5), Voskoboynikov 2021 (6). See also Appendix A1 for details.

Notes:

Country codes: Czechia (CZE), Estonia (EST), Hungary (HUN), Latvia (LVA), Lithuania (LTU), Poland (POL), Slovakia (SVK), Slovenia (SVN), Russia (RUS).

1 2009 is skipped as this year most economies experienced a short-term fall in demand driven output, which was followed by quick recovery.

The post-transition productivity acceleration was also widespread. Figure 1b shows that almost all CEER economies experienced it, excluding Slovenia and Estonia. Both exceptions are partially due to measurement issues. Observations, presented in Figure 1b, are growth rate averages for six years, starting from 1994, rather than 1990, and do not capture the early years of transition with negative MFP growth. Such early reformers as Poland, Latvia, and Estonia, represented on the bisecting line, experienced more intensive productivity accelerations earlier.

In the late 2000s to the 2010s, the global economy entered a period of productivity slowdown. This was observed in almost all developed and developing economies. CEER economies were no exception (Esfahani et.al. 2020). Figure 1c reports that all these economies experienced MFP deceleration, while remaining in the positive zone. What are causes of this global deceleration? Some of them could be similar to the ones impacting other economies. Although it falls after the global financial crisis of 2008–2009, there is some evidence, that MFP started decelerating even earlier. McGowan et al.

(2015) highlight some potential global causes of this slowdown. These include inefficient investments in physical and human capital and increasing job misallocations. Each country also has its own specific causes of this slowdown. For example, CEE economies—new EU members—were impacted by changes in trade flows within the EU. Russia experienced a fall in the productivity of the oil and gas sector. Considering that the share of this sector in Russian GDP varies from 20–25%, the fall deteriorated aggregate productivity growth (Voskoboynikov 2017). Russia was hit by sanctions after the annexation of Crimea in 2014 and has experienced almost a full stop of FDI inflow since then (Kossev and Tompson 2021). Soaring oil and gas prices provided investments inflow and the substantial contribution of capital intensity to labor productivity of some industries (Timmer, Voskoboynikov 2014; Voskoboynikov 2017).

Table 2. Growth accounting decomposition of the market sector of the Russian economy in 1995-2014
(p.p.)

	1995-2002	**2002-2007**	**2007-2014**		**1995-2014**
Real Value Added	2,66	8,03	1,58		3,60
Hours worked	-0,34	0,96	-0,12		0,08
Labour productivity total	3,00	7,07	1,70		3,51
Labour reallocation	1,36	0,80	0,35		0,73
Intra-industry labour productivity	1,64	6,27	1,35		2,78
Capital intensity	-0,35	2,10	2,76		1,52
ICT	0,21	0,19	0,09		0,12
Machinery and Equipment	0,10	1,19	0,92		0,59
Constructions	-0,43	0,50	1,43		0,68
Other assets	-0,23	0,22	0,32		0,13
Total factor productivity	1,99	4,17	-1,41		1,26

Sources: own calculations based on (Russia KLEMS 2017).

Accordingly, there are three important points for the Russian economy, which can be taken off from these preliminary observations. First, the slowdown of labor productivity growth is driven mostly by the fall of TFP. Second, the fall of TFP is observed not only in Russia, but it is about most of the

leading economies of the world. Finally, this TFP slowdown started before 2008 both in Russia and in many major economies, and its roots could be found not only in specific features of the Russian economy, but also in long run trends of global development. At the same time, the crisis of 2008 could contribute to this stagnation and accelerate TFP fall.

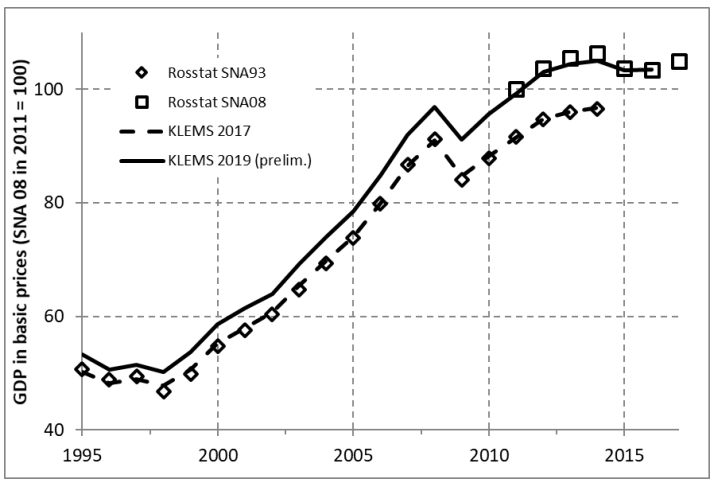
3. Data and approach

3.1. Output

Output series include GO, intermediate inputs and value added both in current and comparable prices. Data construction process and sources of Russia KLEMS releases of 2013 and 2017 is provides by (Voskoboynikov 2012). The series are based on the official SNA data with minor adjustments for differences in SNA releases and backcast estimations of industry-level series in 1995-2003 to bridge the old Soviet industrial classification OKONKh and NACE 1. These series correspond to concepts of output in SNA 93, which was adapted in Russia in early 1990s. The industry level series, based on SNA 93, cover years until 2014 (Rosstat 2015).

Starting from 2011 Rosstat (2017) publishes the series, which match SNA 2008 standards and correspond to the new series of SUTs. The benchmark SUTs starts in 2011 with the following projections. Official SNA 2008 backcast estimations for years before 2011 are not available. The most important issue for output series in this transition from SNA 93 to SNA 2008 is considering the own-account production of housing services by owner-occupiers, which fall at real estate activities (industry code 70 in NACE 1). Proper adjustments back to 1995 have been made in the preliminary version of the upcoming release of Russia KLEMS 2019. Figure 2 shows changes in a real value added in the total economy.

Figure 2. Real GDP trend of the Russian economy. Various releases of the official series and Russia KLEMS
(The level of the official SNA 2008 GDP in 2011 = 100)



Sources: (Russia KLEMS 2017) (KLEMS-17); own calculations for Russia KELMS 2019 (KLEMS-19, preliminary); Rosstat SNA93 (http://www.gks.ru/free_doc/new_site/vvp/vvp-god/tab3.xls , last update 31.12.2015; Rosstat (2015; tab. 2.5.1)); Rosstat SNA08 (http://www.gks.ru/free_doc/new_site/vvp/vvp-god/tab3a.xls, last update 03.04.2018).

3.2. SUTs: adaptation and backcast estimations

Until recently the lack of official SUTs in NACE 1 was a major obstacle for the development of GO based growth accounting for Russia. Fortunately, in March 2017 Rosstat released the first set of benchmark SUTs in NACE 1 for 2011, which covers 178 industries and 248 products. Its projections of SUTs for2012-2015 are less detailed, but enough for the purposes of Russia KLEMS. The next benchmark SUTs for 2016 are expected in 2019.

Taking into account the importance of long run series, we work on the backcast extension of the SUTs series back to 2003 in NACE 1, and 2011-2019 in NACE 2. This extension is based on SNA series of GO, intermediate inputs and value added in 2003-2010, adjusted for the recent version of SNA, and the RAS projection.

3.3. Hours worked

Main source of the series of hours worked is the *Balance of Labor Inputs* (BLI), which is harmonized with the Russian National Accounts. It is published 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, I rely on a combination of data from the *Balance of Labor Force* (BLF) and reports of organizations of *the Full Circle* (FC), which include large, medium and small firms as well as various public administration organizations. The BLF is the oldest system of labor accounts, existed in the Soviet statistics since early 1920s. It is based on FC with additional estimations for self-employed and workers engaged in commercial production in husbandries. 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 implemented. BLF and FC give the numbers of employees, and we assume that employee growth proxies for growth in hours. More details can be found in (Voskoboynikov 2012).

3.4. Capital

The series of capital services in Russia KLEMS are constructed on the basis of net stocks of eight types of assets (computing equipment, communication equipment and software, residential structures, non-residential structures, machinery and equipment, transport, and other assets), standard KLEMS

depreciation rates (Timmer et al., 2010; tab. 3.5), and internal rates of return (Voskoboynikov 2012). The sensitivity analysis of different capital input measures for the Russian economy in terms of GVA-based growth accounting is given by Timmer and Voskoboynikov (2014, Table 1).

3.5. Input's shares

The shares of labor and capital in value added are used as weights in the growth accounting 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 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 Russian National Accounts, but not in the industry statistics. That is why industry level NAS series on labor compensation in industries underestimate labor cost shares. 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 imputations. 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 labor income of self-employed is added. For all industries, except Agriculture, I assume that the hourly earnings of self-employed are the same as for employees. For Agriculture, with a high share of low educated workers, I imputed with the total economy average wage for low educated employees based on data from the RLMS survey. Further details can be found in Voskoboynikov (2012).

One of the adjustments in the official statistics with the transition to SNA 2008 is the further elaboration of input shares, considering informal activities. Proper backcast adjustments in Russia KLEMS series seem to be substantial, and have not been implemented yet.

4. Results and discussions

What is the role of intermediate inputs in Russian growth?

Russian economic growth in two recent decades was volatile. The transformational recession with its negative growth rates was followed by outstanding growth. Table 1 reports growth accounting decomposition of the Russian economy at the aggregate level (market economy sector). The table shows that there has been a steep output growth 7.1 per cent a year in 2003-2007, which followed by years of stagnation around 1.6 per cent in 2007-2014, and negative growth -0.4 per cent in 2014-2017. The period under consideration includes two economic crises, 1998 and 2009, as well as the inter-crises period of rapid resurgence. How did the growth structure change? I split the data into three periods, 1995-2003, 2003-2007 and 2007-2014. In this split I put peaks and troughs of business cycles into the

periods to minimize biases, caused by short-term demand effects. Indeed, in case of a sharp output fall, which happened in 1998 and 2009, the reduction of capital utilization might not be fully captured by capital input measures and can be wrongly attributed to the TFP slowdown. Important take offs from the table are changing structure of capital with the dominating role of machinery before 2007, and constructions in the following years; TFP stagnation in 2010-s and the decreasing contribution of labor reallocation.

Table 1. Growth accounting decomposition of total market economy in 1995-2014 (p.p.)

	1995-2003	2003-2007	2007-2014	1995-2014
Real Value Added	3.43	7.14	1.64	3.47
Hours worked	0.07	0.83	-0.12	0.16
Labor productivity total	3.36	6.31	1.76	3.30
Labor reallocation	1.19	0.72	0.40	0.72
Intra-industry labor productivity	2.17	5.59	1.36	2.59
Capital intensity	-0.09	2.26	2.40	1.41
ICT	0.16	0.23	0.07	0.10
Machinery and Equipment	0.17	1.14	0.81	0.55
Constructions	-0.30	0.46	1.26	0.59
Other assets	-0.11	0.43	0.27	0.16
Total Factor Productivity	2.08	3.26	-1.28	1.00
Labor composition	0.18	0.07	0.24	0.18

Sources: (Russia KLEMS 2017; (Voskoboynikov, Burnell, and Nguyen 2019)).

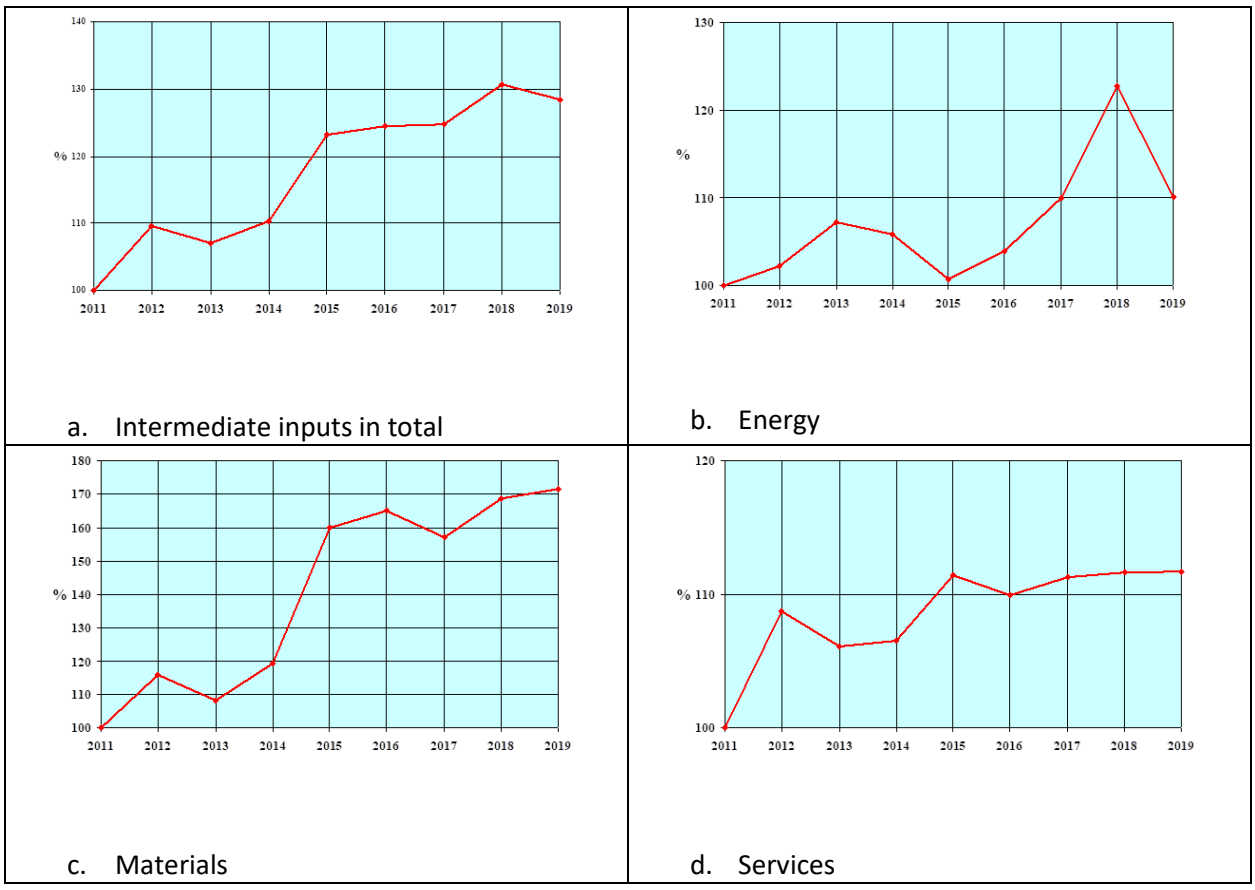
Note: data on labor composition differs slightly from results, reported by Timmer and Voskoboynikov (2016, tab. 8.1), because more detailed statistics on hours worked for different categories of workers was used for the present study.

Until now, Russia KLEMS dataset does not provide the full GO-based growth accounting decomposition, because the official statistics stopped developing SUTs in 2003, based on the benchmark SUTs of 1995. The new benchmark tables for 2011 with the following projections to 2012-2015 have been published in 2016. SUTs unveil two opportunities for Russia KLEMS. First, real value-added series can be revised, considering double deflation. In Russian official statistics, as well as in Russia KLEMS 2017, double deflation has not been adapted. Second, GO-based growth accounting can be

implemented. In both cases, the question of interest is to what extent the story of Russian growth, presented above, will survive. In addition, the issue of new data quality is important.

Growth accounting decomposition in table 1 is based on the decomposition of real value added growth rates. The next step is paying some attention to the role of intermediate inputs since 2011. Its aggregate level trends are represented in in figure 3 both in total (a), and of its components, energy (b), materials (c) and services (d). What can be clearly seen in figure 3a is the sharp growth of intermediate inputs in 2014-2015. Considering that services inputs level off and some moderate fall of energy, it is steep growth of materials (c), which contributed to this growth the most.

Figure 3. Intermediate Inputs for total economy in 2011-2018 (2011 = 100)



Source: Imputed SUT tables in current and comparable prices in NACE 2 classification. Russia KLEMS 2022 (in progress).

Then we look at the effect of the difference between single and double deflation procedures for the estimation of real value-added growth rates. Table 2 represents the GVA-based growth accounting decomposition for one of the industries, “Chemicals and Chemical Products” with both the official and double deflated real value added. If the volume growth rate of value added is calculated with single deflation or derived by the direct observation of volume output series, it will be sensitive to changes in relative prices of GO and intermediate inputs. In case of Russia, the corresponding bias could be

substantial. For example, output prices of export-oriented sectors, such as chemicals, mainly on international markets, whereas intermediate inputs prices (e.g. prices on energy) are formed in the domestic market. These domestic prices might be heavily distorted due to explicit and implicit subsidies. As can be seen from the table, the difference between the single-deflated and the double deflated real value added growth rates are substantial. In 2003-2007 they are almost twice as much as the official ones, while in 2007-2014 both have an opposite direction. At the same time, both the single-deflated and double deflated versions of growth accounting demonstrate that the contribution of TFP becomes smaller.

Table 2. Value added-based growth accounting for Chemicals and chemical products in 2003-2014 (p.p.)

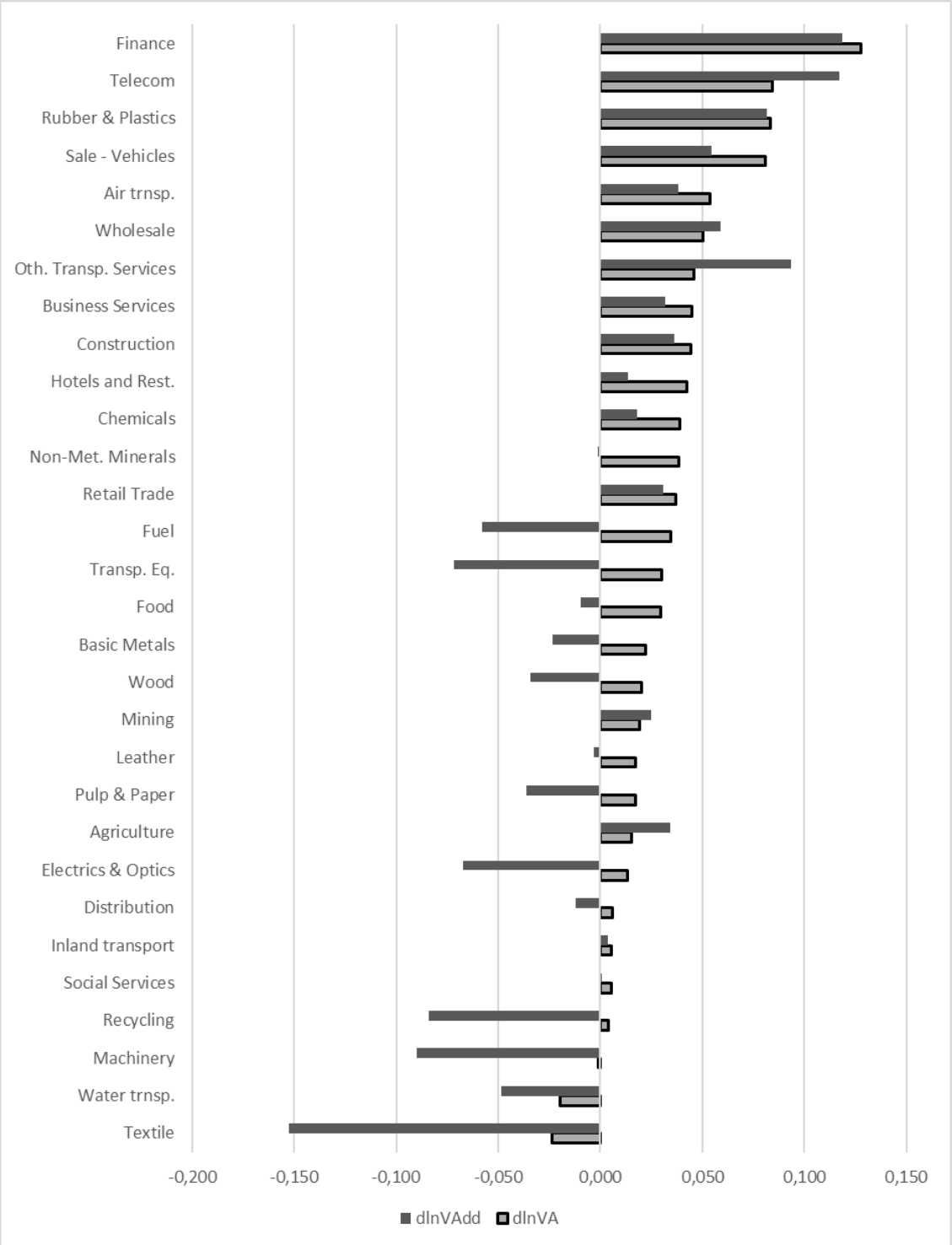
	2003-2007	2007-2014	2003-2014
Real Value Added	3.69	4.03	3.91
Hours worked	-2.82	-2.57	-2.66
Labor productivity	6.52	6.60	6.57
Labor composition	0.13	0.37	0.30
Capital intensity	3.16	3.41	3.04
Total factor productivity	3.22	2.82	3.24
Real Value Added (double deflated)	6.34	-0.39	1.81
Total factor productivity, based on double deflated real value added	5.87	-1.60	1.14
Labor share (%)	59.5	51.6	58.7

Sources: based on official Supply and Use tables in 2011-2014 (http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/accounts/#; retrieved 20.03.2018) and backcast estimations of SUT's in 2003-2010, made by Eduard Baranov, Dmitri Piontkovski and Elena Staritsyna. See also (Voskoboynikov, Burnell, and Nguyen 2019).

Generalization of these observations can be derived from Figure 3, which demonstrates, that the discrepancy between the single and double deflated real value added growth rates for some industries are substantial, being double deflated valued in most cases smaller and negative. Although these findings have to be considered as preliminary and only indicative of the potential importance of this issue given that they rely on preliminary backcast projections for the most years of the period and the sensitivity to measurement errors (Hill 1971), we can assume, that the official/Russia KLEMS 2017 numbers of real value added overestimate economic growth.

Figure 3. Yearly growth rates of single- and double-deflated real value added in 30 industries of the market economy, 2003-2014

(Annual compound growth rates)



Source: Author's calculations on the basis of (Russia KLEMS 2017) and official SUTs in 2011-2014 (http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/accounts/#; retrieved 20.03.2018) and backcast estimations of SUTs in 2003-2010, made by Eduard Baranov, Dmitri Piontkovski and Elena Staritsyna.

Note: Annual compound growth rates of value added volumes by industry. Single deflation-based volumes (light) and double-deflation based volumes (dark)

The final step is the GO decomposition, which is given in Table 3. It shows that GO growth rates in chemicals in 2003-2014 were around 3.5 per cent and relatively stable before and after 2007. Intermediate inputs and, specifically, materials, contributed the most (1.8 p.p.), which seems reasonable for this industry. The role of machinery and equipment (0.6 p.p.) and services (0.9 p.p.) seems also remarkable. For the period under review, the contribution of MFP is small, but it masks the substantial variation before and after 2007. It was strong (1.6 p.p.) before 2007 and negative (-0.5) after 2007. This variation is different from the MFP time pattern of single-deflated GVA-based growth accounting. While GVA-based MFP growth variates around 3 per cent both before and after 2007, GO-based MFP growth is positive before 2007 and negative afterwards. Negative MFP trend can reflect the lower share of outsourcing in the industry in the years of stagnation. Indeed, while before 2007 the contribution of services dominated and energy dropped, after the crisis the contribution of services became smaller by one third, while the role of energy and materials grew. All this took place with GO and inputs' growth rates remain stable. Probably, in years of stagnation many firms, which provided some outsourcing services, withdraw from the market, and producers had to substitute them with own less efficient production.

Table 3. GO-based growth accounting for Chemicals and chemical products in 2003-2014
(p.p.)

	2003 - 2007	2007 - 2014	2003 - 2014
Gross output	3.58	3.52	3.54
Intermediate inputs	1.80	3.64	3.01
Energy	-0.31	0.71	0.33
Materials	0.87	2.22	1.78
Services	1.24	0.71	0.91
Labor input	-0.43	-0.30	-0.36
Hours worked	-0.47	-0.41	-0.45
Labor composition	0.04	0.11	0.09
Capital	0.57	0.67	0.57
ICT	0.04	0.02	0.03
Machinery and Equipment	0.44	0.52	0.46
Constructions	-0.01	0.11	0.05
Other assets	0.10	0.02	0.04
MFP (GO-based)	1.64	-0.49	0.32

Source: own calculations based on (Russia KLEMS 2017) and official Supply and Use tables in 2011-2014 (http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/accounts/#; retrieved 20.03.2018) and backcast estimations of SUT's in 2003-2010, made by Eduard Baranov, Dmitri Piontkovski and Elena Staritsyna.

5. Conclusion

Although sources of Russian growth have been widely discussed in the literature, the role of intermediate inputs remains uncertain. The present paper has attempted to fill this gap. It has shown the increasing role of materials in Russian growth, especially after 2014. Accounting for the shift in relative prices with double deflation changes TFP trends in industries substantially, which highlights importance of inputs for understanding Russian growth. Finally, integration of intermediate inputs into Russia KLEMS framework does not change general observation on TFP slowdown in 2010-s in comparison with the previous decade.

Further research is needed to accomplish GO-based KLEMS framework of the Russian economy, and its integration to the World KLEMS dataset.

References

Blanchard, Olivier Jean. 1997. *The Economics of Post-Communism Transition*. Oxford: Oxford University Press.

Esfahani, Mehrdad, John G. Fernald, and Bart Hobijn. 2020. "World Productivity: 1996-2014." 2020–17. Economic Research. Federal Reserve Bank of San Francisco. https://www.frbsf.org/economic-research/publications/working-papers/2020/17/.

Hill, T. P. 1971. *The Measurement of Real Product: A Theoretical and Empirical Analysis of Growth Rates, for Different Industries and Countries*. Paris: OECD.

Ickes, Barry W. 2018. "Output Fall – Transformational Recession." In *The New Palgrave Dictionary of Economics*, edited by Macmillan Publishers Ltd, 9928–39. London: Palgrave Macmillan UK. https://doi.org/10.1057/978-1-349-95189-5_2691.

Jorgenson, Dale W., Frank M. Gollop, and Barbara Fraumeni. 1987. *Productivity and U.S. Economic Growth*. Contributions to Economic Analysis 169. Amsterdam-Oxford: North-Holland.

Russia KLEMS. 2017. National Research University Higher School of Economics; Groningen Growth and Development Centre. http://www.worldklems.net/data/basic/RUS_wk_march_2017.xlsx.

Timmer, Marcel P., and Ilya B. Voskoboynikov. 2014. "Is Mining Fuelling Long-Run Growth in Russia? Industry Productivity Growth Trends since 1995." *Review of Income and Wealth* 60 (Supplement Issue S2): S398–422. https://doi.org/10.1111/roiw.12132.

Voskoboynikov, Ilya B. 2012. "New Measures of Output, Labor and Capital in Industries of the Russian Economy." GD 123. GGDC Research Memorandum. Groningen: Groningen Growth and Development Centre, University of Groningen. http://hdl.handle.net/11370/870808b8-17cb-41e8-b3a8-034cdc2439f3.

———. 2017. "Sources of Long Run Economic Growth in Russia before and after the Global Financial Crisis." *Russian Journal of Economics* 3 (4): 348–65. https://doi.org/10.1016/j.ruje.2017.12.003.

Voskoboynikov, Ilya B., Derek Burnell, and Thai Nguyen. 2019. "Progress on Australia and Russia KLEMS." In *Measuring Economic Growth and Productivity: Foundations, KLEMS Production Models, and Extensions*, edited by Barbara M. Fraumeni, Bart van Ark, Hak Pyo, and Mun S. Ho, 195–220. Academic Press. https://www.elsevier.com/books/measuring-economic-growth-and-productivity/fraumeni/978-0-12-817596-5.

Vries, Gaaitzen J. de, Abdul A. Erumban, Marcel P. Timmer, Ilya B. Voskoboynikov, and Harry X. Wu. 2012. "Deconstructing the BRICs: Structural Transformation and Aggregate Productivity Growth." *Journal of Comparative Economics* 40 (2): 211–27. https://doi.org/10.1016/j.jce.2012.02.004.

Appendix. List of industries and composition of aggregated sectors

#	Code	Industry	Sector	Aggregated Sector
1	AtB	Agriculture, hunting, forestry and fishing	Agriculture	Market economy
2	23	Coke, refined petroleum products and nuclear fuel	Extended gas and oil	Market economy
3	C	Mining and quarrying	Extended gas and oil	Market economy
4	51	Wholesale trade and commission trade, except of motor vehicles and motorcycles	Extended gas and oil	Market economy
5	15t16	Food products, beverages and tobacco	Manufacturing	Market economy
6	17t18	Textiles, textile products	Manufacturing	Market economy
7	19	Leather and footwear	Manufacturing	Market economy
8	20	Wood and products of wood and cork	Manufacturing	Market economy
9	21t22	Pulp, paper, paper products, printing and publishing	Manufacturing	Market economy
10	24	Chemicals and chemical products	Manufacturing	Market economy
11	25	Rubber and plastics products	Manufacturing	Market economy
12	26	Other non-metallic mineral products	Manufacturing	Market economy
13	27t28	Basic metals and fabricated metal products	Manufacturing	Market economy
14	29	Machinery, nec	Manufacturing	Market economy
15	30t33	Electrical and optical equipment	Manufacturing	Market economy
16	34t35	Transport equipment	Manufacturing	Market economy
17	36t37	Manufacturing, n.e.c. and Recycling*	Manufacturing	Market economy
18	E	Electricity, Gas and Water supply	Manufacturing	Market economy
19	F	Construction	Retail, Construction, Telecom	Market economy
20	50	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel	Retail, Construction, Telecom	Market economy

21	52	Retail trade, except of motor vehicles and motorcycles; repair of household goods	Retail, Construction, Telecom	Market economy
22	H	Hotels and Restaurants	Retail, Construction, Telecom	Market economy
23	64	Post and Telecommunications	Retail, Construction, Telecom	Market economy
24	O	Other Community, Social and Personal Services	Retail, Construction, Telecom	Market economy
25	J	Financial intermediation	Fin. & Business Services	Market economy
26	71t74	Renting of machinery and equipment and other business activities	Fin. & Business Services	Market economy
27	60	Inland transport	Transport	Market economy
28	61	Water Transport	Transport	Market economy
29	62	Air Transport	Transport	Market economy
30	63	Supporting and auxiliary transport activities; activities of travel agencies	Transport	Market economy
31	70	Real Estate Activities	Non-market services	Non-market economy
32	L	Public admin and defence; compulsory social security	Non-market services	Non-market economy
33	M	Education	Non-market services	Non-market economy
34	N	Health and Social Work	Non-market services	Non-market economy

* n.e.c. = not elsewhere classified