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Sectoral Real Effective Exchange Rate and Industry Competitiveness in Russia

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ABSTRACT

One of the most popular measures for the economy's cost competitiveness in foreign trade is the real exchange rate. The common approach to its calculation consists in adjusting the nominal exchange rates for the trade-weighted CPI-based inflation differentials between the domestic economy and its major trade partners. Although such approach is most often used for official statistics, the CPI-based real exchange rate does not accurately capture an economy's competitiveness in foreign trade. The latter is explained by the fact that the CPI naturally considers price changes for both tradable and non-tradable goods. We aim at constructing a set of alternative indicators of REER that would more extensively account for the structure of the Russian economy and its foreign trade and, hence, provide more reliable estimates of changes in Russian economy's cost competitiveness over time. This is done by taking into an account the structure of the Russian economy combined with the specificities of production processes in industries that are extensively involved in foreign trade, as well as integration of Russian industries into global value chains. Against this background, we also show the importance of distinguishing between the output-based and cost-based real exchange rate concepts when addressing the country's trade competitiveness issue.

JEL classification: F3, F41, F63.

INTRODUCTION

Since November 2014 the Bank of Russia introduces a floating exchange rate regime[1]. Despite the fact that a floating exchange rate regime allows the economy to adjust to different kinds of macroeconomic fluctuations and smooth consequences of shocks, it could provide some bias for estimation of economy's performance (in particular, on industry and firm level data). This is explained by the fact that there is a wide range of fundamentals which influence the dynamics of real exchange rates, such as import and export prices, interest rates, risk premium and productivity differentials between domestic and foreign economies, etc.

[1] The implementation of the floating exchange regime in Russia has been gradual and consisted of three main stages. On the first stage, since 1999 it was a de facto fixing, but then in 2005 the operational bands based on the US dollar and euro basket indicators for foreign exchange policy provided some kind of autonomy as the central bank implemented foreign market interventions only for avoiding excessive exchange rate fluctuations and preserving the values of the operational target within certain bands. In 2009, the degree of autonomy expanded with the implementing of automatically changed operational band (depending on the foreign market interventions). Since 2010, the Bank of Russia started to use the interventions for smoothing the excess volatility only. Finally, since November 2014 the Bank of Russia eventually completed the transition to the floating exchange rate regime, the latter being a necessary prerequisite for introducing inflation targeting starting from 2015.

Following significant depreciation of the Ruble in 2014 Russian manufacturing firms received a cost advantage. Against this background, Russian firms' cost advantage along with acceleration in global economic growth gives a clear opportunity for movement along global value chains (GVC) and the further increase in manufacturing exports.

One of the most popular measures for the economy's cost competitiveness in foreign trade is the real effective exchange rate (REER). It was designed to capture the economy's competitiveness on the world markets, as it takes into account the differences in price levels as well as composition of international trade flows. REER helps to assess domestic goods' competitiveness compared to imported goods relative to price levels among major trade partners. Moreover, fluctuations in the real exchange rate (rer)[2] produce reallocation effect between and within industries. The common approach to REER calculation which consists in adjusting the nominal exchange rates for the trade-weighted CPI-based inflation differentials between the domestic economy and its major trade partners provide normally serves as a rough, but not a fully accurate estimate of an economy's competitiveness in foreign trade. Such a simplified and formal approach to REER calculation does not allow to put the exchange rate through a prism of cost competitiveness in foreign trade. The latter argument can be justified by the fact that headline CPI in all countries takes into account changes in prices across both tradable and non-tradable goods and does not replicate the details of the structure of the foreign trade for a certain country being considered (Chinn, 2006).

The motivation of our paper is driven by the fact that the existing literature so far has not provided an accurate and robust estimate of the REER dynamics for the Russian economy given the obvious shortcomings of the conventional CPI-based REER which is commonly used in official statistics. With respect to this, we aim at constructing a set of alternative indicators of REER that would more extensively account for the structure of the Russian economy and its foreign trade and, hence, provide more reliable estimates of changes in Russian economy's cost competitiveness over time. We tend to present our analysis of this issue as an answer to the question *What alternative and presumably more accurately measured REER indicators tell us about Russian economy's competitiveness?* rather than directly testing the empirical performance of newly constructed set of REER indicators (for example, the ability to forecast inflation or other major macroeconomic variables with REER) vis-a-vis conventional CPI-

[2] Real exchange rate measures the price of foreign goods relative to the price of domestic goods.

based REER. We leave that for further research given that choosing a particular comprehensive model specification for performing the latter exercise is by all means a question for separate discussion. Nonetheless, in this paper we expect to receive better predictive power of our newly-constructed indices. Moreover, we expect to capture the difference in the direction of impact of REERs' fluctuations in terms of industry competitiveness based on export (or revenue) and import (cost) structure in certain industry, which the aggregated REER would normally leave out.

There are two main strands in the literature that are dedicated to the current research. *The first* strand is devoted to the analysis of real effective exchange rates. The *second* strand is related to international trade. This paper addresses both questions in the following way: using theoretical background for constructing an appropriate measure for REERs we try to estimate the competitiveness of Russian industries on the global market (i.e. via their performance in international trade).

The free floating exchange rate played a crucial role of the shock absorber after negative developments in external conditions for the Russian economy since the second half of 2014 and eventually helped the Bank of Russia in achieving the pre-announced medium-term 4% inflation target by 2017. At the same time, the adjustment process also typically depends on the economy's integration into GVCs. Presently Russian integration into GVCs is primarily characterised by forward participation and to a much lesser extent backward participation. Against this background, exploring markets for new intermediate and final products appears to be a much more sustainable strategy in terms of promoting economic growth. This is opposed to a riskier approach that would consist in relying just on new trade partners while exporting merely the same goods, especially when the global economy is facing risks of recession that would potentially lead to further weakening in external demand.

Operating in a small open economy, Russian industries are naturally integrated into the international trade. But the level of integration differs significantly among sectors. Figure 1 and Figure 2 describe a great divergence among Russian industries in shares of foreign intermediate consumption in output and shares of export in total output. The major importers of foreign intermediate goods are not the same industries that are the major exporters in Russia. Taking into account that international markets for importing goods usually are not the same as for selling domestic goods it means that during the business cycle the relative real effective exchange rate for cost-part and for output-producing part of production process may move in

opposite directions. In turn, it means that some industries are more vulnerable during economic instability, but others can receive some competitive advantage in the same situation.

Figure 1. SHARE OF FOREIGN INTERMEDIATE CONSUMPTION IN TOTAL INDUSTRY OUTPUT, 2012-2015, %

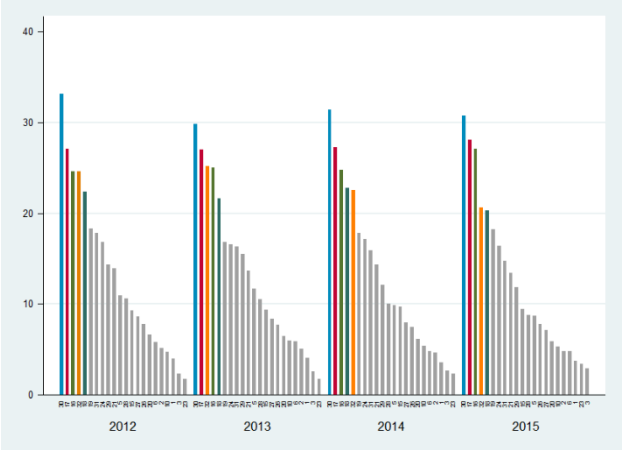
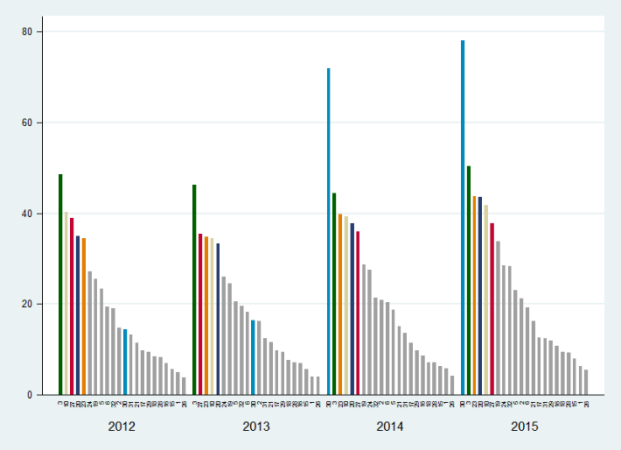


Figure 2. SHARE OF EXPORT IN TOTAL INDUSTRY OUTPUT, 2012-2015, %



Source: Bank of Russia, Federal Customs Service, authors' calculations.

To capture the effect of these divergence another weighting scheme for REER 'may be proposed. A proper choice of a weighting scheme in general depends on the application and/or the specific research question (Chinn, 2006). Goldberg (2004) suggests industry-specific REER which captures the distinctions of trade structure among industries[3]. This measure seems to be more sensitive as the aggregate REER could miss some effects on industry (or company) level.

The proliferation of the GVCs changes our perception of what is an appropriate way to calculate REER (Antras, 2015). Recent literature stresses the importance of inter-industry linkages and GVC participation for construction of REER on a country or industry level (Bems and Johnson, 2017). This is even more important for Russia since it has recently been listed as a country with one of the highest levels of divergence in cost competitiveness across sectors (Patel et al., 2014) against the background of significant sectoral differences in openness and GVCs participation.

[3] The weights of each trade partner currency in the IS-REER are the shares of that partner in the home country's exports of imports of specific industry being considered.

Hummels et al. (2001) introduce the concept of vertical specialization of trade (or vertical trade), which is defined via three main characteristics (1. a sequential production process, 2. stages of producing goods take place in at least two countries, 3. at least one of the partner countries imports intermediate goods and uses them for further export).

Koopman and Wang (2012) develop the idea of Hummels et al. (2001) in order to eliminate limitations of initial model (due to assumption of equality of intensity of the use of imported inputs in exported and domestically consumed goods). Daudin et al. (2009) divide international trade into “standard trade” and “value-added trade”. Authors highlight that the former may provide overvaluation due to double-counting as it measures trade flows based on their market value when they cross borders.

Historically Russia’s participation in GVCs is limited to first stages of GVCs. Russia supplies energy and raw materials for manufacturing processes: index of forwarding participation is estimated at 38.7%, while the index of backward participation is about four times less and estimated at 9.36% (Kadochnikov, 2015). This brings concerns about diversification of Russia’s exports and competitiveness among manufacturing industries (Torvinen and Väätänen, 2013).

Following Berthou&Dhyne (2018) and Ahmed et al. (2015) we estimate the exchange rate elasticity of exports taking into account the divergence of export and import among industries and the sectors’ rate of participation in GVCs. We contribute to the literature on the impact of exchange rates on export growth in Russian economy.

In this study we put our attention to the role of the exchange rate as an instrument of Russian economy’s accommodation to negative external shocks associated with a sharp decline in oil prices and rising geopolitical tensions that Russian economy has recently faced, as well as a measure of Russian industries’ competitiveness in international trade with respect to structural shifts in the economy. The rest of the paper is organized as follows. **Section** 1 is devoted to the discussion of the methodology and its pros and cons. **Section** 2 provides some stylized facts and describes in detail our dataset. **Section** 3 reveals our empirical results. **Section 4** concludes.

1. METHODOLOGY

1.1. Empirical Strategy

We follow the common definition of real effective exchange rate, as the weighted average of the domestic currency in relation to an index or basket of major currencies. To investigate the impact of real exchange rate fluctuations on export on the industry level we try to capture the marginal impact of different types of REERs (conventional and industry-specific) on growth of export volume taking into account time and industry fixed effects and controlling for changes in foreign demand. We use the approach of Berthou and Dhyne (2017) and try to quantify the role of peculiarities in the structure of industry-level exports with respect to exchange rate dynamics in Russia.

Berthou and Dhyne (2017) highlight the importance of firm heterogeneity for deriving better estimation of export reaction to exchange rate movements. Authors show that this weak reaction can be explained by two main factors on the firm-level.

First, the fact that aggregate exports concentrated into highly productive firms may lead to diminishing the overall effect of exchange rate fluctuations. This effect is called intensive margin. *Second*, the productivity distribution of exporters biased towards highly productive firms, so industries with high population of low productive firms tend to respond more to exchange rate movements. Due to the absence of firm-level data we focus our attention on the industry-level. We also clustered errors at the industry level to account for heteroskedasticity and arbitrary within-industry correlation in independent variables.

The baseline model

We use the following baseline model in order to assess the REER elasticity of export on the aggregated level[4]:

$$\Delta \ln V_{it} = \alpha + \beta \Delta \ln AREER_{t-1} + \gamma \Delta \ln FD_{it} + \varepsilon_{it} \quad (1)$$

[4] We use also the value of exchange rates in period *t* for all our specifications for robustness check.

where $\Delta \ln V_{it}$is yearly variation of industry i's export at time t; $\Delta \ln AREER_{t-1}$ is yearly variation of the aggregated real effective exchange rate with the one-year lag; $\Delta \ln FD_{it}$ is a variation of foreign demand in sector i at time t; $\Delta \ln Z_t = \ln Z_t - \ln Z_{t-1}$for the main explanatory variables.

We derive foreign demand through the foreign absorption of the trade partners:

$$FD_{it} = \sum_{j \neq c} \frac{V_{cjit}}{V_{cit}} (Y_{jit} + M_{jit} - X_{jit}) \quad (2)$$

where $\frac{V_{cjt}}{V_{ct}}$ is a share of bilateral export of industry i from Russia to country j in total Russian export of this sector at time t; Y_{jit} is the total output of country j in sector i at time t; M_{jit} are total imports of country j in sector i at time t; X_{jit} are total exports of country j in sector i at time t.

We expect the positive and significant impact of foreign demand and negative and insignificant impact of exchange rate volatility. Based on traditional macroeconomic models a depreciation of national currency have a positive effect on export due to expenditure switching mechanism. It means that foreign demand for local goods increases due to relatively lower prices (domestically produced goods in this case will be more competitive compared with foreign-produced goods). Freund and Pierola (2012) for instance show that in developing countries depreciation of national currency increases manufacturing exports. Eichengreen and Gupta (2013) stress the importance of industry-level analysis as they find evidence of the stronger effect of the real exchange rate fluctuations on service exports rather than exports of goods.

Industry-specific model

Aggregate data may mute the overall impact of the real effective exchange rate fluctuations as the effects could be opposite for different industries because of sectors' specific characteristics or other observed and unobserved factors.

We introduce industry-specific real effective exchange rate into our baseline model:

$$\Delta \ln V_{it} = \alpha + \beta \Delta \ln IS - REER_{t-1}^{i} + \gamma \Delta \ln FD_{it} + \lambda_i + \lambda_t + \varepsilon_{it} \quad (3)$$

Here we anticipate the positive and significant impact of foreign demand and significant impact of exchange rate volatility. Industry-level data may help us in capturing the opposite effects of the fluctuation of the REERs on sectors' exports.

Robustness

For robustness check we consider REER for the current year against lagged REER. We also made a specification with the assumption that all bilateral payments are made in US dollars and euros only. Moreover, we use average value for foreign demand and REER to reduce the noise from yearly variations. Average value for the variable of interest is calculated as follows:

$$\overline{\Delta \ln Z_t} = \frac{1}{2}(\Delta \ln Z_t + \Delta \ln Z_{t-1}) \quad (4)$$

1.2. Exchange rate movements and competitiveness

Introducing the appropriate measure of price competitiveness of countries seems to be a crucial factor to estimate its impact on so-called export-led growth.

A stricter definition of trade competitiveness is provided by the World Economic Forum. According to it competitiveness is "the set of institution, policies and factors that determine the level of productivity of a country". And the measure of competitiveness is a set of weighted indicators, Global Competitiveness Index. In this research we use an industry-level definition of competitiveness from the production process view.

As a benchmark REER we use the data published in Bank of Russia's statistics. This indicator is calculated based on 2-year lagged trade statistics and consumer price index (CPI) deflator. Moreover, we construct similar aggregated REER (AREER) based on our trade data and using different deflating schemes.

First, we compute rer for each country. We use PPI, CPI, and unit labor costs (ULC) as deflators in order to describe the better tool for our purpose. We use a common formula for computing RER for each of the Russian trade partner:

$$rer_t^c = ner_t^c * \frac{deflator_t^c}{deflator_t^{RUS}} \quad (5)$$

where ner_t^c is bilateral nominal exchange rate of country c's currency in terms of domestic currency (Ruble); $\frac{deflator_t^c}{deflator_t^{RUS}}$ is the ratio between corresponding indices (PPI, CPI, or ULC) in foreign country with respect to home country (RUS).

Second, we compute the conventional REER based on the volume of trade between countries, Aggregated Real Effective Exchange Rate (AREER). The shares of export (import) to (from) each partner country c in total Russian export (import) define countries' weights in the aggregated index. The final AREER consists of trade flows from major trade partners only. We assume that a trade partner has a significant impact if its share of export (import or trade) is greater than 0.5%. Figure A. 5 shows the coverage ratio of trade flows of the major partners compared with the official data.

Thus, the aggregated real effective exchange rate is a geometrically weighted average of bilateral exchange rates. The AREER in year t is calculated by the following formula:

$$AREER_t = \prod_{c=1}^{n(t)} (rer_t^c)^{w_t^c} \tag{6}$$

where rer_t^c is bilateral real exchange rate of country c; w_t^c is the weight of country's c currency in the index in period t, $\sum_c w_t^c = 1$; $n(t)$ is time-varying number of major trade partners

$$w_t^c = \frac{Y_t^c / Y_t * \boldsymbol{I}\,(Y_t^c / Y_t > 0.005)}{\sum_c [Y_t^c / Y_t * \boldsymbol{I}\left(Y_t^c / Y_t > 0.005\right)]} \tag{7}$$

where Y_t is a corresponding trade volume measure (export or import) at time t.

$$w_t^{tc} = \frac{X_t^c / X_t * \boldsymbol{I}\left(X_t^c / X_t > 0.005\right) + M_t^c / M_t * \boldsymbol{I}\left(M_t^c / M_t > 0.005\right)}{\sum_c \left[X_t^c / X_t * \boldsymbol{I}\left(X_t^c / X_t > 0.005\right)\right] + \sum_c \left[M_t^c / M_t * \boldsymbol{I}\left(M_t^c / M_t > 0.005\right)\right]} \tag{8}$$

where, X_t^c represents exports from Russia to country c at time t; X_t – total Russian exports at time t; M_t^c – imports from Russia to country c at time t; M_t – total Russian exports at time t.

Taking into account a substantial divergence between Russian industries, we follow Goldberg (2004) and construct industry-specific real effective exchange rate (IS-REER) with time-varying weights. Such correction appears to be important as currency volatility may influence industries with different direction and power. This assumes the introduction of weights based on discrepancies in trade structure of industries. The calculated index is thus supposed to be more effective as compared to the traditional aggregate trade-weighted exchange rate,

since it considers industries' competitive advantages raised from the difference the structure of imports and exports.

Similarly, we use three different weighting schemes: *export-weighted*, *import-weighted*, and *trade-weighted*:

Table 1

IS-REER	Weights
$xrer_t^i = \sum_c [w_{xt}^{ic} * rer_t^c]$	$w_{xt}^{ic} = \frac{X_t^{ic}}{\sum_c X_t^{ic}}$
$mer_t^i = \sum_c [w_{mt}^{ic} * rer_t^c]$	$w_{mt}^{ic} = \frac{M_t^{ic}}{\sum_c M_t^{ic}}$
$ter_t^i = \sum_c [(0.5 \frac{X_t^{ic}}{\sum_c X_t^{ic}} + 0.5 \frac{M_t^{ic}}{\sum_c M_t^{ic}}) * rer_t^c]$	

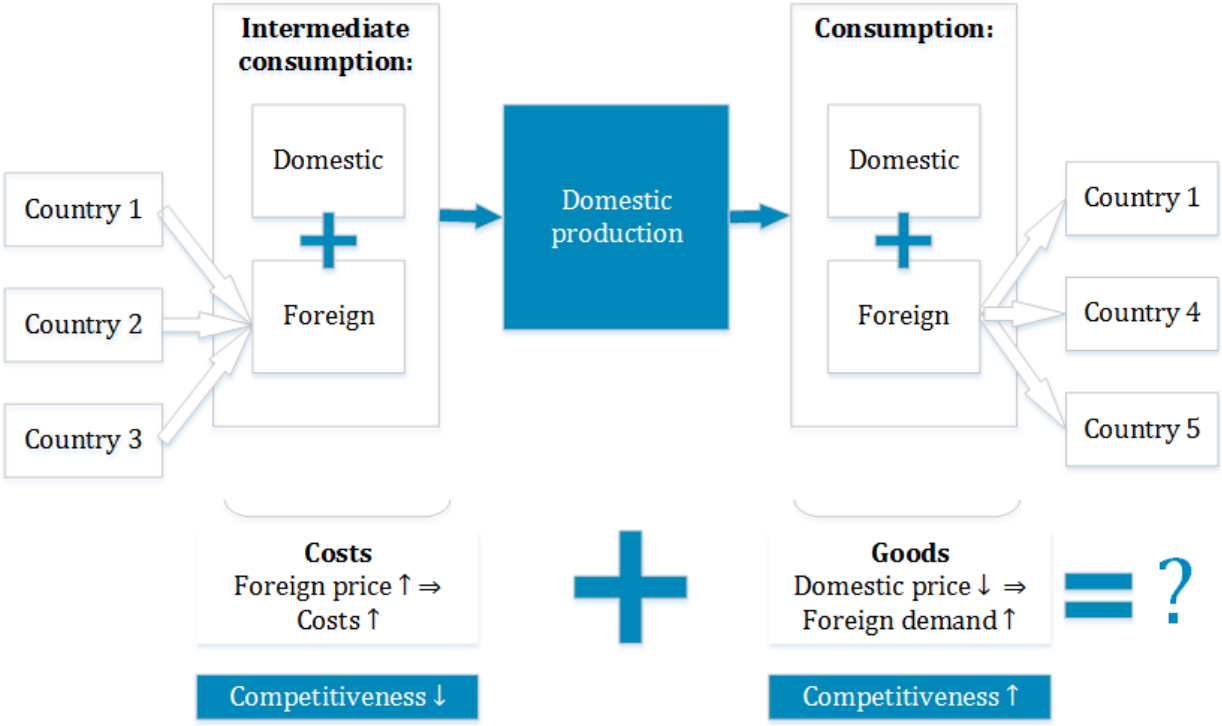
Source: Goldberg (2004).

where w_{xt}^{ic} is the share of industry i export to a partner-country c in total export; $\sum_c w_{xt}^{ic} = 1$; $xrer_t^i$ is export-weighted IS-REER for industry i; w_{mt}^{ic} is the share of industry i import to a partner-country c in total import; $\sum_c w_{mt}^{ic} = 1$; mer_t^i is import-weighted IS-REER for industry i; ter_t^i is trade-weighted IS-REER for industry i.

We next proceed with considering GVCs as cross-border supply chains may affect the REER elasticity of exports.

The dynamic of exchange rate can influence industry competitiveness via two main channels. Consider the simple model of the production process (Figure 3) The left-hand side describes the input process when some mix of domestic and foreign intermediate goods is used for production by some company or industry in generalcompany. At the same time, foreign intermediate goods can be imported from a country acting as a foreign supplier (Country 1, Country 2 etc.). The right-hand side of the chart below describes the output process when final (or value-added intermediate) domestic goods are sold on either domestic or foreign market. Generally speaking, international markets could coincide or differ from suppliers' foreign market.

Figure 3. TWO MAIN CHANNELS OF EXCHANGE RATE INFLUENCE ON COMPETITIVENESS



From this point of view, two main channels for exchange rate influence can be identified. The first one is the cost channel. The second one is the output channel. Assume now that the national currency depreciates against foreign suppliers' and consumers' currencies. *On the one hand*, it means that costs will increase as relative prices for foreign intermediate good will rise. The higher the costs, the greater the pressure on industry competitiveness. *On the other hand*, the same depreciation will make domestic goods relatively cheaper, which will stimulate foreign demand and thus boost industry competitiveness.

Therefore cross-border production may affect the REER elasticity of gross exports for two reasons. First, there is an ambiguous influence from cost-channel and output-channel. Second, in the case of exporting intermediate goods for further processing and exporting to a third country depreciation of domestic currency may raise the level of competitiveness of the downstream producers. So there are two opposite ways of exchange rate fluctuations' influence. The resulting direction could be ambiguous and depends on the foreign input and output structure in each industry and its integration in GVCs.

The first step of assessing the impact of exchange rate on the industry competitiveness consists in introducing newly weighted real effective exchange rates based on the sectoral structure of the Russian economy. It comes from understanding that aggregated (conventional) REER could show the absence of any impact due to the aggregation of opposite directions of influence. Industry-level data can help to partially mitigate this effect and reveal some significance. For our purpose, the proxy for the above mentioned *output channel* is export-based IS-REER. For the approximation of *cost channel* we use input-output tables and import-based IS-REER.

The simplified diagram of an ordinary Input-Output table (IOT) is described in the Appendix (Table A. 1). We derive the adjusting coefficient from IOT using the share of foreign intermediate goods in overall costs. So, weight of product i in the cost structure of industry j is:

$$a_{ij} = \frac{m_{ij}}{C_i} \tag{9}$$

Cost-based REER (CREER) is derived using the following formula:

$$CREER_{it} = mrer_{it} * \sum_j a_{ij} \tag{10}$$

Then we use these proxies (export-based IS-REER and adjusted import-based IS-REER) to find the impact of exchange rate fluctuations based on input-output structure:

$$\Delta \ln V_{it} = \alpha + \beta_1 \Delta \ln CREER^i_{t-1} + \beta_2 \Delta \ln xrer^i_{t-1} + \gamma \Delta \ln FD_{it} + \varepsilon_{it} \tag{11}$$

This specification could provide more accurate information about the impact of exchange rate on industries' competitiveness.

1.3. Endogeneity of trade weights

Recent methodology could bring about some questions about the likely endogeneity of trade weights. In contrast to existing methodology we use weights that better reflect recent changes in patterns, but at the same time employ the similar trade pattern for the certain in-

dustry and year. It means that exchange rate movements could potentially affect trade patterns. Following Goldberg (2004) we test newly-constructed weights for the endogeneity problem.

First, we checked for stability of weights among partners. Figure A. 1 and Figure A. 2 show variations in weights used for constructing REERs according to official statistics published by the Bank of Russia and in our study correspondingly. We received generally persistent weights in annual data. The main outlier is China, whose weight has been risen from 7.02% in 2005 to 11.48% in 2013 and then 16.86% in 2019. Another outlier are the Netherlands with the weight's change from 6.74% in 2004 to 9.43% in 2013 and 7.66% in 2019 (maximum 11.11% in 2014). The final outlier from the Top-3 is Belarus: from 8.01% in 2004 to 5.31% in 2013 and 5.93 % in 2019 (minimum in 2015 4.62%). Other countries' variation is less than 1. In the period 2004-2019 which is not used in the analysis the Ukrainian weight influences the results: since 2014 it falls quickly from 6.97% in 2013 to 2.49% in 2019.

Second, we constructed our REERs using lagged values of weights. Table 2 presents correlations between IS-REERs with lagged and current weights. Generally we received lower correlations as compared to results in Goldberg (2004) due to a smaller range of included industries (manufacturing) and shorter data sample (annual data for 13 years). Nonetheless, for majority[5] of industries the correlation is greater than 65% for export-weighted REER and 90% for adjusted import-weighted REER. It means little effect on the final newly-constructed REERs' series on industry level at least.

Table 2. CORRELATION BETWEEN CONTEMPORANEOUS AND LAGGED TRADE WEIGHT CONSTRUCTS OF INDUSTRY EXCHANGE RATES

Measured contemporaneous correlations ($corr$)	Number of industries in each correlation grouping out of thirty industries: $xrer_i$ vs $xrer'_i$	$CREER_i$ vs $CREER'_i$
$corr \geq 0.75$	8	13
$0.50 \leq corr < 0.75$	7	2
$corr < 0.50$	1	1

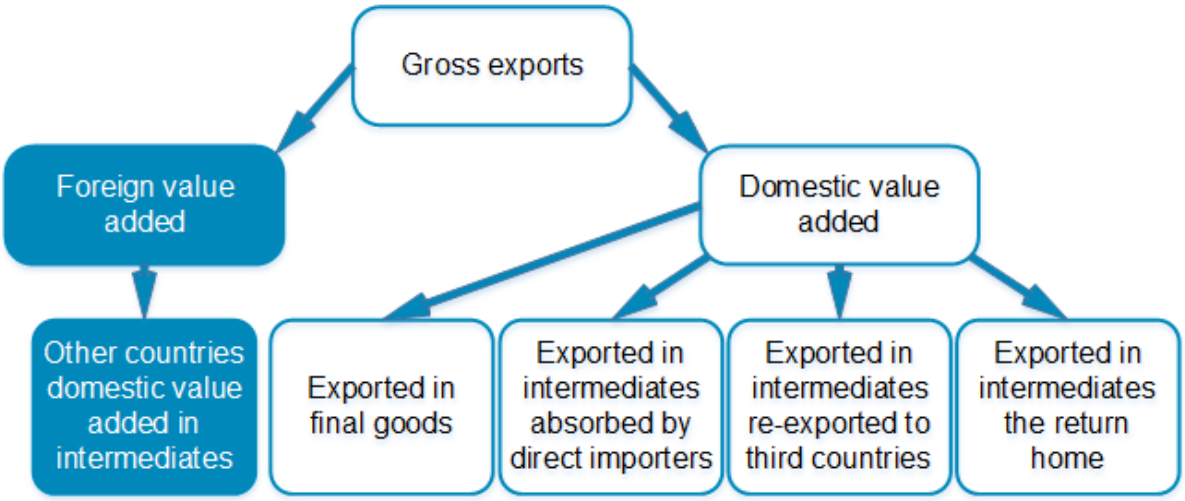
Source: Goldberg, 2004, authors'calculations.

[5] Majority is associated with more than 60% of observations.

1.4. GVCs measures and REERs

The next step is introducing GVC as recent high degree of globalization imposes the necessity of implementation of cross-sectors relations. Figure 4 represents the scheme of gross trade accounting suggested by Koopman et al. (2010). Gross exports could be decomposed into foreign value added (or foreign intermediates used in domestic production) and domestic value added. The latter consists of 4 elements: exported final good, exported in intermediates and absorbed bu direct importers, exported in intermediates and re-exported to third countries, exported in intermediates and return home.

Figure 4. GROSS TRADE ACCOUNTING SCHEME.



Source: Koopman et al. (2010).

The level of industry integration into GVCs could be included into the analysis of REERs elasticity of exports via two main ways. The first one is suggested by Patel et al. (2014) and represents designing new weighting schemes for REERs taking into account sectors' place in GVCs. The second one is suggested by Ahmed et al. (2015) and represents the inclusion of different GVCs measures and its interactions with REERs into the baseline regression.

Patel et al. (2014) designed the theoretical framework for this purpose. Due to the lack of up-to-date information we do not focus on this methodology now and postpone it for the further research. Instead we assess the industries' participation in GVCs using available Rosstat's data.

We start with the main indicators of country's integration to the global markets. Following HIY, we focus on the “value-added” approach for assessing vertical trade. It provides a better understanding of net trade flows between the original producer and the final consumer. Thus, the total value added is a sum of each industry’s difference between its value of production and the value of all inputs utilized in this sector. Cappariello (2012) suggests the following formula for computing the total value added in a country:

$$VA = \sum_i VA_i = \sum_i (Y_i - INT_i) = \sum_i [Y_i - va_i] \quad (11)$$

where Y_i is the value of the production of a sector i; INT_i —inputs for sector i; va_i is the ratio of value added content on sector’s production (including compensation of employees, pre-tax profit and rent).

The first approximation of the degree of country’s participation in GVCs is the share of domestic value added in gross exports (DVA). This measure provides information about the contribution of domestic value added to the industry’s exports assuming equality of value added for domestic consumed and exported goods.

$$DVA = 1 - Int_{total}/X_{total} \quad (12)$$

where Int_{total} is a total of an imported intermediate consumption goods; X_{total} is a country’s total exports.

Further, HIY suggest three main measures for evaluating trade flows within vertical trade concept. First, VS shows the share of imported inputs used for producing export goods. HIY calculate the share of imported intermediate consumption goods in total country’s export using the following formula:

$$VS = \boldsymbol{u}\boldsymbol{A}^{\boldsymbol{M}}\boldsymbol{X}/X_{total} \quad (13)$$

where u is a $1 \times n$ vector of 1’s; A^M is the $n \times n$ matrix of coefficients for imported intermediate consumption goods (as a share of output in basic prices); $\boldsymbol{X}$ is an $n \times 1$ vector for industry exports; X_{total} – country’s total exports; n is a number of sectors.

But as this measure does not take into account export goods for intermediate consumption and the value of domestic export in imported goods, it provides a biased estimation of trade flows. So the value of imported goods used indirectly in producing exported goods using

the correction matrix must be calculated. The share of imported intermediate consumption goods in export is computed as follows (*first measure*):

$$VS = \boldsymbol{u}\boldsymbol{A}^{M}[\boldsymbol{I} - \boldsymbol{A}^{D}]^{-1}\boldsymbol{X}/X_{total} \quad (14)$$

where $\boldsymbol{I}$ is the identity matrix; A^{D} is the $n \times n$ domestic coefficient matrix.

The additional source of possible bias is relatively aggregated sector data from IOT. For instance, positive (negative) correlation between exports and imported inputs/gross output ratio within a sector implies downward (upward) bias of VS when the sector-level data is used.

Second measure, $VS1$, evaluates the country's participation level in the longer value chain, when exported goods are used for intermediate consumption in the partner country. Koopman et al. (2010) define this measure as "forward linkages. *Third measure*, $VS1^{*}$, evaluates a part of $VS1$ that is further imported back for final consumption in the domestic country. Although, the latter two measures provide more accurate information about international trade, it needs matched bilateral trade flow data with use matrices for all trading partners.

The measure of country's (or industry's) integration in GVCs via both backward and forward participation is called the participation index, ($Participation$). It is given by the following formula:

$$Participation = VS + VS1 = Backward + Forward \quad (15)$$

The participation index does not give the full picture of the country's integration into GVCs. Koopman et al. (2010) define the additional measure, $Position\ Index$. It helps to identify the specialization of country on upstream or downstream activities in production or whether the country is a resource or final good provider. The upstreamness (downstreamness) means that a country have high forward (backward) relative to backward (forward) linkages.

$$Position = \ln(1 + VS1) - \ln(1 + VS) \quad (16)$$

The integration into the GVCs seems important as when a country is integrated in global production process the volatility of the real exchange rate affects the competitiveness of a fraction of the value of exporting goods. The latter means that the participation in GVCs should lower the REER elasticity of exports, while GVC position (whether the country is upstream or downstream) has an ambiguous sign because of complicated linkages between different producers and final consumers.

Following Ahmed et al. (2015) we evaluate the impact of sectors' GVCs integration on the REER elasticity of export. For our purpose we add to the industry-specific model the interaction of the $IS - REER$ and GVC variables. We estimate 3 specifications: (1) with GVC participation; (2) with GVC participation and GVS position; and (3) with backward and forward participation.

2. DATA

2.1. Data sources

Table 3 presents a short overview of our main data sources. We have an unbalanced panel for years 2000-2013. Our dataset contains value of exports and imports for 22 industries and 149 trade partners, nominal exchange rates for 34 currencies, CPI and PPI for the main trade partners, foreign demand for industries calculated via WIOT, wage dynamics for calculating ULC for 9 main countries.

Table 3. DATA SOURCES AND DESCRIPTION.

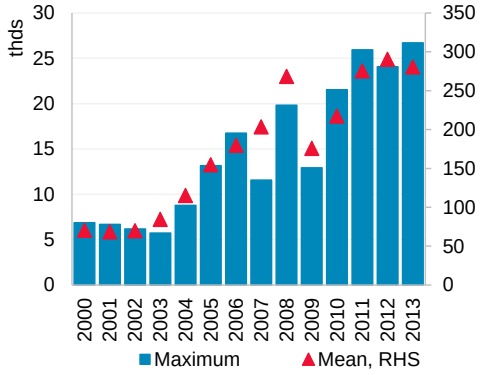
Data	Source	Description
Nominal exchange rate	Bank of Russia	• 2000-2016; daily • 34 currencies for 74 countries
Consumer price index	IMF	• 2000-2016; annually; • 191 countries
Producer price index	OECD	• 2000-2016; annually; • 35 countries
Trade flows	GTAP	• 2000-2013; annually; • 135 destination countries; • 21 industries.
Services trade	Bank of Russia	• 2002-2016; annually .85 destination countries (+RoW)
Input-Output tables	WIOD	• 2000-2014; annually; • 59 industries.

Source: authors.

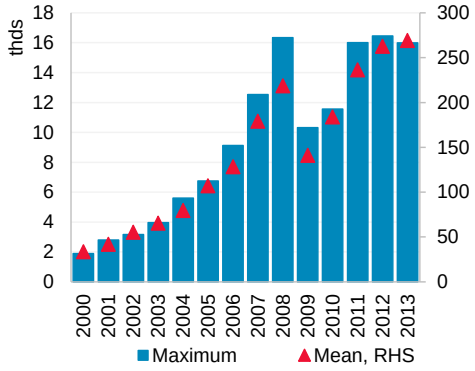
We use nominal exchange rates, CPI, and major trade partners' weights to evaluate aggregated real effective exchange rate for 2000-2013. For each trading partner we constructed corresponding annual nominal exchange rates provided by the Bank of Russia. Annual nominal exchange rates are, according to the Bank of Russia's official definition, simple geometric mean of daily data. We use local currency exchange rates for major partners (74 countries). For the remaining 75 countries, we assume US dollar as the main currency. For all countries we use CPI published by the IMF as average annual consumer price index (2010=100%).

SUMMARY STATISTICS Table 4.

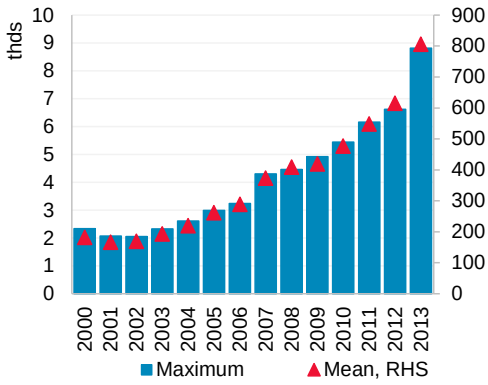
Export



Import



Foreign demand



Number of years	14
Number of industries	24
Number of trading partners	152
Average export	178.1
Average import	148.3
Average foreign demand	366.4

Figures 1-2 and Figure A. 3 represent the difference in the structure of exports and imports for Russian industries. The most import-dependent sectors are textiles, wearing apparel and fur, machinery, and rubber and plastic.

In line with the export structure of resource-rich countries, mining and coke and refined petroleum products show the highest export values. Traditionally, industries with more significant value added (or higher degree of participation in GVCs) are characterized by lowest export values. In case of Russia, such industries are textiles, wearing apparel and fur, and forestry.

For deriving the Russian degree of integration into the GVC we also use partly Global Trade Analysis Project (GTAP) database. GTAP is “a global data base describing bilateral trade patterns, production, consumption and intermediate use of commodities and services”. GTAP database covers information across different countries and industries. It uses both national statistical sources and data from various international organizations (such as the World

Bank, IMF, UN Statistics). The recent available release of GTAP database covers information for 129 countries and regions and 57 industries for 2011.

Kadochnikov (2015) provides the following estimates of Russian vertical specialization trade for the two latest GTAP databases:

VERTICAL SPECIALIZATION TRADE Table 5

	VS, %	VS1, %	VS1*, %
2007	9.36	38.70	2.01
2011	8.06	37.92	1.44

Source: Kadochnikov (2015).

According to Kadochnikov (2015), general index of Russian level of participation in GVCs in 2007 was about 48.06% with further decrease up to 45.98% in 2011. This drop realized in both backward participation (the share of imported inputs used for production of exported goods) and forward participation (the share of exported domestic goods for intermediate consumption in other countries) levels. The so-called backward participation is measured by VS, while forward participation is estimated via $VS1$. Russian 'component participation' dropped by 1.3 p.p during the observed period and reached 8.06%. At the same time, 'goods participation' decrease was less significant and was 0.78 p.p. stabilized on the level of 37.92% in 2011.

In general, the degree of Russian integration into the GVCs is presently insignificant. Despite the fact that more than one third of Russian exports is used for intermediate consumption in other countries ($VS1$), Russia is still far from being the final consumer in GVCs. The share of Russian exports, which is further imported back for final consumption along the chain, was 2.01% in 2007 and diminished down to 1.44% by 2011.

In this paper we used WIOT to study possible evidence of the additional explanatory power of sectoral real effective exchange rate adjusted to Russia's participation in GVCs (Patel et al., 2014). The database provides information for exports, as well as domestic and import intermediate consumption for different industries and trade partners.

Despite the fact that this database does not allow us to calculate $VS1$ and $VS1^*$[6] there are two main reasons for focusing on it. *First*, the main characteristics of Russian vertical specialization have been thoroughly studied and covered, for instance, in Kadochnikov (2015). *Second*, we may use more recent data (until 2014) which is not available for GTAP dataset yet.

[6] The database does not cover matching bilateral trade flow data to input-output relation.

3. RESULTS

3.1. Exchange rate movements and competitiveness

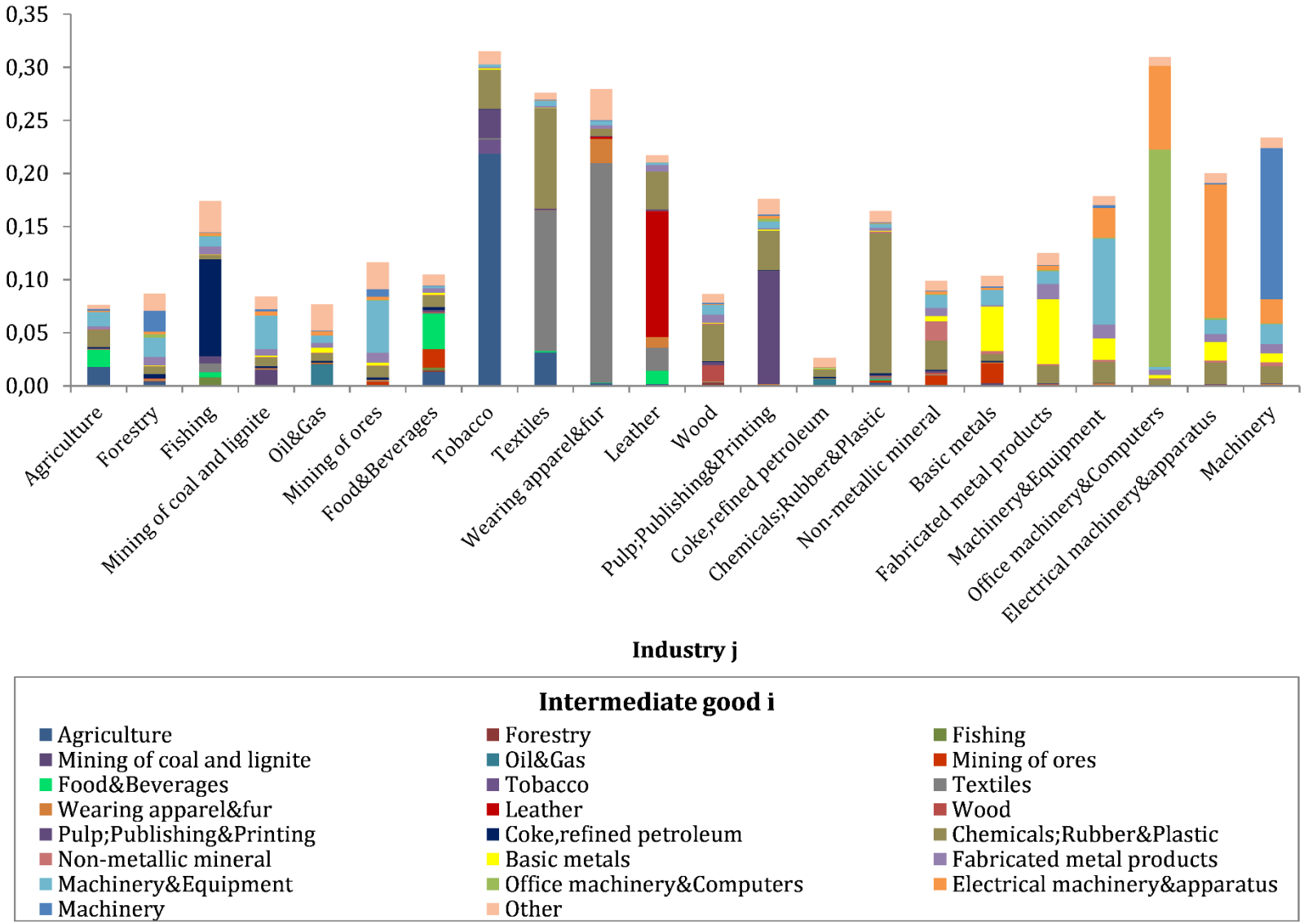
We present the structure of imported intermediates by industry in Figure 5. Coloured bars for each industry represent decomposition of costs of imported intermediates. For instance, the major foreign intermediate goods for machinery production (the far right column) is machinery products (dark blue part of the bar) and electrical machinery products (orange). Wearing apparel and fur companies import mostly textiles. The least import-dependent Russian industries are coke and refined petroleum, oil and gas, and mining. The most import-dependent industries are tobacco, office machinery and equipment, wearing apparel and fur, textiles, leather, machinery, and electrical machinery and apparatus.

As it is presented on the picture, cost structure of imported intermediates for each sector differs significantly by industry and includes goods and services across different branches of the economy. Thus, given the wide range of sources of imported intermediates, we can observe diverse picture of how industry-level performance depends on movements in the exchange rate, relative prices across different trade partners.

Another dimension of variation in industry performance caused by exchange rate movements is the difference between relative prices of imported intermediate goods and movements in prices of the final goods. In order to highlight the different behavior of these price indicators we construct an output price based industry-level REER indicator and a cost-based industry-level REER indicator.

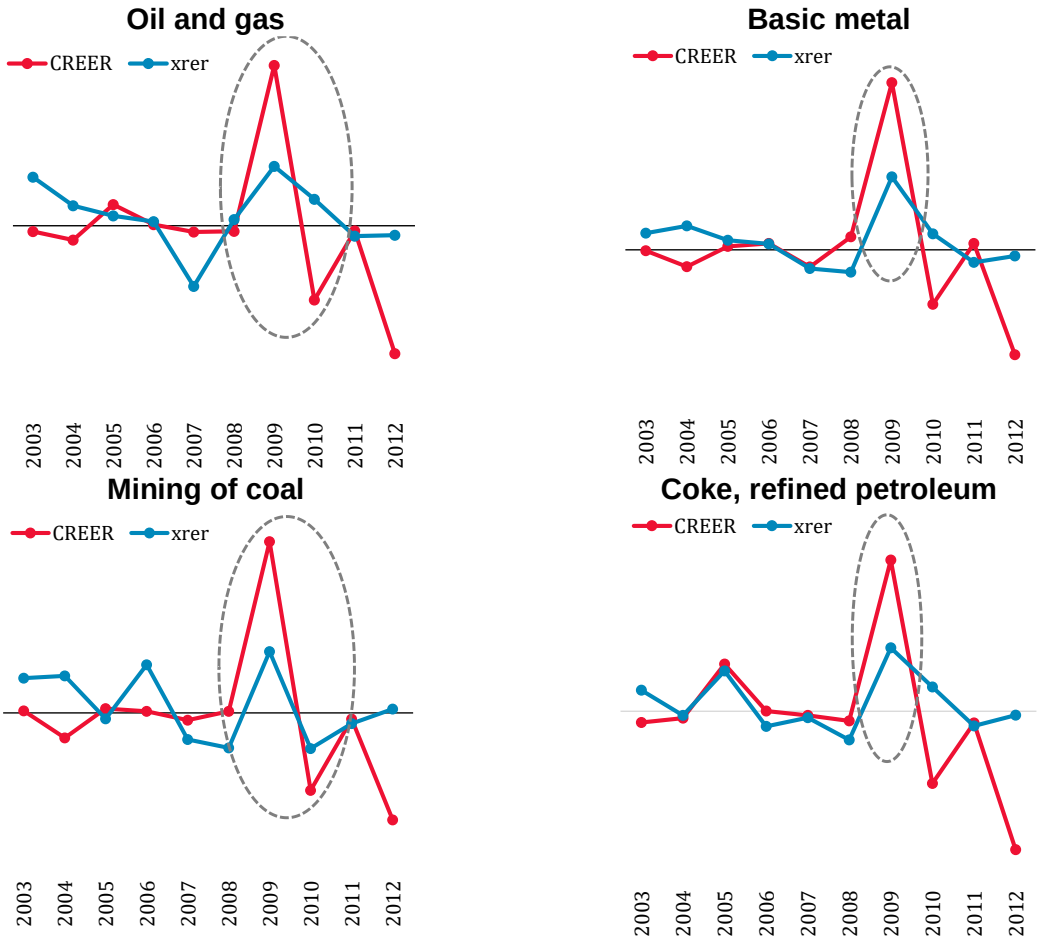
The cost-based and the output-based REER indexes are based on adjusted REER according to import structure and export structure. Figure 6 and Figure 7 represent the dynamics of these indicators for 2003-2012 for some industries.

Figure 5. STRUCTURE OF IMPORTED INTERMEDIATES BY INDUSTRY



Source: Bank of Russia, Federal Customs Service, authors' calculations.

Figure 6. DYNAMICS OF COST-BASED[7] AND OUTPUT-BASED REER INDEXES FOR EXPORT-ORIENTED INDUSTRIES, 2003-2012

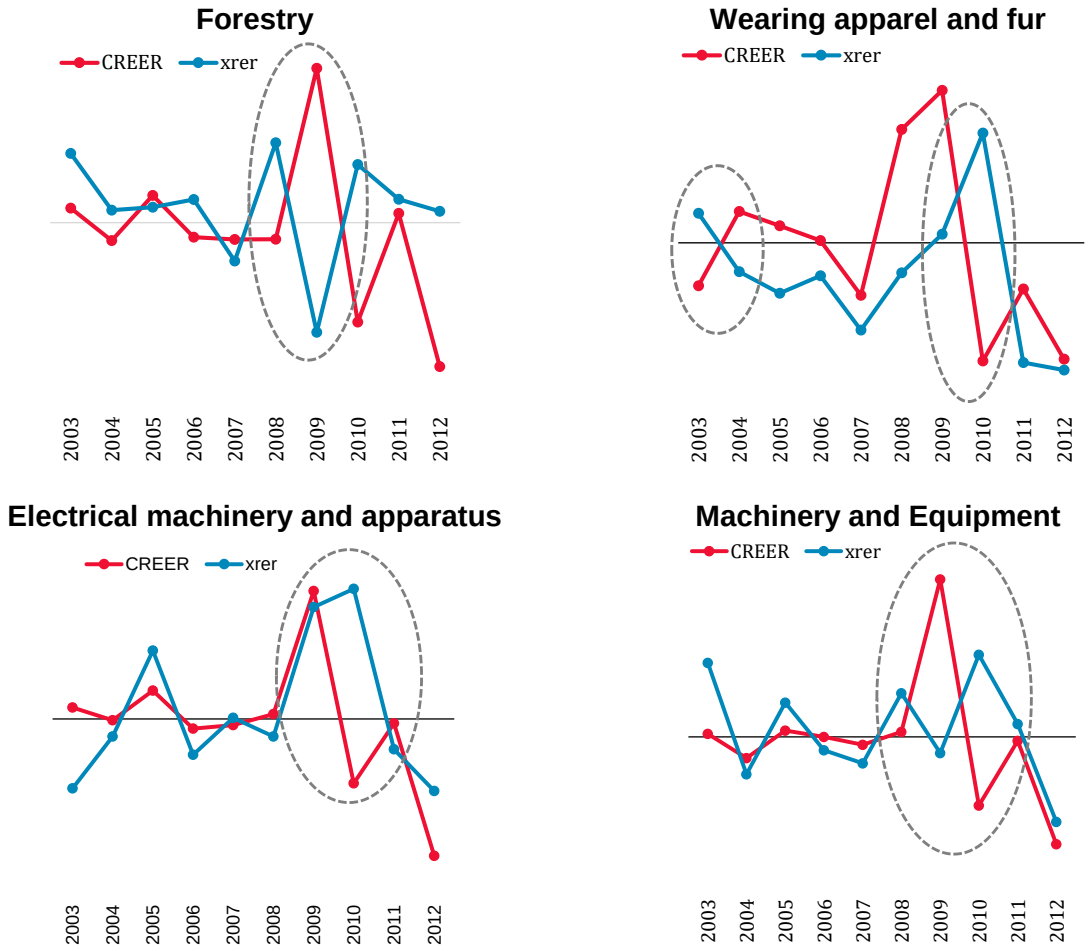


Source: authors' calculations.

The co-movement of these REER measures means that during the period of currency fluctuations changes of company's costs of imported intermediates will be matched by the corresponding changes in the price of its output. For instance, as it is presented on the graph above (see Figure 6) during episodes of depreciation of the Russian ruble in 2008-2009, relative cost advantages of Russian export-oriented industries (oil and gas, basic metals, coal, coke), were accompanied by increases in the cost of imported intermediates used in the production process, which is presented by spikes in the cost-based REER measure.

[7] Not adjusted, CPI-based.

Figure 7. DYNAMICS OF COST-BASED[8] AND OUTPUT-BASED REER INDEXES FOR IMPORT-ORIENTED INDUSTRIES, 2003-2012



Source: authors' calculations.

There are industries which presented multidirectional dynamics of the cost- and output-based REER measures. Depending on the relative movements of the two measures this could be a signal of either favourable developments (when output-based REER depreciates, this gives a competitive advantage for industry output on the destination markets; at the same time cost-based REER appreciates, which means that domestic costs of imported intermediates decrease, as costs of production go down) or negative developments (this is the case when output-based REER appreciates at the same time as cost-based REER depreciates).

Gaps in the dynamics of the cost and output-based REERs reflect the difference between foreign markets of suppliers and consumers. That said, during the same stage of the business cycle REER based on the import structure may depreciate, while output-based REER may

[8] Not adjusted, CPI-based.

appreciate, the latter case, as mentioned above, making the negative pressure during unstable periods more sizable.

From this point of view, more vulnerable sectors are mostly import-dependent or have different foreign markets for suppliers and customers. Perhaps the most illustrative cases for Russia are forestry in 2009-2010, electrical machinery and apparatus in 2010, wearing apparel and fur in 2010-2011, and machinery and equipment in 2009-2010.

3.2. The difference among different REER weighting schemes

Figure A. 5 shows the difference in trade flows coverage taken for constructing conventional REER (officially published by the Bank of Russia) and newly weighted REERs (based on share of export/import)[9]. During the whole sample period the coverage rate exceeds 80% for the conventional weighting scheme. At the same time, new weights cover at least 90% of trade flows during 2004-2013. So, compared with weights used by the Bank of Russia for similar calculations, the coverage ratio based on recent trade flows is wider for each year. Moreover, for each period the latter measure uses trade structure in the particular year, while the shares for official REER calculation are by convention based on the structure with a two-year lag.

We then proceed by constructing REERs for 2000-2013 using different weighting schemes and deflators.

The ULC-based REER is constructed by means of statistical data on unit labor costs covering the manufacturing sectors in Russia, *on the one hand*, and its major trading partners, *on the other hand*. The respective estimates of ULC for Russia are derived from Rosstat's sectoral data on output, nominal wages and employment. We use information from national statistical agencies, IMF and CEICDATA to compute similar estimates for Russian trading partners and, eventually, the ULC differential. Due to the problem of data availability, we come up with the ULC estimates for the rest of the world that encompass 8 major trading partners: euro area, China, United States, United Kingdom, Japan, Turkey, Belarus, Ukraine. We assume that this truncated sample of trading partners generally fits the purpose of our exercise aimed at studying the change of Russian economy's cost competitiveness, as the total share

[9] The main trade partners are those countries whose trade flows with Russia exceed 0.5%.

of Russian foreign trade with the countries and country groups listed above is persistently above 70%.

We find empirical evidence for the common drawbacks of using conventional CPI-based real exchange rate indicators, which automatically take into account production costs of both tradable and non-tradable goods, to characterize Russian competitiveness among its major trading partners. Against this background, the real exchange rate of the Ruble calculated via manufacturing unit labour costs advocates for clear gain in competitiveness of the Russian economy during the episodes of 2008-2009 and 2014-2015 currency crises (Figure A. 6).

Consequently, cost competitiveness and widely discussed import substitution may give way to a sustainable revival of the Russian economy that has currently been experiencing structural changes in the tradable and non-tradable sectors. This finding is much less clear in case if we put the real exchange rate of the Ruble through a prism of headline CPI. On top of that, results of our estimation of above-mentioned models introduced in the paper show that specifications employing the time series for the ULC-based REER generally show a better empirical fit.

3.3. Baseline model results

We estimate our baseline model based on Berthou and Dhyne (2017) with existing aggregated REER CPI-deflated and PPI-deflated.

Table 6 provide preliminary results for the subset of manufacturing industries for 2000-2013. The main specification assumes one-lagged real effective exchange rate. We receive significant positive coefficients for foreign demand $\Delta \ln \overline{FD}_{it}$ for all specifications. We also find negative and significant impact of the current value of REERs, both CPI-deflated and PPI-deflated. But the lagged value of REER has ambiguous impact and is insignificant for all regressions.

We expected the significance of the lagged value of the real effective exchange rate due to some inertia inproduction process. Change in the sign of coefficients in the regression (2) implies weak stability of the results on the aggregated level. In order to look for more stable dependences we apply the proposed methodology on the industry level.

AREER, 2000-2013, MANUFACTURING Table 6

VARIABLES	(1)	(2)	(3)	(4)
$\Delta \ln FD_{it}$	0.379***	0.307***	0.372***	0.296***
	(0.106)	(0.102)	(0.109)	(0.110)
$\Delta \ln AREERppi_{t-1}$	0.0394	-0.00707		
	(0.0689)	(0.0611)		
$\Delta \ln AREERppi_t$		-0.155***		
		(0.0479)		
$\Delta \ln AREERcpi_{t-1}$			0.0720	0.0775
			(0.0689)	(0.0677)
$\Delta \ln AREERcpi_t$				-0.197***
				(0.0587)
Constant	0.0344*	0.0467**	0.0349*	0.0483**
	(0.0194)	(0.0199)	(0.0190)	(0.0201)
R-squared	0.003	0.004	0.003	0.004
Observations	13,098			
Number of id	1,390			

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

3.4. Industry-specific model results

Table 7 shows the results for the industry-level model. We receive significant positive coefficients for foreign demand ($\Delta \ln FD_{it}$) for all specifications similar to the baseline specification results. The first lag of export-based REERs, both CPI-deflated and PPI-deflated also has positive but less significant impact.

The sign of the coefficients coincides with model predictions, implying importance of both final demand and REER for export performance of Russian industries. The positive sign correlates with the economic intuition: the depreciation of the national currency provides lower costs for local producers and thus increases the level of competitiveness. By comparing different deflators in the REER estimates we could see the relative strength of the CPI-deflated REER measure on the industry level.

EXPORT-BASED REER, 2000-2013, MANUFACTURING Table 7

VARIABLES	(1)	(2)	(3)	(4)
$\Delta \ln FD_{it}$	0.379***	0.358***	0.350***	0.384***
	(0.0989)	(0.0895)	(0.0955)	(0.0986)
$\Delta \ln xrer - ppi_{t-1}$	0.0659*	0.0576		
	(0.0352)	(0.0392)		
$\Delta \ln xrer - ppi_t$		-0.0228		
		(0.0482)		
$\Delta \ln xrer - cpi_{t-1}$			0.211**	0.208**
			(0.0921)	(0.0943)
$\Delta \ln xrer - cpi_t$				0.0646
				(0.0670)
Constant	0.0345*	0.0374*	0.0350*	0.0301
	(0.0184)	(0.0201)	(0.0183)	(0.0203)
R-squared	0.003	0.003	0.004	0.004
Observations	13,098			
Number of id	1,390			

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8 shows the results for cost side of production process and the respective impact of cost-based IS-REER. Again we receive significant positive coefficients for foreign demand but negative and significant coefficients for the first lag of adjusted import-based REERs, both CPI-deflated and PPI-deflated.

The sign of the coefficients coincides with general economic intuition: when national currency depreciates it makes it more costly to provide imported intermediate goods for production. Hence, there is a negative influence on domestic producers' competitiveness.

COST-BASED REER, 2000-2013, MANUFACTURING Table 8

VARIABLES	(1)	(2)	(3)	(4)
$\Delta \ln FD_{it}$	0.391***	0.326***	0.224**	0.388***
	(0.106)	(0.100)	(0.105)	(0.109)
$\Delta \ln CREERppi_{t-1}$	-0.0262	-0.0738		
	(0.0508)	(0.0577)		
$\Delta \ln CREERppi_t$		-0.238***		
		(0.0717)		
$\Delta \ln CREERcpi_{t-1}$			-0.0665	-0.113
			(0.138)	(0.150)
$\Delta \ln CREERcpi_t$				-0.277***
				(0.102)
Constant	0.0356*	0.0528***	0.0614***	0.0346*
	(0.0189)	(0.0190)	(0.0215)	(0.0181)
R-squared	0.002	0.006	0.002	0.004
Observations	13,098			
Number of id	1,390			

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9 shows the estimation results of equation (11). The impact of foreign demand is still positive and significant and fluctuates between 0.256 and 0.355. Column (4) presents the specification, which includes both cost- and revenue-based REERs, lagged and current values. We received expected and significant coefficients for all variables.

IS- REER, 2000-2013, MANUFACTURING Table 9

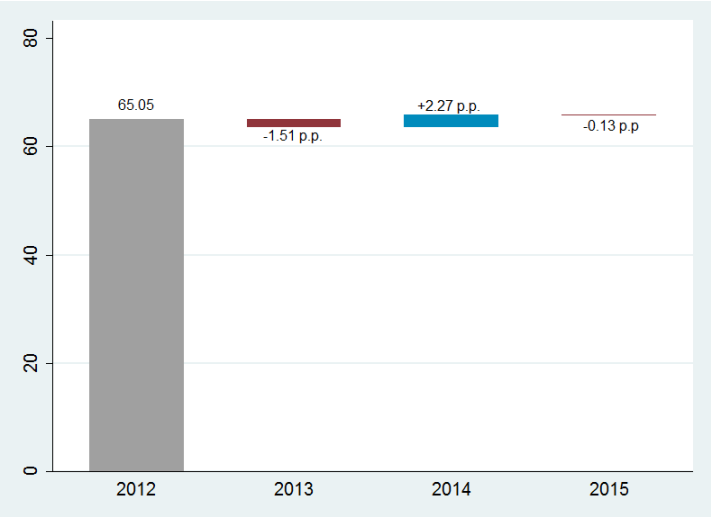
VARIABLES	(1)	(2)	(3)	(4)
$\Delta \ln FD_{it}$	0.355***	0.346***	0.344***	0.256***
	(0.0989)	(0.0939)	(0.0885)	(0.0961)
$\Delta \ln CREERppi_{t-1}$	-0.113**			-0.149***
	(0.0466)			(0.0499)
$\Delta \ln CREERppi_{t}$				-0.288***
				(0.0805)
$\Delta \ln xrer - ppi_{t-1}$	0.116***			0.101***
	(0.0279)			(0.0383)
$\Delta \ln xrer - ppi_{t}$				0.0941**
				(0.0449)
$\Delta \ln CREERcpi_{t-1}$		-0.122	-0.189	
		(0.121)	(0.136)	
$\Delta \ln CREERcpi_{t}$			-0.273***	
			(0.0999)	
$\Delta \ln xrer - cpi_{t-1}$		0.226**	0.208**	
		(0.0906)	(0.0950)	
$\Delta \ln xrer - cpi_{t}$			0.112	
			(0.0696)	
Constant	0.0403**	0.0390**	0.0481**	0.0590***
	(0.0168)	(0.0185)	(0.0204)	(0.0224)
R-squared	0.004	0.004	0.005	0.007
Observations	13,098			
Number of id	1,390			

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

3.5 GVCs and REERs

Figure 8 and Figure 9 show the share of domestic value added in gross export (DVA) for 2012-2015. According to Rosstat Input-Output tables, domestic value added in gross export for all industries was 65.05% in 2012 as it then increased up to 65.69% by 2015. The major growth was observed in 2014 (+2.27 p.p. y/y).

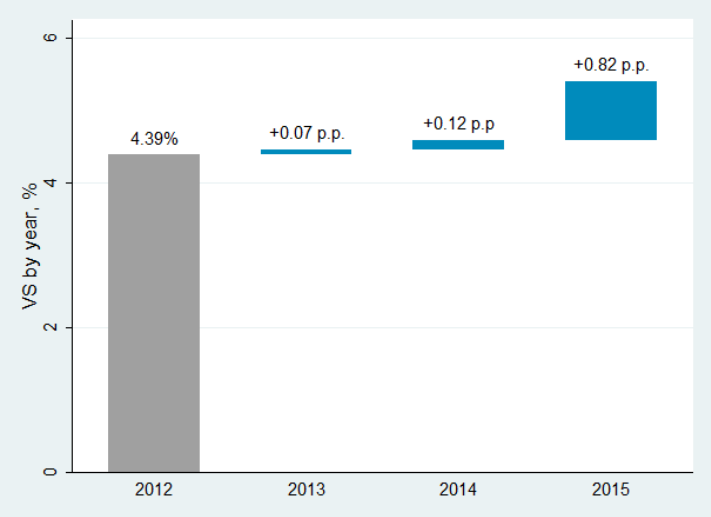
Figure 8. DOMESTIC VALUE ADDED IN GROSS EXPORTS, 2012-2015, %



Source: Rosstat, authors' calculations.

Figure 9 shows respective dynamics for import goods for intermediate consumption (VS). In 2012 it was around 4.4% with further growth up to 5.4% in 2015. Comparing with the results received by Kadochnikov (2015) using GTAP database for 2011, the share of imported inputs used for producing export goods is almost twice smaller. This drop could be explained by differences in the dataset used in the estimation process, as well as by the use of additional correction matrix for domestic goods (A^d). The most significant growth was in 2015 (+0.82 p.p.) when the measure has reached 5.4%. Moreover, this growth was accelerating since 2012.

Figure 9. DYNAMICS OF IMPORT GOODS FOR INTERMEDIATE CONSUMPTION (VS) IN RUSSIA, 2012-2015

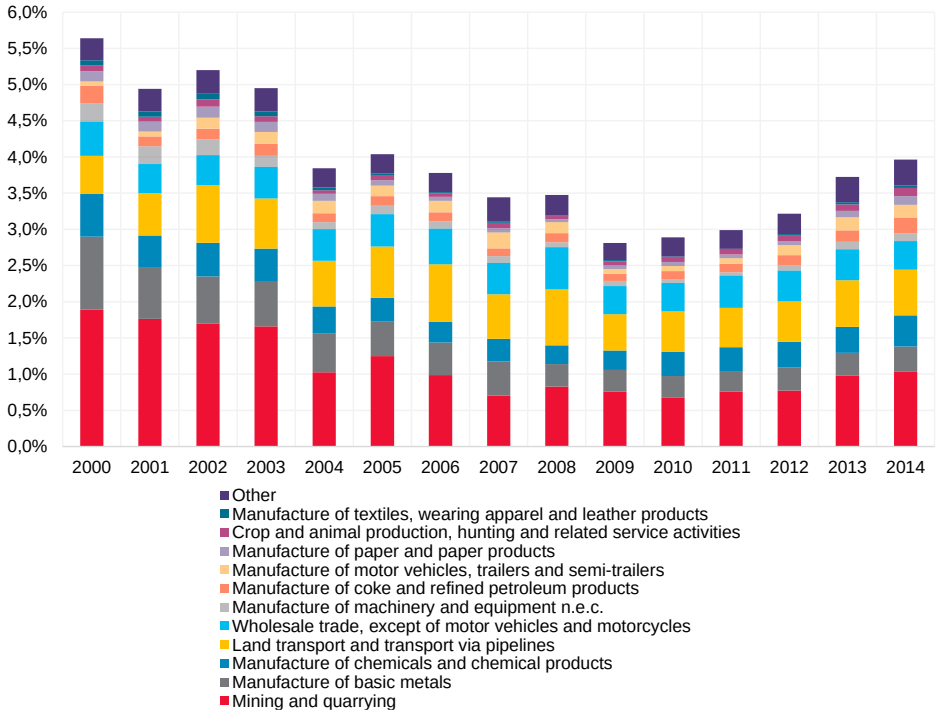


Source: Rosstat, authors' calculations.

Relatively higher degree of integration into GVCs correspond to such industries as primary metals, chemicals, ships, aircraft and spacecraft, oil and gas extraction, air and space transport, cars, coke and petroleum. Moreover, higher GVC participation level corresponds to traditional resource-rich sectors and defence.

Figure 10 shows the dynamics of VS by sectors in 2000-2014, which is calculated based on the WIOT. Before the Financial crisis of 2008-2009, there was a sharp contraction of Russian backward participation in GVCs (mainly due to mining and quarrying and manufacture of basic metals). After 2009 there is a graduate recovery of VS by better evaluation of mining and quarrying, manufacture of motor vehicles, and manufacture of coke and refined petroleum.

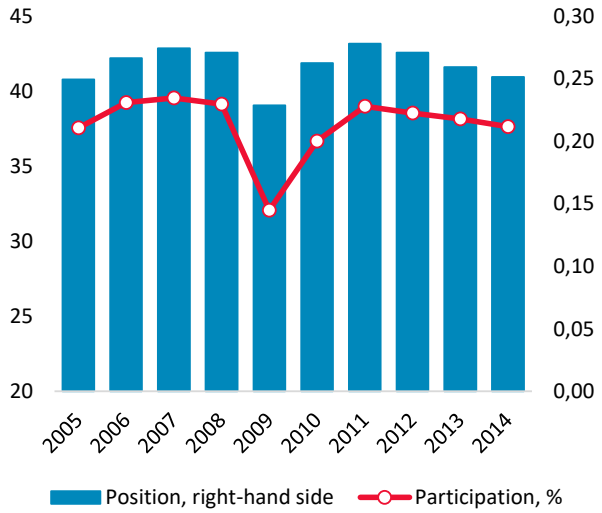
Figure 10. DYNAMICS OF IMPORT GOODS FOR INTERMEDIATE CONSUMPTION BY INDUSTRY (VS) IN RUSSIA, 2000-2014



Source: WIOT, authors' calculations.

Figure 11 represents the dynamics of Participation and Position indices in Russia in 2005-2014. The calculations are based on our evaluation of backward participation using WIOT and the measure of forward participation from the TiVA dataset.

Figure 11. DYNAMICS OF POSITION AND PARTICIPATION INDICES IN RUSSIA, 2000-2014



Source: https://stats.oecd.org, authors' calculations.

$Position$ and $Participation$ indices move similarly. We see the sharp drop after the Financial crisis in 2008-2009 in both measures and further gradual recovery. As $Position\ Index$ shows how far the country from the downstream position is, the results based on Russian data show the country's upstreamness (or conventional integration into GVCs at first stages of production). Naturally, Russia is more upstream than the group of emerging and advanced countries[10]. Aslam et al. (2017) estimate $Position\ Index$ for the group of advanced countries less than or close to 0 for each year during 1990-2013 moving more downstream. EMEs excluding China move more upstream during this period (close to 0.1 in 2013). Our estimations for this measure fluctuates between 0.2 and 0.25 (the sample period corresponding to the Financial crisis in 2009 was not considered).

As $Participation\ Index$ shows the intensity of involvement of a country in GVCs, the larger the measure, the greater the intensity. Based on data for Russian economy, $Participation\ Index$ during 2005-2014 does not exceed 45% being close to 40% (excluding the period of the Financial crisis in 2009). For advanced countries[11] this measure has grown

[10] Based on calculations in Aslam A., Novta N., Rodrigues-Basros F. *Calculating Trade in Value Added.* – IMF Working paper, 2017.
[11] Aslam A., Novta N., Rodrigues-Basros F. *Calculating Trade in Value Added.* – IMF Working paper, 2017.

from about 47% in 1990 to about 63% in 2013, and for EMEs excluding China it has grown from about 40% in 1990 to about 55% in 2013[12].

We next introduce GVCs' measures into the analysis:

$$\Delta \ln V_{it} = \alpha + \beta_1 \Delta \ln CREER^{i}_{t-1} + \beta_2 \Delta \ln xrer^{i}_{t-1} + \eta Position + \mu Participation + \gamma \Delta \ln FD_{it} + \varepsilon_{it} \quad (17)$$

Table 10 shows the results for equation (17). The impact of foreign demand is still positive and significant with values similar to previous specifications. We also receive similar but less significant values for our IS-REER measures (cost- and output-based). The $Position$ index has negative and significant coefficients (columns (2)-(4)). It means that the closer industry to the final consumer (diminishing $Position$), the higher level of competitiveness it has (increasing export). $Participation$ index has positive and significant impact (columns (3)-(4)). It means that the higher the level of intensity of involvement of an industry into GVCs, the more competitive the industry is. In the last column results of the full specification are presented with the highest R-squared received in recent framework.

[12] The direct comparison of $Position$ and $Participation$ indices estimated by Aslam et al. (2017) and based on the TiVA dataset could be inaccurate due to differences in methodology for estimating forward and backward participation, as well as constructing Input-Output Tables.

IS- REER AND GVC, 2000-2013, MANUFACTURING Table 10

VARIABLES	(1)	(2)	(3)	(4)
$\Delta \ln FD_{it}$	0.356***	0.376***	0.286***	0.204*
	(0.0830)	(0.0894)	(0.0903)	(0.108)
$Position$	-0.119	-0.136*	-0.162**	-0.210**
	(0.0750)	(0.0777)	(0.0791)	(0.0991)
$Participation$	0.0233	0.0255	0.0298*	0.0376*
	(0.0166)	(0.0173)	(0.0171)	(0.0206)
$\Delta \ln CREERppi_{t-1}$		-0.120**		-0.156**
		(0.0550)		(0.0623)
$\Delta \ln CREERppi_{t}$				-0.286***
				(0.0838)
$\Delta \ln xrer - ppi_{t-1}$		0.104***		0.0536
		(0.0324)		(0.0509)
$\Delta \ln xrer - ppi_{t}$				0.0204
				(0.0587)
$\Delta \ln CREERcpi_{t-1}$	-0.131		-0.186	
	(0.131)		(0.148)	
$\Delta \ln CREERcpi_{t}$			-0.286***	
			(0.104)	
$\Delta \ln xrer - cpi_{t-1}$	0.242**		0.225**	
	(0.111)		(0.109)	
$\Delta \ln xrer - cpi_{t}$			-0.0162	
			(0.0763)	
Constant	0.0269	0.0279	0.0432	0.0496*
	(0.0246)	(0.0248)	(0.0263)	(0.0267)
R-squared	0.006	0.006	0.008	0.01
Observations	11,532			
Number of id	1,216			

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4. CONCLUSION

In the light of complicated inter-industry and inter-countries linkages in international trade and GVCs, the perception of the impact of exchange rate movements on an economy's competitiveness in foreign trade has been changed. Conventional approach for building REER (based on lagged trade flows and CPI deflator) could be ineffective and useless from this point of view. The alternative indicator should take into account the following issues:

First, the structure of a country's economy. As Russia is a small open economy, the industries are integrated into the international trade, but the level of integration differs among sectors. So each sector will be affected by real exchange rate fluctuations differently and the overall impact on the whole economy is not obvious.

Second, specificities of a production process in different industries (or companies). We derived two main channels of the impact of exchange rate movements on industry's competitiveness: *cost channel* (based on industry's intermediate import structure) and *output channel* (based on industry's export structure). We show that the least import-dependent Russian industries are coke and refined petroleum, oil and gas, and mining, and the most import-dependent industries are tobacco, office machinery and equipment, wearing apparel and fur, textiles, leather, machinery, and electrical machinery and apparatus. The influence from this channels is ambiguous, so the same movement of exchange rate can make the industry's performance either stronger or weaker. The co-movement of these REER measures means that during the period of currency fluctuations changes of company's costs of imported intermediates will be matched by the corresponding changes in the price of its output (for example, in such industries as oil and gas, basic metals, coal, coke). The multidirectional dynamics of the cost- and output-based REER measures could be a signal of either relatively favourable or relatively adverse developments (like in forestry, electrical machinery and apparatus, wearing apparel and fur, and machinery and equipment).

Third, industry's position in GVCs. Historically, Russia participates in the global value chains at the first stages being a supplier of raw materials for foreign producers. In literature the level of country's integration in GVCs is usually measured by the participation and the position indices calculated using backward and forward participation measures. By using the WIOT dataset we find a sharp contraction of Russian backward participation in GVCs in 2008

(mainly due to mining and quarrying and manufacture of basic metals) and its graduate recovery after 2009 (mining and quarrying, manufacture of motor vehicles, and manufacture of coke and refined petroleum being the major drivers). Based on TiVA dataset we show the upstreamness and relatively small degree of integration of Russian economy in GVCs: $Position\ Index$ for 2005-2014 fluctuates between 0.2 and 0.25 (except of 2009 with the consequences of the Financial crisis) compared with 0.1 for EMEs excluding China and negative values for advanced economies. $Participation\ Index$ for Russia does not exceed 45% being close to 40% compared with 55% in 2013 for EMEs excluding China and 63% in 2013 for advanced economies.

The corrections introduced are helpful tools for understanding the impact of REER's movements on a certain industry (or specific company) and, consequently, on the economy's general level of trade competitiveness. Using the empirical strategy developed by Berthou and Dhyne (2017) we estimate the impact of conventional and industry-specific REERs on growth of export volume taking into account time and industry fixed effects and controlling for changes in foreign demand. For the subset of manufacturing industries for 2000-2013 we receive significant and positive coefficient for foreign demand and significant positive impact of exchange rates. Moreover, we observe that the results are, nevertheless, sensitive to the choice of a deflating scheme. In our paper we do not yet aim at directly testing the empirical performance of different REER indicators compared with conventional methodology of constructing CPI-based REER in terms of the ability to forecast other major macroeconomic variables. We leave that for further research given that choosing a particular comprehensive model specification for performing the latter exercise is by all means a question for separate discussion.

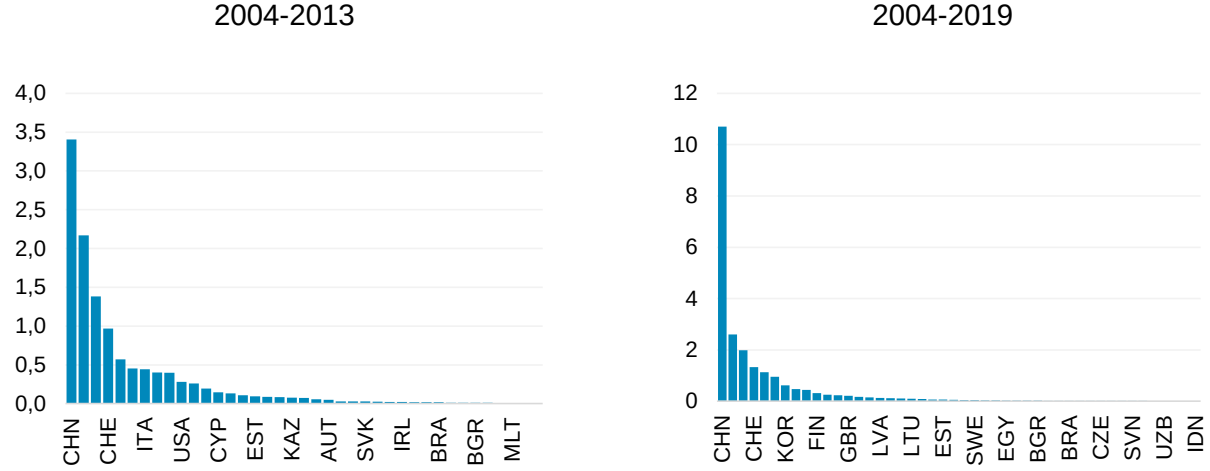
APPENDIX

SIMPLIFIED STRUCTURE OF INPUT-OUTPUT TABLE Table A. 1

	Industry i	
	domestic	foreign
Intermediate good j	d_{ij}	m_{ij}
	$C_i = \sum d_{ij} + \sum m_{ij}$	

Source: authors.

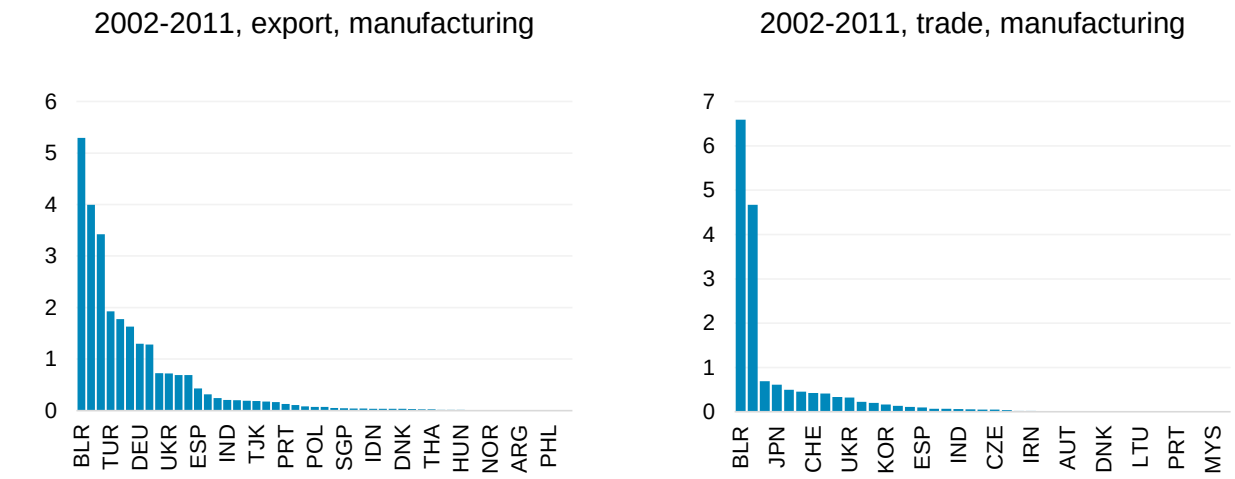
VARIATION IN WEIGHTS USED MAJOR PARTNERS DURING THE PARTICULAR PERIOD, CONVENTIONAL[13] Figure A. 1



Source: Bank of Russia, authors' calculations.

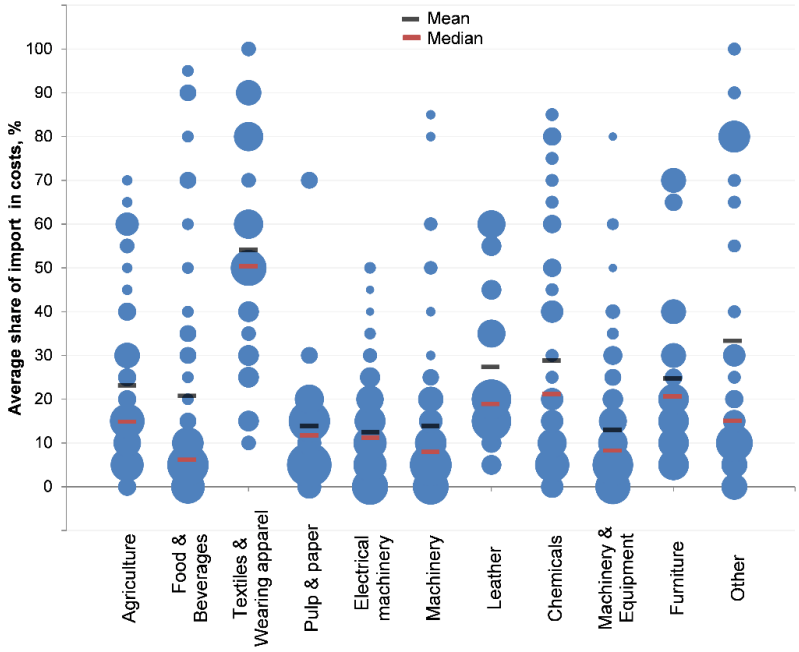
[13] The period since 2004 has been taken as the earliest available data begins since 2004.

VARIATION IN WEIGHTS USED MAJOR PARTNERS DURING THE PARTICULAR PERIOD, NEWLY-CONSTRUCTED[14] Figure A. 2



Sources: GTAP, authors' calculations.

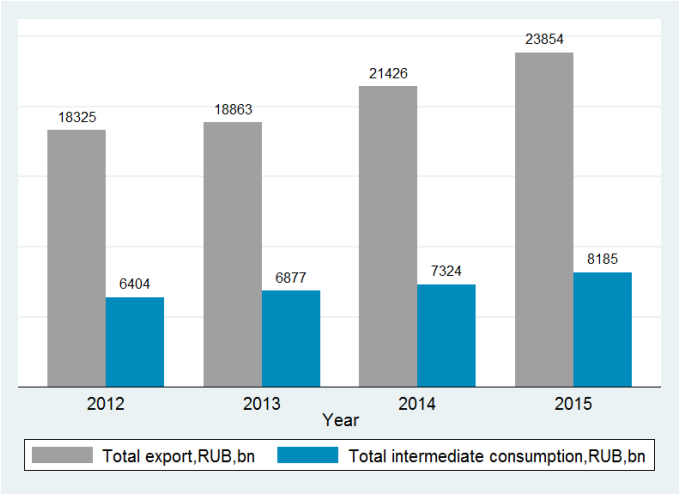
DISPERSION OF AVERAGE IMPORT SHARE OF COSTS Figure A. 3



Sources: Bank of Russia Company Survey, December 2016.

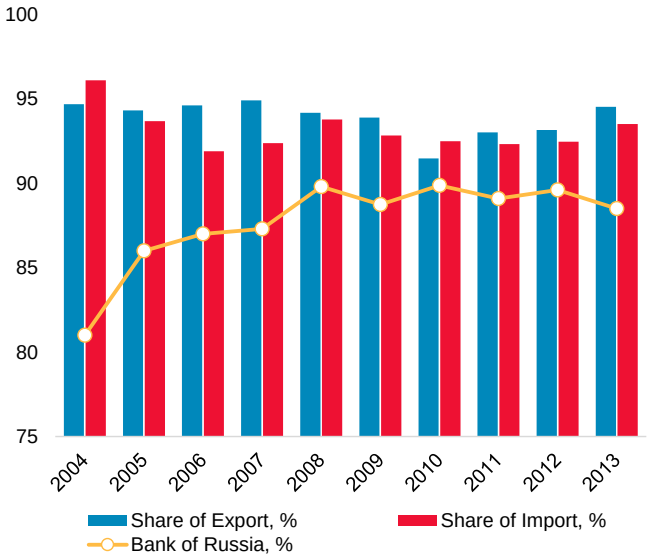
[14] The period since 2004 has been taken as the earliest available data begins since 2004.

DYNAMICS OF TOTAL EXPORT AND TOTAL INTERMEDIATE CONSUMPTION, 2012-2015 Figure A. 4



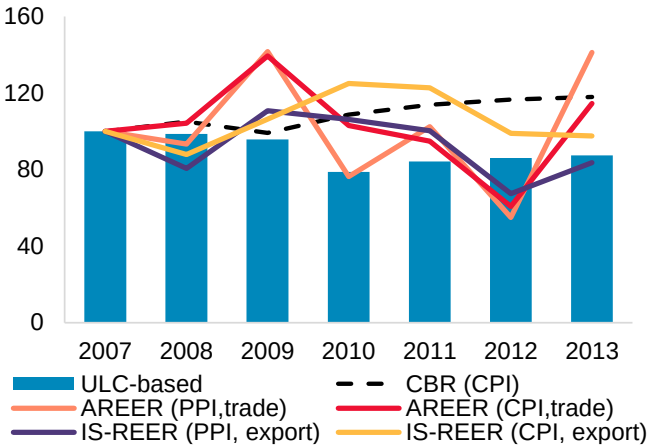
Source: Rosstat, authors' calculations.

COVERAGE OF MAJOR TRADE PARTNERS, % Figure A. 5



Source: Rosstat, authors' calculations.

THE DYNAMICS OF REERS BASED ON DIFFERENT WEIGHTS, 2007-2013 Figure A. 6



Source: Rosstat, authors' calculations.

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