

Russia's diversification prospects

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Abstract

The Russian economy heavily relies on exports of its natural resources. However, the resource-based status quo does not seem to be the route towards Russia's long-run prosperity. To improve its position in the global income ranking, Russia needs to diversify its exports and make them more complex. Using highly detailed data on trade flows and applying network theory apparatus, we evaluate the level of export complexity in Russia from 1995 to 2016 and compare it with that of its BRICS fellow members. We find that Russia is stagnant with respects to its relative level of export complexity. This sluggishness embraced the entire period between 1995 and 2016, much longer than the stage of anemic growth that started there a decade ago. We also conclude that the current stock of know-how in Russia is relatively low and fragmented, thus not letting Russia diversify into a broad range of more complex products. Russia might also need to export a wider variety of products to richer economies. Today, on a par with Brazil and South Africa, it supplies a broader range of goods to its slowly growing next-door neighbors.

Keywords: export diversification, economic complexity, export destinations.

JEL classification: F14, O33, O40.

1. Introduction

Monotonically increasing economic complexity is a precondition for sustainable economic growth. The causal link between economic complexity and growth was established in Hausmann et al. (2007), where economic complexity of a particular economy is approximated as a weighted income in all other countries exporting similar products. For instance, if the Pakistani economy becomes an exporter of an ultrasound imaging system, the latter fact is taken into account by setting an association between this product and income levels of its established exporters. Thus, by reflecting how rich a new exporter might potentially become if it survives international competition and keeps exporting products of a higher

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level of complexity, this simple economic complexity metrics provides an opportunity to estimate the growth potential of the economy of interest. The measure, which is called EXPY, turns out to be a robust predictor of the future growth rates. Moreover, Cherif et al. (2018) argue that EXPY is the only predictor of economic growth rates that survives a long list of sophisticated robustness checks.

Even though building a complex and diversified export economy might be considered as an exemplary path to prosperity, the empirical ubiquity of such a path is not very common, to say the least. In the second half of the XX century, only a handful of countries successfully transited from a large group of poor economies exporting simple products such as garments or foodstuffs, to a much smaller group of countries exporting a variety of complex products, such as automobiles, high-speed trains or electronics. South Korea, Taiwan and Singapore, to name a few examples of the post-World War II economic miracles, have not only distanced themselves from the group of poor countries, but also avoided the middle income trap (see Eichengreen et al., 2013). South Korea joined OECD, the club of rich economies, in 1996.

Unlike South Korea or Taiwan, Russian economic growth within the second half of the XX century was at best episodic. Even though this economy was clearly specific because of its settings dictated by its central planning nature, in terms of growth rates it nevertheless was similar to a large group of developing economies (Kar et al., 2013, Andrews et al, 2017), which failed to catch up with the most developed nations. However, building a complex and diversified economy is still Russia's ambition. Like many other economies in transition, Russia aspires to replicate the export triumph of China and Korea, even though this aspiration is so far predominantly just a declaration. In any case, such a potentiality is at best its future, and presumably a distant one.

Per contra, because of its position among the top 10 most populous economies of the world, Russia has no functional alternative, but to replicate the export success of South Korea, Taiwan or Finland if it aims to reach a comparable level of wellbeing. Its chronically anemic growth rates over the last 10 years are closely related to its poor ability to increase its level of economic complexity. This outcome is hardly the cause of weak growth in itself, but rather the result of a variety of more fundamental deficiencies, such as an underdeveloped national innovation system, poor protection of property rights and deficient infrastructure, etc. However, a developmental alternative of focusing on a small set of simple industries, such as tourism, natural resources and agriculture, might be a sufficiently powerful growth basis for a country with a small population such as Iceland, but is hardly enough to be a growth engine for larger economies. Consider Georgia, a home country for 3.7 million people, which is 11 times the size of Iceland in terms of population. Even though it exports agricultural products worldwide and has a competitive tourism sector of at least regional importance, its PPP per capita GDP level in 2017 was less than a quarter that of Finland.¹ Even though the latter is merely 1.8 million more populous than Georgia, it is nevertheless a host country for internationally competitive high-tech companies, such as paper manufacturing equipment exporters, icebreakers and ferries shipbuilders, telecommunication companies and the chemical industry, etc. To let its 144-million population

¹ <https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD>

prosper, Russia needs to build many more export capabilities than Finland has successfully built so far. Its growth rates cannot be sustainably fueled by resource incomes, since the latter are highly volatile and might have a relatively low upper limit due to rapidly advancing technological frontier and intensifying international competition in the petroleum sector.

At the same time, a wide perception of Russia as a petro-state capable of exporting natural resources is an oversimplified description of the true state of economic complexity that currently exists in Russia, as well as its growth opportunities. Russia is a typical emerging economy with unsustainable, i.e. episodic, economic growth (see Kar et al., 2013). It is indeed still fairly far from a leading technologically developed country featuring a wide range of competitive industries, comprising various productive skill-sets, know-how, reliable property rights protection, inclusive financial system and competitive markets, etc. Russia clearly does not belong to the group of economic complexity leaders, such as Germany, Japan or the US. However, neither does it lie among a group of economic complexity laggards. In fact, we claim that Russia's position lies somewhere above the median in the world complexity ranking.

To see that the latter is indeed the case, we use the country space: a network that uses the idea of relatedness among exporting economies. Each node of this network corresponds to a particular economy and each link reflects export similarity between the corresponding pair of economies. For instance, since Israel and Morocco both export oranges, they have at least one product which both of them sell internationally. To build this network, we use export data from the Atlas of economic complexity². Since we discuss the main methodological building blocks later in the paper, here we provide a brief and intuitive description of the applied approach. The idea behind the country space is similar to the one introduced in Hidalgo et al. (2007). More complex economies are likely to have more technological and export commonalities. This follows from the fact that two randomly selected economies are more likely to export many products in common if both of them are well-diversified. Paraphrasing, if two randomly selected economies both export a wide range of goods, there is a higher chance of an overlap between their export baskets. But a higher level of diversification is a feature of more complex economies (see Tacchella et al., 2012). Thus, it is more likely that two random economies are more similar to each other if both economies have a wide arsenal of various exporting industries, both simple and complex. At the same time, two economies with a narrow range of exporting industries have reduced chances of having a wide range of similar products to export.

The country space spans 133 economies in the year 2016. To obtain better visualization results, we omit weak links between economies, thus disregarding minor similarities between a random pair of economies.

Russia is clearly not a part of the densely linked group of rich and upper middle-income industrialized economies (Fig. S1, Supplementary material 1). We name the latter “the technological core”. This group comprises countries characterized by a relatively high level of export sophistication. The Russian economy, however, is located in the immediate proximity to the technological core, on a par with South Africa, Argentina and Ukraine, as well as Australia, Ireland and

² <http://atlas.cid.harvard.edu/data>

Norway. A group of petro-economies, such as Oman and Bahrain, are clustered in the lower left corner of the country space, fairly distant from Russia, as well as from its more economically complex neighbors.

Even though we can use arguments outlined above to claim that the current state of economic complexity in Russia is more optimistic than is currently articulated by the gloomy petro-state narrative, the situation is more complex. First of all, the claim is static and does not inform the reader about the position of Russia in the previous snapshots of the country space. Is Russia gradually drifting towards a group of petroleum suppliers? Or, perhaps, it is slowly docking to the dense part of the country space? More importantly, the analysis tells us little about Russia's export opportunities. At best it implies that Russia has a potential to build a more complex economy, but does not provide for possibilities and ways of doing it beyond its visualization reach. However, being able to discover a set of export opportunities is important for looking into a possible future for the Russian economy. Is it more likely that Russia will move closer to the dense part of the country space, the technological core, and eventually join the group of complex products exporters? Or, alternatively, will it be trapped in its current position as an important natural resources supplier, and remain a peripheral exporter of more sophisticated products? Or, perhaps, it will instead be pushed out from its current position by its competitors and will find its market share in complex products narrowing, thus moving further away from the technological core of the country space towards the deep technological periphery? We try to answer these questions later in this paper.

In the following section, we briefly introduce the methodological building blocks of the study and the dataset we use to calculate various indicators related to economic complexity and diversification. Then, we investigate the evolution of economic complexity in Russia and compare it with that of the other BRICS³ members. We then link export diversification results in BRICS economies with their structural transformation patterns. Later, we evaluate Russia's export opportunities, both in terms of technological feasibility and geographic coverage, and again compare it with the possible export prospects of its BRICS co-members. Finally, we briefly discuss the difference in the geography of export diversification of BRICS economies.

2. Basic methodology

We start this section from an introduction of the method, which provides an intuitive picture of the mechanics of economic complexity methodology. We base this introduction on a relatively new, but rapidly growing literature on economic complexity. The fundamental analytical insights of this literature are presented in Hausmann and Klinger (2006, 2007), Hidalgo and Hausmann (2009), Hausmann et al. (2011). However, we do not provide a rigorous description of all algebraic proofs and derivations in this paper, focusing instead on the intuition of the method. An interested reader is invited to check all the algebraic blocks of the method in the complementary paper.⁴

³ BRICS is a group of five major emerging economies, which are Brazil, Russia, India, China and South Africa.

⁴ For a more fundamental description of the method, see Lyubimov et al. (2018).

We start here with the definition of revealed comparative advantage (RCA) introduced by Balassa (see Balassa, 1965):

$$RCA_{c,p} = \quad (1)$$

where $x_{c,p}$ corresponds to the value of product p , which is supplied by country c internationally. RCA can be interpreted as a ratio between the share of country c in the total value of product p 's global export and the share of economy c in the world economy. This interpretation is meaningful, as it posits that a larger economy is expected to be a larger exporter of each internationally traded product. RCA, therefore, measures the importance of economy c as an exporter of product p .

We then set a threshold value of RCA to distinguish between who should be considered as a marginal exporter of a particular product, and who is, by contrast, a sufficiently large exporter of product p . This threshold level is an essential ingredient of the method, as a large economy exporting a dozen of intercity buses a year clearly does not have comparative advantage in exporting intercity buses, and thus should not be considered on a par with an economy exporting thousands of intercity buses per annum. The conventional boundary value, which is typically used in the literature on economic complexity, is 1, i.e. it is typically recommended to assign 0 to any $RCA < 1$, and 1 whenever $RCA \geq 1$. We, however, use a less restrictive threshold value. We deviate from the conventional threshold of 1 since Russia is a large exporter of natural resources. Whenever natural resources become more expensive, the denominator of expression (1) might become larger. This introduces a possibility that a natural resource exporter might artificially fail to qualify as an important supplier of a particular non-resource product. If we follow this rule of thumb and use the conventional threshold, we can erroneously conclude that an economy is not a prominent exporter of a product, while it might actually be so. The opposite can also hold true: a declining resource price might synthetically cause the appearance of a range of intensively exported non-resource products on our radar. To mitigate the impact of resource prices on RCAs, we reduce the threshold value to 0.5.

RCA values form the product-country matrix $M_{p,c}$. In the latter, any of its entries is either 0 or 1. Each column of $M_{p,c}$ is thus a description of an economy in terms of its export basket composition. Does a particular economy have a revealed comparative advantage in exporting product A ? 1 in front of the corresponding row-name indicates that the answer is positive, while 0 implies “no”.

Because of the binary structure of $M_{p,c}$'s entries, two randomly selected columns of $M_{p,c}$ can be easily compared if we need to know whether two economies export similar products. A more diversified and complex economy exports a larger variety of products. Such an economy is likely to export a product, which another random economy also exports, regardless of the complexity of the latter. For instance, both Japan and Germany export automobiles and medical equipment, tractors and medications. Their export structures clearly exhibit some commonalities. The Israeli economy is also complex. Similarly to Japan and Germany, it is an exporter of medications. But it also exports what the simpler economy of Morocco sells abroad as well. Israel and Morocco are both exporters of oranges.

Thus, the Israeli economy possesses the same skill-set as Morocco with respect to exporting citrus fruit. If we associate these export similarities with links, then the more diversified and complex economies clearly have more links with the rest of the world than the less diversified nations. In other words, the former are more central in terms of their connectedness with the rest of the world than the latter. We can apply a network centrality approach to measure the level of centrality of both, economies and products. Eigenvector centrality has the specific advantage of allowing us to account for nodes (countries) directly and indirectly linked to a particular node (another country). When applying this measure of centrality, we receive a vector which lets us rank each economy according to its relative economic complexity level. The respective measure of centrality is known from the literature (Hausmann et al., 2011) as economic complexity index (ECI).⁵

ECI is calculated as follow. First, we calculate a stochastic Markov matrix:

$$W_C = \quad (2)$$

where $k_{c,0}$ is a simple measure of diversification, equal to the column sum of matrix $M_{p,c}$, while $k_{p,0}$ is a basic measure of product ubiquity, a row sum of $M_{p,c}$. $M_{p,c}^T$ is a transpose of $M_{p,c}$.

We then take the second-largest eigenvalue and its corresponding eigenvector. All the elements of the eigenvector corresponding to the largest eigenvalue are of the same value because of normalization and therefore do not add any information.

After we calculate the eigenvector corresponding to the second-largest eigenvalue, we standardize this eigenvector to receive the following result:

$$W_C = \quad (3)$$

where \vec{K} is the eigenvector of W_C corresponding to the second-largest eigenvalue, $Av_{\vec{K}}$ is its average value, and $Stdev_{\vec{K}}$ corresponds to its standard deviation. Expression (3) defines ECI.

We can also apply a similar logic to calculate the product complexity index (PCI) which provides a distribution of products according to their level of techno-

⁵ Along with providing the formal definition of ECI, we might want to use a simple metaphor to illustrate the idea behind its calculation. Compare an economy with a word, where each letter corresponds to a particular product exported by a given economy. A more diversified and complex economy sells more products internationally, both simple and complex, and therefore its export basket corresponds to a longer word. “Pneumonoultramicroscopicsilicovolcanoconiosis” is a 45 letters long word which contains 16 original letters, i.e. more letters than a half of the English alphabet counts. This word’s meaning is a “lung disease caused by the inhalation of silica or quartz dust”. Clearly, such a long word has at least one letter in common with thousands of other words, both short and long. On the contrary, such a 3-letter word as “rye”, which means “a cereal plant that tolerates poor soils and low temperatures”, has two letters in common with “pneumonoultramicroscopicsilicovolcanoconiosis”, but has neither letter commonalities with equally short “bit”, nor even with such a giant as “floccinaucinihilipilification”, whose meaning is “the estimation of something as valueless”. Therefore, longer words have more letters in common with other words. If we associate stronger letter commonalities with a link, then a longer word is clearly characterized by a larger number of links than a shorter one. Longer words are better related to longer words, since they have a larger share of common letters. Shorter words are weakly related to both shorter and longer words, as it is less likely that a short word has many letters in common with other words. Having more links, such a word can therefore be considered as a more central one. Similarly, a more diversified and complex economy is more central, as it has more products which are also exported by other nations, and therefore it is better related to the rest of the world, predominantly to its more developed part, than a less diversified country.

logical complexity. Parallel to our discussion of export similarities among exporting economies, we argue that more complex products are better connected to others than the less complex products.

We do not replicate all the steps here, as they follow the same logic as the derivation of ECI. The complexity measure for products PCI is defined as follows:

$$PCI = \frac{\overline{Q}}{Av\overline{Q} \cdot Stdev\overline{Q}} \quad (4)$$

where \overline{Q} is the eigenvector corresponding to the second-largest eigenvalue of the respective adjacency matrix, with its entries reflecting weighted and normalized co-export of different pairs of products, $Av\overline{Q}$ is its average value, and $Stdev\overline{Q}$ corresponds to its standard deviation.

$M_{p,c}$ can also be used to build the product space, which is a network of all internationally traded products and their technological links. Since nodes clearly correspond to products in this network and therefore are easily identifiable, what is left to be done is to decide how to determine links. We use a definition which is based on the following key assumption (see Hausmann et al., 2011). Consider two random products and calculate how often these two products are co-exported, i.e. how many economies have both of them in their export baskets within a particular year. If two products, A and B , are predominantly exported in tandem with each other, we assume that A and B are technologically related. These two products might be t-shirts and polo shirts or buses and trucks which clearly have substantial amount of know-how in common. Given this assumption, we can calculate the frequency of co-export for any pair of products. This frequency, which is called proximity, corresponds to the following expression:

$$proximity_{q',q} = \frac{\min(k_{q,0}, k_{q',0})}{\max(k_{q,0}, k_{q',0})} \quad (5)$$

where q' and q are two products, $m_{q',c}$ and $m_{q,c}$ are row vectors of the product-country matrix $M_{p,c}$, each showing which economies have comparative advantage in exporting the respective product. $k_{q,0} = \sum_c m_{q,c}$ and $k_{q',0} = \sum_c m_{q',c}$ are ubiquity measures of products q and q' respectively, each calculating the number of economies having revealed comparative advantage in exporting product q or q' . We select the maximal of the two ubiquity values, as otherwise we can receive a misleading estimate of proximity between two randomly selected products. For instance, if 20 economies export product A , while B is exported by 15 countries, and A is exported every time product B is exported, it is clear that the frequency of co-export of A and B is equal to $15/20$ or $3/4$, not to $20/20$ or 1. This follows from the fact that exporting product B implies exporting product A , but not vice versa.⁶

⁶ One can question the empirical reliability of the approach, codified by expression (5), as a way to measure technological relatedness of a pair of products. Ubiquitous goods, such as t-shirts and carrots, can be frequently co-exported, however, they are clearly technologically unrelated. It is important to take into account that proximity is far from providing the absolute level of reliability, but its relative reliability is sufficiently high, as it allows to identify correctly as many as 70% of links. The remaining proximities link technologically distant products and should be dismissed. Even though the probability that the approach interprets a spurious link as a correct one looks quite large, it is nevertheless tolerable if our goal is to visualize the general structure of the product space and to see the role a particular economy plays as a product exporter.

Given the definition of proximity determined in (5), we can build a graph, where each node represents a product and each link represents a proximity between a pair of products. We start by applying the maximum spanning tree algorithm, which builds a “skeleton” of the graph by connecting all its nodes. We then add all strong links to the skeleton, excluding any links weaker than 0.55. Finally, we also use a force spring algorithm to achieve a better visualization of the graph.

We use data from the Atlas of Economic Complexity⁷, which provides a refined version of the United Nations Statistical Division data on trade. We use the Harmonized System (HS) 4-digit export data classification, where a 4-digit code is assigned to each product. Using a larger number of codes, HS provides a more detailed description of the world trade flows than an alternative of SITC 4-digit codes. The data are then refined by the Atlas of Economic Complexity team, which transforms the initial dataset into a more reliable version.

We have to emphasize that these data have two important shortcomings. First, even though the data provide a detailed answer to who exports what and where, there are, however, no data on services exports. This is a serious flaw, since services are becoming more and more important part of global trade.⁸ Moreover, these data do not let us dissect a particular product and track it globally in the form of a global value-added chain, even though a substantial portion of products are produced exactly within global value chains (see Timmer et al., 2014). Therefore, these data count a simple assembly operator as an exporter of the entire product, which might produce a substantial upward bias when evaluating the export complexity of the respective economy. However, these data limitations are not critically distorting for our argument. The resulting ranking is quite intuitive, placing Japan, Germany, the United States, China and France at the top of the economic complexity ranking and Guatemala, Kenya, Madagascar, Peru and Tanzania at its bottom. It has the same precision as many internationally recognized rankings, such as the Corruption Perception Index, which is annually published by Transparency International.⁹ The latter clearly provides a boundary line between the group of low corruption leaders and the group of laggards, but it is difficult to conclude if Brazil is actually less corrupt than Argentina, since both countries are located only a few positions away from each other in the latest version of the ranking.¹⁰

3. Economic complexity dynamics in Russia and its BRICS counterparts

We do not provide the entire ranking that covers 133 economies here (but we can provide the ranking by request). Instead, we present ECI values for five BRICS economies, therefore tracking the evolution of economic complexity in BRICS member-countries from 1995 to 2016.

As it follows from Fig. 1, China stands out as a different (most complex) economy if we contrast it to the rest of BRICS with respect to economic complexity. India is showing some moderate progress in building a more complex economy,

⁷ <http://atlas.cid.harvard.edu/data>

⁸ <http://atlas.cid.harvard.edu/press-release>

⁹ <https://www.transparency.org/>

¹⁰ https://www.transparency.org/news/feature/corruption_perceptions_index_2017

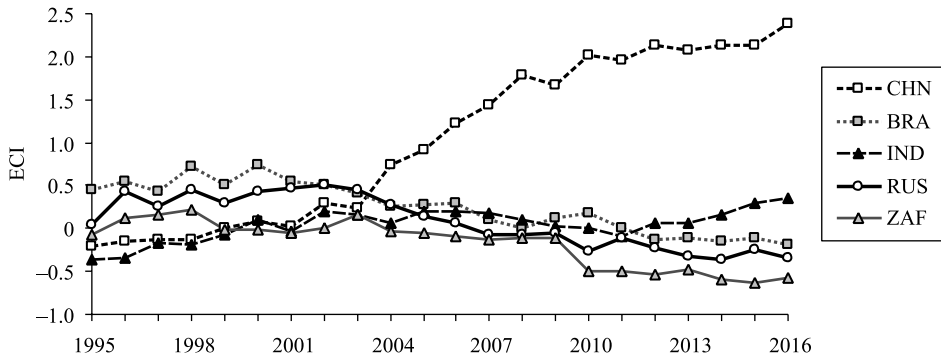


Fig. 1. ECI values for BRICS economies, 1995–2016.

Source: we use the data from <http://atlas.cid.harvard.edu/data> and apply expression (3) to derive this result.

but there is so far no certainty regarding its ability to sustain this ascent. As for Russia, Brazil and South Africa, unlike China and India their level of economic complexity is at best stagnant. As ECI is a relative measure of complexity, this implies that Russia, Brazil and South Africa might gradually lose their relative complexity positions as a consequence of international technological spillover.

For instance, in the second decade of the XXI century there are many more economies than 70 years before, where local engineers have sufficient skills to build a national electric grid. As a consequence of technological spillover and penetration, many more economies can build and develop their electricity infrastructure using their own capabilities. Moreover, they might themselves start exporting technical solutions to international customers, thus increasing the global supply of electrical grid systems. This might drive incomes of traditional exporters of electric grids down. However, the latter economies might not become less complex in absolute terms, as they retain the stock of their know-how as time passes. What they might lose is the technological race against a range of their competitors, both developed and emerging.

We receive a similar result after we build a graph representing a network where nodes correspond to all globally exported products which are ciphered with HS 4-digit codes, and links measuring technological proximity, which is determined in (5), between each pair of products. This network is known in the literature as the product space (see Hausmann et al., 2011). We use this visualization tool to see how BRICS countries evolve over time with respect to their economic complexity level. We visualize their progress by representing all BRICS economies in the product space separately, one after another.

Fig. S2 (see Supplementary material 2) features the product space, a network of all globally exported products and their technological links. More complex goods, such as chemical products, machinery and industrial goods are located in the dense central part of the product space, while agriculture, forestry, fuels and garments are predominantly located at its periphery. More complex products are placed in the central part of the product space because of their more central position in the network (see our discussion of network centrality in the previous section). To portray the export structure of a particular economy, we place a black square corresponding to the revealed comparative advantage of the economy in exporting a product above the respective node (product) in the product space.

As it follows from Fig. S2 (see Supplementary material 2), with respect to its level of economic complexity and diversification, Russia is much closer to Brazil and South Africa than to India and China.

Russia exports substantially fewer products belonging to the dense core part of the product space than China or India. What it exports predominantly corresponds to the next-door neighborhood of the core part of the product space, as well as to its periphery. This implies that Russia by and large exports goods which might be attributed to the initial stages of globally engineered value added chains, such as the extraction of natural resources and a following few stages of their processing, as well as relatively simple final products.

Thus, our conclusion here is that India and China are clearly more diversified and complex economies than the remaining three members of BRICS: Brazil, Russia and South Africa. Later in the paper, we will discuss another important distinction between these three BRICS economies on the one hand, and China and India on the other. In the continuance of this section we provide more details about economic complexity in Russia.

It follows from Fig. S3 (see Supplementary material 3) that the time span which corresponds to the period of relative technological stagnation in Russia is much longer than the decade of slow growth, 2008–2017.¹¹ Russia's technological stagnation is at least as long as 22 years, covering the entire period of 1995–2016. It is definitely incorrect to conclude from this result that the economy of Russia is the same in 2016 as it was in 1995. But its overall level of complexity is indeed close to what it was a few years after the collapse of the USSR. Russia's long-term growth is strongly attached to its level of economic complexity. Its rapid growth in 2000s was, first of all, a result of the increase in commodities prices at the beginning of the XXI century, and, second, a consequence of the inward multiplicative response to the growth of resource revenues, which chiefly propelled internally oriented and non-complex industries and services. As soon as this shock faded away, the economy returned to its fundamental growth rates associated with its level of complexity.

This argument is consistent with what we can conclude from Fig. S4 (see Supplementary material 4), where we depict import profiles of Russia in 1995 and 2016 respectively. Within this time span, Russia definitely improved its position as an importer of products. However, as an exporter Russia is stagnant. Its economy was at best as complex in 2016 as 22 years before. Because of high oil prices in 2000s, Russia was able to import a variety of consumption and investment goods. The latter, however, did not play an important role in building a broad range of export capabilities. The expansion of import was predominantly associated with consumption and internally oriented production boom, sponsored by growing oil and gas revenues.

4. Structural transformation and productivity growth in BRICS economies

The difference between export diversification progress in China and India on the one hand, and the lack of such a progress in Brazil, Russia and South Africa on the other, might reflect the contrast in the direction of structural transforma-

¹¹ <http://prosyn.org/9uOFAIL>

tion in these economies. While China, and to a much lesser extent India, experienced a transition from low-productivity to high-productivity sectors since 1995, the other three BRICS countries were much less successful in reshaping their economic structure. After years of economic reforms, the latter three economies still rely on a combination of sectors, which provides relatively low level of productivity.¹² This does not imply that the level of productivity in these countries stays stagnant, as it can still grow because productivity might increase within economic sectors. However, the number of sectors which are highly productive remains low.

McMillan and Rodrik (2011, 2014) argue that the growth of productivity in Latin American and African economies is predominantly powered by the “within sectors” component of economic growth, which, like in the Solow model (see Solow, 1956) relies on capital accumulation and technological progress, while the “structural” component in spirit of the Lewis model (see Lewis, 1954) provides a negative change in the level of productivity in these countries. The latter outcome, McMillan and Rodrik argue, is a result of a *laissez-faire* approach towards globalization, which caused manufacturing sectors to shrink and forced discharged employees to migrate towards less productive sectors.

During the 1990s, the economy of Brazil experienced a reduction in its manufacturing sector. McMillan and Rodrik (2014) indicate that the released labor masses transited to relatively unproductive sectors, such as personal and community services and wholesale and retail trade. Even though Firpo and Pieri, who analyze the case of Brazil in (McMillan et al. 2016), indicate that within 1993–2008 this trend was slightly reversed, the structure of Brazilian economy heavily relies on financial and personal services, wholesale and retail trade, hotels and restaurants. At the same time, Rodrik (2016) considers the expansion of manufacturing sector as the primary engine of positive (i.e. productivity-increasing) structural transformation for developing economies. In his view, manufacturing is also closely related to export, as industries use global markets to increase their output and incomes. Therefore, negative structural change goes hand-in-hand with the lack of export diversification. The latter conjecture is supported by our analysis in the previous section, as well as by sectoral export statistics provided by the Atlas of economic complexity, which also takes into account data on services. In 1995, the largest articles of Brazilian exports were iron ore and concentrates, solid soybean residues, coffee, sugarcane and unwrought aluminum. Then, sectors such as agriculture, metals, minerals, textiles and stones contributed near 2/3 to the total value exported by Brazil. The situation had changed little 21 years later. The share of more complex manufacturing sectors declined, while services acquired a larger role. Within services, information and computer technology was a leading sector in 2016, while in 1995 it was transportation.

Firpo and Pieri (see McMillan et al. 2016) argue that it might be too difficult to reindustrialize the economy of Brazil. They suggest not to prioritize one sector over another, but instead to rely on horizontal developmental approach by improving, for instance, the quality of mass education to lift the level of pro-

¹² It does not matter if a particular economy reached this sectoral structure after it had gone through the process of deindustrialization (see Rodrik, 2016), or if it has never experienced any higher level of manufacturing. More important is that after years of reforms, the economy is still shaped by a mix of economic sectors which are unable to generate a discernibly higher level of per capita income.

ductivity in the entire economy. Their prescription, however, might be infiltrated with serious flaws, as some sectors, such as manufacturing or finance, are more scalable than others, such as personal and community services. Therefore, it might still be important to support export-oriented manufacturers and services, since, first, they can pay off by generating larger output and incomes and, second, as argued by Rodrik (2016) and McMillan and Rodrik (2011, 2014), that was the lack of state support during the era of globalization which caused the contraction of manufacturing.

The South African economy is yet another story of insufficient positive structural transformation. As is argued in Goga et al. (2018), the economy of South Africa shifted its structure towards low-productivity and resource-based activities. Almost 64% of South African exports in 2016 relied on simple sectors, such as agriculture, metals, minerals, textiles and stones, which is even more than their combined share in 1995. More complex industries have a varying share in total exports and, overall, exhibit no tendency to increase. Goga et al. (2018) argue that the country requires reindustrialization and building a more complex economy to improve its level of productivity. These outcomes require a better coordinated industrial policy and improved mass education attainment. The share of services remains stable—near 13% of total exports value both in 1995 and 2016—and “travel and tourism” keeps the leading position.

Even though Russia was one of the most prominent industrialization stories of the XX century, its industry was distinguished by a gargantuan military segment. This feature of the Soviet industry was among the reasons behind low growth outcomes of the Soviet industrialization (Cheremukhin et al., 2013). After the collapse of the Soviet Union, the economy of Russia went through large-scale structural transformation. However, this process did not result in the mass emergence of highly productive sectors. Instead, the economy of Russia, like those of its BRICS fellow members, Brazil and South Africa, employs large masses of its labor force in inward-oriented low-productivity sectors and relies on exports of relatively simple products. A total of 14% of its working individuals are employed within two single occupations—drivers and sellers, and near half of its employed labor force work in 28 professions, including, besides aforementioned drivers and sellers, security and cleaning staff, porters, junior medical staff, etc. (Vishnevskaya et al., 2017). Both in 1995 and 2016 more than $\frac{2}{3}$ of Russian exports value was made up by agriculture, metals, minerals, textiles and stones. What clearly distinguishes Russian exports in 2016 from its position in 1995 is the export of services. As a share in total Russian exports, services are stagnant because their contribution varies within the 13.6–14.6% range in 1995 and 2016. But in 2016 its largest component was ICT services, followed by transport and travel and tourism sectors, while in 1995 the latter was the largest and the former—the smallest service sectors out of the three. However, the leadership of ICT sector among service industries was common for BRICS economies, with the exception of South Africa, where travel and tourism was far ahead of other service industries in 2016. Moreover, insurance and finance sector was also a prominent part of Indian and Chinese services exports in 2016, which was not the case for Russia. As for more complex industries, such as electronics, vehicles, machinery and chemicals, their share in the total exports of Russia shows no stable tendency to increase.

Since the 1990s, the Indian economy, by contrast, can be characterized by a positive structural shift from low-productivity agriculture to modern sectors of the economy, including manufacturing (McMillan and Rodrik, 2014), even though the latter played a relatively small role in the process of transformation. The share of simple sectors, such as agriculture, metals, minerals, textiles and stones, in the total value of Indian exports, declined from 67% in 1995 to 41% in 2016. Complex industries, such as chemicals, machinery, vehicles, electronics total more than 21% of Indian exports value in 2016, while in 1995 their contribution was around 17%. However, the main drivers of the structural shift and export diversification in India are predominantly high-skilled service sectors, such as ICT and finance and insurance, showing large expansion in the structure of Indian exports. However, these sectors can not employ a vast majority of India's less educated workforce. This implies that India needs to continue restructuring its economy to attain higher levels of export diversification and to integrate larger masses of its population into highly-productive exporting sectors.

Finally, within the considered period of time, China went through remarkable positive structural transition. The structure of its economy shifted from low-productivity sectors, such as agriculture, to high-productive export-oriented industries. The share of agriculture, metals, minerals, textiles and stones declined from 53% of the total value of Chinese exports in 1995 to 31% in 2016. At the same time, complex industries totaled 61% of exports value from China in 2016, while in 1995 their contribution was 21% smaller. McMillan and Rodrik (2014) emphasize the active role of industrial policy as an important ingredient of positive structural change in China. In particular, it was using its huge market size as a bargaining argument with its counterparts to organize a mass transfer of technology from the West and also from Russia.¹³ Such an opportunity does not seem to be feasible in the case of Russia, since it does not have such a large market size, and thus its bargaining power is much weaker. Since the late 1970s, China has also been successful in picking up its next industrial priorities, by fitting new industries and available production capabilities more carefully than under the Great Leap Forward policy (Lin, 2012).

Therefore, positive structural transformation goes hand-in-hand with export diversification. A detailed overview of policies behind structural transformation stories of BRICS economies is beyond this paper's scope. Here, we provide a sketch of what might be a useful approach to increase the level of product sophistication of a particular economy.

McMillan and Rodrik (2014) and Rodrik (2016) emphasize the importance of industrial policy in architecting a positive structural shift in China and the lack of such a policy in Latin American and African economies. In Russia, industrial policy is often flawed with corruption and import substitution priorities. However, industrial policy alone can not be a key to successful structural transformation. Fundamentally, it should also be accompanied by human capital accumulation, as a higher level of productivity and a more complex economy both demand a lot of knowledge and know-how. However, in the short term a particular economy might be lacking a different growth factor. Brazil might experience difficulties while attracting investment (Hausmann et al., 2005), Russia might need better

¹³ <http://prosyn.org/zPmOz47>; <https://carnegie.ru/2017/11/02/ru-pub-74601>

protected property rights and South Africa should probably be more careful when introducing policies which might impair its stock of human capital¹⁴. Which constraint is the most binding for a particular BRICS economy is a matter of careful growth diagnostics and individual policy prescriptions. As soon as the most binding constraints are weakened, a new round of growth diagnostics should take place to reveal the next cohort of binding constraints.

5. Russia's export diversification prospects

To evaluate diversification prospects of Russia, we use the same approach as Hausmann et al. (2011). We identify a set of products which Russia does not currently export at the level of revealed comparative advantage, but which are technologically feasible for Russian exporters given the country's stock of know-how. For instance, if a particular economy has capabilities in exporting bogies and buses, it might also be able to synthesize a technological solution for producing trams. At the same time, it is much less likely that the capacity to export bogies and buses is an advantage for exporting ferries. To identify technologically related products, we introduce a measure of technological distance between a new product and the economy's stock of know-how. If the distance is fairly short, we identify the respective product as technologically feasible given the economy's production frontier.

We apply the following methodological approach. Given the product-country matrix $M_{p,c}$, which shows who exports what, we can find its opposite, a matrix which instead exhibits what each economy does not export at the level of revealed comparative advantage. To do this, we first subtract $M_{p,c}$ from the matrix of the same dimension as $M_{p,c}$, but with each entry equals to 1. $I - M_{p,c}$ represents a set of country-products that are not intensively exported. We can pick up a random economy which corresponds to a column of matrix $I - M_{p,c}$ and see which products the latter does not export intensively. Then we might want to focus on a particular product which does not belong to this economy's current export basket. Our goal is to measure the technological distance between such a new product and the entire export basket of the economy of interest. Such a distance can serve us as a metrics that calculates the likelihood to start exporting a new product given the stock of know-how accumulated in a particular country. An economy exporting diamonds and tropical fruits is unlikely to become an exporter of supersonic jets. This measure, which is called Density, is determined in the following expression (see Hidalgo et al., 2007):

$$Density_j = \quad (6)$$

where x_i corresponds to $RCA_i = 1$, i.e. it points at a product i which is already exported at the level of revealed comparative advantage; proximity_{ij} is defined in (5) and reflects the level of technological relatedness between a new product j and product i .

Thus, in the numerator of (6), we first point at those products which the economy of interest already exports at the level of revealed comparative advantage

¹⁴ <http://prosyn.org/qmtF45B>

and then calculate the technological distance between each of these products and a new product. The numerator of (6) thus evaluates if the stock of know-how that allows for the export of the current basket of products also fits the goal of exporting the new product. We then calculate the ratio between the numerator and the total sum of proximities between the new product and all other products. We thus take into account the density of the export basket of a particular economy. The fewer products the economy exports, the lower the likelihood that it has know-how to start exporting a new product.

As it follows from Fig. 2, Russia's export basket is not well connected to the rest of the product space. However, the same result also applies to Brazil and South Africa. Moreover, the latter two economies show a clear tendency to be better connected to simpler products than Russia. On the contrary, China has substantially better diversification prospects, as it is better connected to the dense part of the product space and has better chances to diversify into complex products. India is a follower up, but, in contrast to China, it has better opportunities to diversify into simpler products than complex goods.

It follows that given its current technological base, Russia has limited opportunities to diversify into a wide range of more complex goods. It might need to reindustrialize and develop new sectors to complement its current exports with

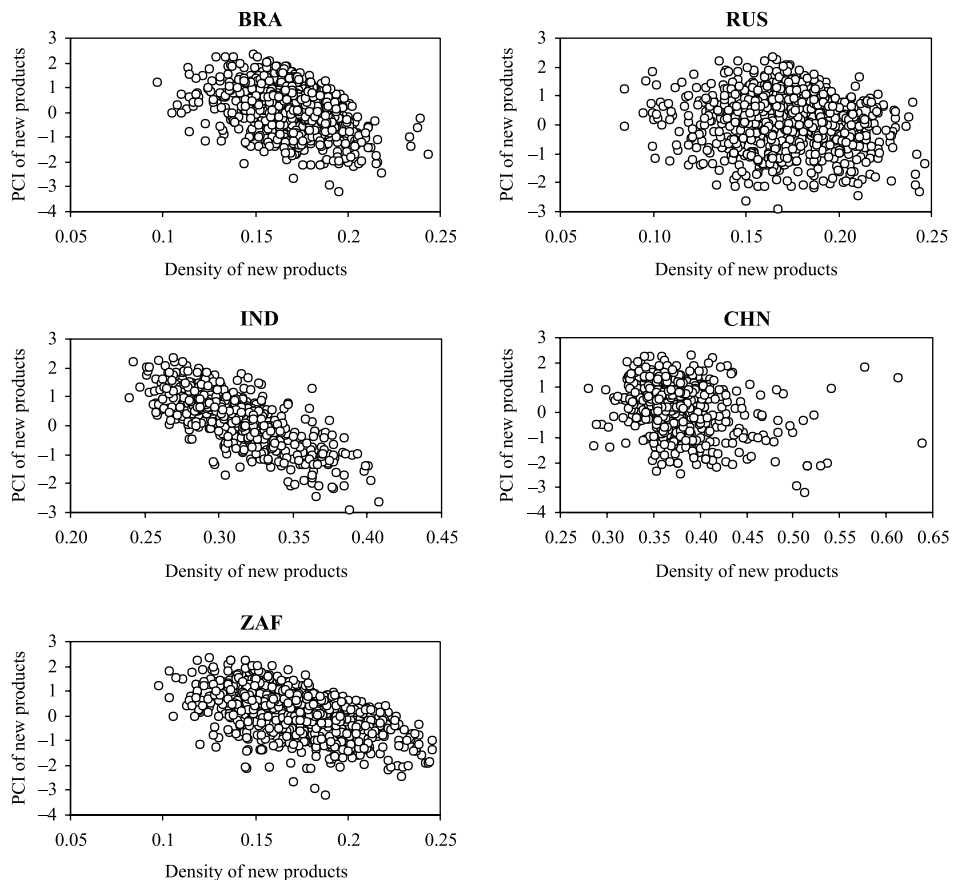


Fig. 2. BRICS economies' diversification prospects.

Source: Atlas of Economic Complexity, <https://intl-atlas-downloads.s3.amazonaws.com/index.html>

more complex products. But the latter requires a more developed national innovation system, technological inflows and better protected property rights.

6. Destinations

So far, we focused our analysis on: “what do Russia and its BRICS fellow members currently export?” and “what can they also export given their current export capabilities?” questions. We used standard tools of economic complexity theory to characterize the progress of economic complexity in Russia and compare it to that of its BRICS fellow members. We also briefly characterized its diversification opportunities from the point of view of technological feasibility. Paraphrasing, so far we have focused our discussion on the supply side of Russia’s and its BRICS companion-countries’ economic complexity and their export diversification potential.

However, for a more meaningful analysis we also need to identify potential importers of Russian products. This is at least as important as learning what else can Russian producers potentially export. However, such an important component of economic complexity as geography has up to now been totally missing from our analysis. Yet, neglecting geographic dimension, i.e. the demand side of export diversification issue, is a serious analytical flaw. We address the question of Russian export destinations in the present section.

We can derive at least two important conclusions from considering where a particular economy exports its products. First, export destinations help us reassess the economic complexity of the economy in question. To see why this is the case, consider two automobile producers, one exporting its products predominantly to poorer economies, where a typical consumer can afford a basic car lacking safety and climate control systems, with many mechanisms such as window lifters powered manually, not electrically. The other company supplies its automobiles to richer economies, where people are wealthy enough to pay a higher price to be able to drive safely and comfortably. Even though both producers qualify as cars manufacturers, they clearly export different products. The advanced car incorporates much more know-how than the basic one - i.e. the former is a more complex product than the latter (see Ferranti et al., 2003). Therefore, export destinations can, in principle, provide us with additional information about the level of economic complexity of a particular economy, thus complementing ECI.¹⁵

¹⁵ Geographically fragmented export does not necessarily point to the technological inferiority of a particular exporter. It is likely that New Zealand is not the main destination for snowmobiles, icebreakers are hardly exported to Austria and climate control systems are not the most demanded product in Lapland. It is also possible that a particular product does not fit the technology that is used by an importer. For instance, even though metro carriages are globally exported, it might be that the supply of Russian metro carriages has only regional coverage. Indeed, Russian producers supply metro carriages to Budapest, Warsaw, Prague, Baku and Tbilisi, etc. It might be that Russian metro carriages fit Soviet-built underground railway systems but not their technological alternatives implemented outside the ex-Socialist economies. Many Russian products might still be exported within old technological networks, thus relying on idiosyncratic value-added chains designed in the Soviet economy. If this is correct, then expanding its current exports or diversifying into related goods might be problematic for Russian producers. Thus, it is more feasible that Russia will be able to export more by joining global value-added chains where it might play a role of a supplier of particular mechanisms and components. At the same time, the Russian economy might keep exporting more sophisticated products to the network of traditional consumers, as long as the latter stay attached to the old technological solution.

We identify Russia's export destinations for each product exported at the level of revealed comparative advantage. By considering the geographic coverage of Russian exports, we can make additional conclusions regarding the level of complexity of Russian products or their technological features.

Second, export destinations can also help us evaluate the potential for export expansion of a particular economy. For instance, exporting products to a rich economy might signal that the corresponding exporter might be a reliable contractor. Such a signal might be similar to royal warrants of appointment in the United Kingdom. Since the 15th century, these warrants have been issued to those producers who supply products and services to the Royal court or certain members of the Royal family. Such a producer was then able to advertise itself as a supplier of the Royal family, thus signaling the high quality of its products. A similar opportunity to signal the quality of products also existed in pre-revolutionary Russia.

As export destinations, rich economies can in a sense play a similar role to the royal families of the past. They are wealthy and therefore can afford to be highly selective with respect to choosing a contractor. Their choice might serve as an implicit recommendation for the rest of the world market, indicating high reliability of the respective supplier. Thus, if an emerging economy diversifies into a developed market, it might, by earning a high reputation, expect to reap benefits from a large scale effect later on, selling its products elsewhere in the world.

We use the same data as we used in the previous sections to identify the main destinations of BRICS economies export flows. We again use product-country matrix $M_{p,c}$ to track the geographic terminus of exported products. We then calculate the importance of economy A as a destination place for country B 's export of a particular product:

$$Share_{p,c}^z = \quad (7)$$

where $v_{c,p}^z$ is the value of product p which country c exports to economy z and x_p^c is an indicator variable taking the value of 1 if the economy has revealed comparative advantage in exporting p and 0 in the opposite case.

We then construct a matrix where each entry corresponds to (7), i.e. each entry of (7) corresponds to the share of a particular destination in the total export value of a product which is a BRICS economy supplied at the level of revealed comparative advantage in 2016. We then summarize the products to reveal which geographic destinations are more important in terms of product variety.

We use a heatmap representation, which is a graphical tool designed to visualize matrix-form data. The heatmap representation reflects the range of products BRICS members export to each of their partner-economy. If a BRICS country exports a broader arsenal of its product to a particular economy, then this fact is marked with a lighter blue color

Fig. S5 (see Supplementary material 5) informs us about the main destinations of BRICS economies export flows. One common feature of export destinations of all five BRICS economies becomes clear. All five BRICS members export a large variety of their products to their immediate geographic neighbors. The difference between Brazil, Russia, and South Africa on the one hand and

China and India on the other, is that the former three do not seem to have many trade partners beyond their closest geographic circle, willing to buy a broad arsenal of their products.

In the case of Russia the exception is Germany while Brazil exports a large variety of its products to the United States. By contrast, China and India are able to access many more rich markets to sell a broad range of their products. To put it another way, Chinese and Indian exporters conquered not only their immediate geographic neighbors, but also the rich markets of developed nations. Russian and South African exporters, by contrast, predominantly conquered their next-door nations' markets. The latter does not imply that Russian exports to Japan or the United States are too few. On the contrary, the latter two economies are among the important destinations of Russian exports. This implies that the range of exports to these developed economies is more fragmented compared with the arsenal of products Russia exports to some of its immediate geographic neighbors. It seems that China and India are succeeding in conquering the premium part of the world market, while Brazil, Russia and South Africa are less successful in consolidating their presence in the rich part of the world economy.

Thus, Fig. S5 (see Supplementary material 5) clearly places China and India on a pedestal, both in terms of their overall capability to export a wide range of goods globally, as well as their ability to supply this range to richer places. Even though Brazil, Russia and South Africa also sell a wide arsenal of their goods to wealthier markets, on average they supply much more to their next-door neighbors. This finding does not contradict the gravity model (see Combes et al., 2008), which claims that export flows from a particular economy are positively associated with the size of the economy of its trade partner, but has negative association with the distance between them; i.e., in principle, it is easier to supply products to a market which is geographically close to your own location, or to be a supplier for a market where customers have a lot of money to spend. More complex economies find a better balance between the two types of markets, while less complex countries are more likely to supply more products to their geographic neighbors.

This might have the following negative effects for the economy of Russia. In common with a vast majority of emerging economies, most of Russia's next-door neighbors are relatively poor. Moreover, they grow episodically, not continuously (Kar et al., 2013). Therefore, it might take a long time for these economies to reach a point where they can afford to buy more products from Russia. On the contrary, richer economies have much larger markets. Furthermore, they grow slowly but continuously and therefore might on average be a better place to export products to.

Being less successful as a supplier of developed economies might also signal that the exporter is yet to become a reliable contractor, which might limit its current opportunities to expand its exports globally. The good news is that concerns that more sophisticated Russian products might be geographically unscalable because of technological peculiarities or insufficient quality seem not to be true at least for certain segments of its more complex goods. Indeed, in 2010 Russia predominantly, if not exclusively, exported self-propelled rail vehicles, as well as many other types of rail equipment, to its ex-Soviet companion-economies. But within the following years Russia substantially broadened its exports' (com-

prising its rail equipment) geographic destinations, including the most developed economies.

7. Concluding remarks

In this paper, we use data on global trade flows to study the evolution of economic complexity in Russia and its BRICS fellow members. The Russian economy is widely perceived to have been stagnant since the second half of 2000s.¹⁶ We, however, claim that its fundamental economic sluggishness has persisted for much longer than a decade. Technologically, Russia has been stagnant for at least 22 years spanning the entire period of 1995–2016. This does not, however, imply that Russia was using exactly the same technologies in 2016 as it had been using in 1995. Global technological spillover effect and national R&D efforts substantially reshaped Russia's technological frontier over these 22 years. But its relative level of complexity is indeed close to what it was a few years after the USSR collapsed. Russia's rapid growth in 2000s was predominantly driven by the oil market boom of the early XXI century as well as manufacturing and services expansion in response to increasing oil income inflows. Such expansion, however, was chiefly inward-oriented and therefore had no substantial impact on export complexity. That Brazil and South Africa, two more BRICS members, exhibit a similar stagnant complexity of their economies can hardly be a consolation for Russia.

The level of complexity of Russian non-resource products is our main concern. These products are associated with a lower level of know-how than might be necessary to diversify the Russian economy into a broad range of more complex products. Currently, because of its weak relative bargaining position, Russia has no access to the wholesale technological adoption opportunities of the early 1930s, when the economic downturn motivated many manufacturers from the United States and Germany, as well as many other industrialized economies, to transfer know-how to the Soviet Russia within concessions with its authorities (see Sutton, 1970). Russia's current technological base might be too low or fragmented to develop a wide range of more sophisticated products. Therefore, its only alternative is to try to complement global producers within international value-added chains, which might also open new global markets to Russian exporters. This, however, requires certainty about the protection of property rights and a learning society (see Stiglitz and Greenwald, 2014); both are yet to be established in Russia.

The lack of export diversification in Russia, as well as in Brazil and South Africa, goes hand-in-hand with the lack of positive structural transformation in these three economies. The reasons are inadequate or unqualified industrial policy, the lack of the relevant human capital and country-specific binding constraints which should be carefully diagnosed. Industrial policy in Russia is flawed with corruption and mismanagement. In recent years, it also overprioritizes import substitution, since it prefers imperfect product localization over integration in the global value chains, where it can learn about new technologies and management practices. It also prefers subsequent distribution of its products via the state trade representation network inherited from the Soviet Union in-

¹⁶ <http://prosyn.org/9uOFAIL>

stead of building alliances within international value chains having much broader access to global markets.

The export destinations of Russian exporters also figure among our concerns. On the one hand, Russian exporters are able to supply their products to a variety of markets, both less and more rich. However, Russia (similar to Brazil and South Africa) exports a much broader range of its products to its next-door neighbors than to rich economies. The former, however, are not only much poorer than the latter, but also might have weaker growth prospects. The cause of such a pattern of trade between Russia and its partners may lie within a range of various technological, tariff/trade or political obstacles. As a result, building a reputation of a reliable supplier of high-quality products is impeded. It is therefore important to keep on eliminating these barriers to expand and consolidate Russia's presence in the richer part of the global markets.

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Supplementary material 1

The country space in 2016

Author: Ivan Lyubimov

Data type: Image

Explanation note: The country space reflects technological linkages between each pair of economies. It shows how similar a random pair of economies is. Two similar economies are located closer to each other.

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Link: <https://doi.org/10.32609/j.ruje.5.34753.suppl1>

Supplementary material 2

BRICS economies in the product space

Author: Ivan Lyubimov

Data type: Image

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Supplementary material 3

Russian exports in the product space, 1995 and 2016

Author: Ivan Lyubimov

Data type: Image

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Supplementary material 4

Russian imports in the product space, 1995 and 2016

Author: Ivan Lyubimov

Data type: Image

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Supplementary material 5

Where do BRICS economies export their products?

Author: Ivan Lyubimov

Data type: Image

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