AN ECONOMIC COMPLEXITY ANALYSIS OF THE KALININGRAD REGION: IDENTIFYING SECTORAL PRIORITIES IN THE EMERGING VALUE CREATION PARADIGM

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The ongoing technological development leads to the emergence of a new value-creation paradigm that calls for changes and structural transformations in economic systems at different levels. Structural transformations are prompted by growing economic complexity. In this context, the selection of industrial strategies and the validation of key regional industrial policies is of paramount importance. Economic complexity (EC) analysis is a new effective tool to address the issue. Its application at a subnational level is, however, limited by methodological problems.
To analyse economic complexity at a subnational level, a basic methodology and special software were developed within this study. The object of the research is the exclave Kaliningrad region, whose location makes it possible to capture accurate and comprehensive data on international and interregional trade. Based on the EC analysis theory and practice, the study involved the development of methods, algorithms, and software to form a source database and measure economic complexity.
The findings may guide the use of EC analyses in regional policies. The article suggests activities for sequential upgrading of the industry in the Kaliningrad region. These activities will facilitate the development of the existing and new capabilities, improve the business environment, and increase the complexity of products, productions, and industries.

Keywords:
economic complexity, capability, sector strategy, industrial policy, international and interregional trade flows, exclave, Kaliningrad region

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Introduction

The economic complexity (EC) of a country (region, state, city, etc.) is understood as its ability to produce more diverse and complex products by means of accumulating capabilities[1] [1]. Being well-studied in various contexts [see, for example, 2—4], the concept of capability acquires a new meaning within the framework of economic complexity theory. According to its founders, in a broad sense, capabilities are non-tradable productive inputs [5], in the narrow sense, these are technologies, ways or methods of work, know-how, legislation, modern institutions, organizational skills, relational capital, etc. These capabilities are embodied in useful knowledge that is formed at the level of individuals, organizations, and even network structures [6, p. 16]. The structure of capabilities required for the production of a certain product is referred to as *product complexity* [7], while *economic complexity* is associated with the capabilities locally concentrated on a specific territory. It determines the differences between economic systems both in their ability to produce complex products and, as a result, in the possibilities they have for economic growth.

The EC analysis provides insights into the competitiveness and development prospects of certain types of products, industries and sectors. Thus, it has become an important analytical tool successfully used at the country level in different parts of the world. Another advantage of the approach is that it allows for consideration of current technological trends and the ongoing value creation paradigm shift. The explanatory power of the EC theory is constantly growing, which is confirmed by numerous international studies as it finds its application in various domains, including diversification, knowledge diffusion, unemployment and employment, productivity, patent rights, agglomeration effects, energy consumption and emissions, etc. [8, 9]. However, currently, the most relevant application, which has also been empirically tested, lies in using it to underpin industrial policy decisions and development priority selection.

Given that economic activity in regions has a number of specific features, the results of studies at the national level and the EC analysis methodology originally developed for countries are not always applicable at subnational level. For this reason, the practice of economic complexity analysis in regions is limited.

This study aims to further develop EC methodology in terms of its application for prioritizing sectoral strategies and selecting key industrial policies at subnational level.

This requires consideration of modern practice of EC theory application and identification of its specific features, the development of basic methodological framework and software for EC analysis at subnational level, and experimental testing. The aforementioned works were carried within the RFBR scientific project No. 19-410-390002 “Economic Complexity and Sector-Specific Strategy

[1] Authors’ note: it is worth mentioning that in Russian research on Economic Complexity there is no established equivalent of the term “capability” yet.

Selection by the Regions of Russia in the Context of the Emerging Value Creation Paradigm, Using the Case of the Kaliningrad Region." The article presents the final results of the testing of the developed methodological approach.

The research object is the exclave Kaliningrad region, whose location makes it the most convenient object for modelling and testing economic tools and methods, as it is close to the idealized concept of the "region". Another reason is that the EC analysis at subnational level relies on both global and regional trade statistics data, and the exclave provides the best possibilities for capturing all trade flows in the region.

Drawing on the results of the study and the analysis of the economic complexity of the Kaliningrad region, the study puts forward recommendations on application of the method in state and regional governance and examines specific proposals to justify choice of industry strategies and the formation of a new industrial policy.

A significant limitation of the study is that at this stage it is impossible to carry out a comparative analysis of the application of the developed methodological approach to other Russian and foreign regions. The reason is threefold. Firstly, it requires a bigger research team including both Russian and international experts. Secondly, access to sources of information needed for the source database is limited. Thirdly, given the differences in regional specifics, data processing and results evaluation are time and money consuming.

Nevertheless, despite the limitations, the results of the study are of interest in terms of developing both the EC methodology and analytical tools that can be applied to select sectoral priorities and to identify ways to change the existing production structure in order to ensure a highly productive vector of growth and development of regional economy both in Russia and in other countries.

Theoretical importance of the economic complexity analysis and the practice of its application

Every 50—70 years there is a major shift occurring in the way the value is created in society due to emerging technologies with a systemic impact across most sectors of the economy [10]. Throughout the industrial history, there were five of such major shifts in technology paradigms that have laid the foundation for transformations and changes in countries and regions (macro-level), sectors of the economy (meso-level) and organisations and people's lives (micro-level) [11]. These are 1) the industrial revolution (1770), 2) the steam engine paradigm (1830), 3) the heavy engineering paradigm (1870), 4) the combustion engine paradigm (1910), 5) the digital paradigm (1970).

These paradigm shifts have had a considerable impact on the economy. On the micro-level, they have changed the way value is created, and consequently, the structure of organizations as well as the tasks that make up a certain job. On the meso-level, they have laid the foundation for the creation of new sectors and for the demise of existing ones. On the macro-level, they have altered the boundary conditions for growth of a region's prosperity or its decline without successful policy intervention [11].

It is worth noting that all the paradigms have gone through the same stages of development: an emergence, which is followed by one or more bubbles; a recession (which is also a turning point, with the new ways of value creation now perceived as the basis for the future with associated deep transformation of institutional framework in and across economies); a long era of prosperity; a decline in productivity laying the foundation for the next paradigm. At the moment, the global community is at the beginning of the prosperity period of the digital paradigm.

During paradigm shifts, there is a dramatic increase in the creative destruction across an economy. This means that a company, as well as any other type of organization, must choose to adopt new technologies and change its way of value creation or be expelled from the market. Thus, shifts in the value creation paradigm mean radical changes in the structure of the economy.

Looking at shifts in specific technologies in terms of changes in the ways of creating value, one can notice the following patterns [10]:

— distribution of new technology causes major reallocation of resources between sectors;

— growth primarily takes place in sectors providing new technology-enabled offers, the major beneficiaries are the first mover sectors and firms;

— growth is also observed in sectors providing input to the first movers, as well as sectors and firms that provide products and services complementing the products and services from the first movers;

— more divergence between sectors of the economy linked to the new ways of creating value accelerates their growth. In those linked to the old way of creating value, growth slows down, eventually leading to their decline.

Each paradigm shows its unique causality between innovation, diffusion, institutional change, productivity change, change in the number of firms and employees and relative factor prices [12]. The same applies to spatial distribution of emerging technology-enabled sectors that changes over time contributing to the imbalance in net jobs [13].

In this regard, economic complexity plays an important role since a capability base is causally related to the absorptive capacity of the economy [10; 14; 15]. Numerous studies confirm that there is a strong correlation and causality between the level of economic complexity in a region and its prosperity [1; 6].

The core concept of EC is that specific products are produced when knowledge, natural resources and monetary capital come together in a specific way, with each economy having its own combination of the three factors. EC theory proposes that since natural resources and monetary capital are scarce, it is by increasing the amount of knowledge in an economy that more products can be made available for production, specifically for export. Thus, it is the differentiation of knowledge capital between economies that shapes each economy's unique economic complexity measures. Being a relative measure of existing capabilities for production and export of products, the EC allows us to evaluate the prospects and benefits to be gained by an economy from shifting to more complex products [8].

The economic complexity theory first proposed by Hausmann & Hidalgo [1; 5; 6; 16] was further developed in works studying EC impact on economic growth and welfare, income inequality, middle-income trap, labour market and job polarization, structural shifts in value chains, etc. [8]. Today, researchers pay special attention to technological congruence, study the principle of relatedness, the diversification of economic activity, the dominance of technological innovation and optimization of the diffusion of productive knowledge [9]. Combined with value-added mapping and technology foresight, economic complexity is a powerful tool for industrial policy development [17]. The best-known and largest project of this kind is the EU Smart Specialization strategy [see, for example, 18].

Hausmann & Hidalgo propose two complementary measures to assess the amount of knowledge capital in an economy: a) diversity, reflecting the number of different products exported by the economy; and b) ubiquity, reflecting the number of countries exporting a particular product [6; 8]. The ubiquity of a product reveals information about the amount of knowledge required for its production, while the diversity can indicate the relative level of knowledge in an economy compared to other economies. Reliance on the ideas put forward by Hausmann & Hidalgo [1; 6], combined with the global trade statistics data, a network approach and econometric tools, has allowed researchers to empirically prove the existence of a systematic relationship between the diversity of a country's exports and the ubiquity of its products, thus providing an alternative to the popular theories of economic growth and international trade.

Two major indicators are used to measure the level of economic complexity: 1) Economic Complexity Index (ECI) and 2) Product Complexity Index, (PCI). Within this framework, the following derivatives or related indicators are calculated [6]:

— revealed comparative advantage (RCA) as per Balassa's definition [34];

— opportunity value (OV) and complexity outlook index (COI) — the value to be gained by an economy from shifting production to unexploited prospects (more complex products);

— relative opportunity gain (OG) and complexity outlook gain (COG) — the 'spillover' benefit to an economy from producing new products in terms of providing capacity for producing even more complex products;

— diversity, ubiquity, density and distance.

Calculation of the above indicators (the detailed calculation algorithm is provided in [1; 6]) allows one to identify the current level of the economy's complexity and its positions the global product space. The capabilities available in a country or a region determine the products for which there is, or, conversely, there is no comparative advantage. The information on the density of the product space, proximity of and distance between more complex products and those that are produced (or can be produced) underpin industrial strategies. It helps identify the areas for existing capability development and new knowledge accumulation. Shaping new industrial policies based on an increase in economic complexity involves the development of measures supporting various industries (declining industries, emerging industries that are highly complex, new industries with growth potential or ability to fill structural holes, etc.) at various territorial levels, especially the regional one. 17][2]).

Today, the annual country data is available from two official sources: 1) the Atlas of Economic Complexity[3] developed by the Center for International Development at Harvard University and 2) the Observatory of Economic Complexity[4] — supported by the MIT Media Lab consortia for undirected research.

Judging by the limited number of publications and research on the subject in Russian [see, for example, 19; 20—22], the EC analysis has not received proper development in the country yet. The Russian works on the economic complexity of regions use the methodology developed for the country-level analysis and are thus not applicable at the subnational level. They take into account only international trade flows leaving interregional trade out. They neither investigate the shift towards more complex products nor provide any justification for the selected industry priorities. In this regard, a comparison of the results obtained in this research and earlier studies is not possible due to significant methodological differences.

The main difficulty of applying the EC approach to regional studies, which largely explains the low interest among not only Russian but also international researchers, is its poorly developed methodology for subnational analysis. That the methodology does not incorporate services and that trade data may not reflect the actual value-added of final exports due to geographically dispersed production constitute significant drawbacks of the EC approach. Fragmentation of global value chains further distorts the picture, so an assembly industry will significantly increase the complexity of an export portfolio [9].

Despite the ongoing development of the approach, there are still no theoretical works on the methodology for measuring subnational economic complexity. The scope is limited to a few empirical studies at the regional level of individual countries [8]. The most significant and interesting works on economic complexity analysis at subnational level include those on Spain [23], Brazil [24][5], Australia [25; 26], China [27], USA [28], Eastern European countries [29].

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[2] A structural hole is a sector that is currently absent in the economy, but if it existed it would connect two or more existing sectors. An example is the drone service sector serving both the agricultural and mining sectors.

[3] *The Atlas* of Economic Complexity. URL: http://atlas.cid.harvard.edu (access date: 10.10.2019).

[4] https://atlas.media.mit.edu — The Observatory of Economic Complexity.

[5] There was an Economic Complexity resource created within its framework: DataViva — http://dataviva.info.

The conducted theoretical review indicates the relevance of measuring subnational economic complexity. The importance of developing the methodology stems from the approach's significance for the development of economic systems (at micro-, meso, macro-levels), and the need to design special measures to support the development of existing and the emergence of new productions, industries, sectors in the context of the new value-creation paradigm. Providing a favourable environment for new export- and growth-oriented firms (start-ups or spin-outs) grounded in emerging and converging technologies is of particular importance.

Methodology and software for subnational economic complexity analysis

The accuracy of measuring the economic complexity of an economy (of a country, state, region, etc.) depends substantially on the quality and completeness of the source data, as well as on the assessment methods and algorithms chosen by the researchers. Therefore, the methodology and software for the EC analysis at the subnational level developed within the framework of this study has some specific features and is based on the following provisions.

1. Choosing between global and national product spaces in assessing the regional economic complexity.

When it comes to Russian regions, some studies consider the global export space, while earlier works assess export diversity through the national product space. International studies assess regional economic complexity not only taking into account the region's position in the global product space but also using various databases characterizing intra-national trade flows to analyze its interactions with other regions of the country or with the rest of the country as a whole. This study considers the economy of the region as a separate statistical unit in the global and national product spaces. Therefore, it takes into account two types of trade flows: a) international export and import and b) inter-regional export and import.

2. Selecting available sources of international trade statistics for measuring subnational economic complexity.

There are several sources of international trade data traditionally used for this type of analysis: UN Comtrade, BACI, Atlas of Economic Complexity, Center for International Data,[6] etc. However, there are numerous examples of using alternative data sources. For instance, patent and trademark databases, distributed global network of R&D centres, input-output tables. Conventional supplementary sources of information include customs export and import declarations, business registers, transport and logistics flows, etc.

This study relies on the data presented in the Atlas of Economic Complexity of Harvard University. As, firstly, they have already been adjusted to measure eco-

[6] The Center for International Data. URL: https://cid.econ.ucdavis.edu (access date: 10.10.2019).

nomic complexity. Secondly, they include the latest relevant information (2017). Thirdly, they are presented in HS classification corresponding to the EAEU Commodity Nomenclature of Foreign Economic Activity used to register international trade in Russia.

3. Evaluating the scope and quality of national and regional sources of international trade statistics, the level of disaggregation and relevance to world trade statistics databases.

The problem with data sources is twofold: 1) the availability of regional customs statistics on all commodity items at the HS 4-or 6-digit level, and 2) refinement of data (accounting for transit flows, non-coincident producing and exporting regions, the balance of trade by exporting and importing countries, etc.). For this reason, the research relies on customs statistics providing detailed international trade data for regions (see, for example, IAS "Customs" by Expert-FEA; IAS "Mosaic", by NeoStatis; Customs statistics of the Russian Federation by Monitoring-FEA, etc.).

4. Accounting for inter-regional trade flows at the subnational level.

Most often, researchers do not include inter-regional trade flows citing the lack of such information in open sources or the difficulty of collecting it [19]. There are also issues around the level of disaggregation of international trade data. An even more significant problem is considered to be the difference between competition in the national and international markets. Researchers believe that for this reason a part of a region's exports, including interregional trade flows, reflects "… import substitution and the result of lobbying efforts" [30, p. 33], while the analysis of economic complexity is replaced by measuring the industrial complexity of a region's economy. This is often underpinned by the fact that the volume and structure of inter-regional trade in Russia are largely explained by the peculiarities of the spatial distribution of manufacturing in the Soviet period and can hardly be considered a reflection of market patterns in the formation of regional comparative advantage [31].

However, accounting for interregional (intranational) trade flows is indispensable for the economic complexity analysis, since value creation potential and identification of key areas for economic diversification depend not only on the complexity of internationally traded products but also on the complexity of products traded intra-nationally. The analysis of interregional trade allows for assessing any region's capacity to increase the output of complex products it exports within the country and to include them into its international export portfolio. The proposed methodological approach is discussed below.

The sources of the Kaliningrad region's interregional trade statistics include the Federal Customs Service of the Russian Federation, Kaliningrad Regional Customs, Rosstat and Kaliningradstat (national and regional statistics authorities respectively). These data sources differ in their completeness and coverage of regional trade flows. Moreover, they are often incompatible due to the difference in classification systems used. Therefore the creation of a unified database posed a methodological problem. To resolve the issue, the authors developed correspondence tables and HS-OKPD keys allowing to combine the data from several sources. The tables also applied the unique algorithms to "clean" the information from data on transit and customs procedures not related to the movement of locally produced goods.

5. Choosing between the linear method of measuring complexity, The Method of Reflections (MR) [1], or the non-linear method, The Fitness-Complexity Method (FCM) [31], as well as their derived metrics and modifications that have emerged in recent years.

The methods differ in the accuracy of medium- and long-term forecasts, as well in ranking of products and/or countries. At the same time, according to recent studies [33] the differences are insignificant. Therefore, the authors of the article refined the publicly available basic algorithms of Harvard University based on The Method of Reflections.

The result was the procedure for measuring subnational economic complexity presented in Fig. 1.

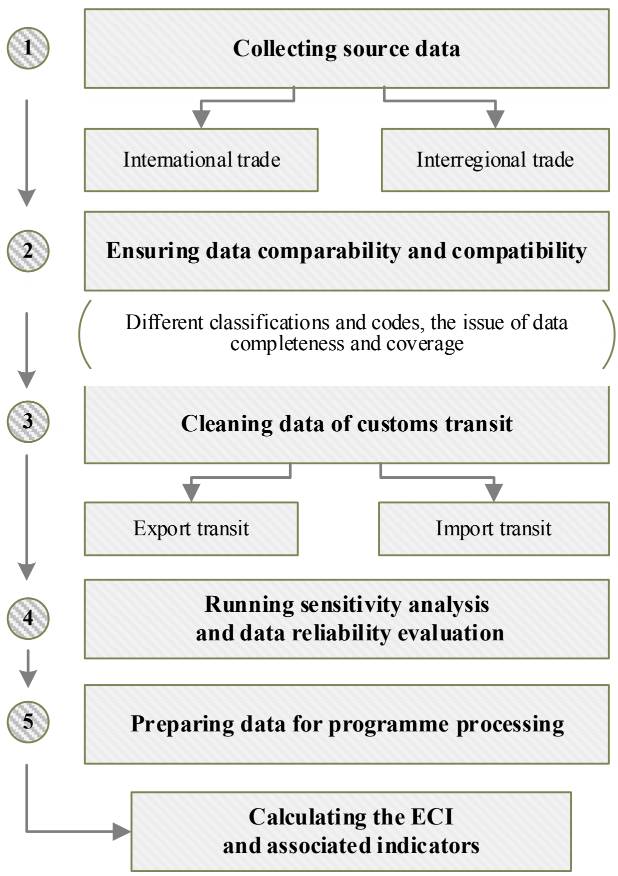


Fig. 1. Algorithm for measuring economic complexity at the regional level

However, methodologically, measuring the economic complexity of the Kaliningrad region needs to reflect the region's trade flows in the global product space. This implies the integration of its international and interregional trade data into the original global trade database (Fig. 2):

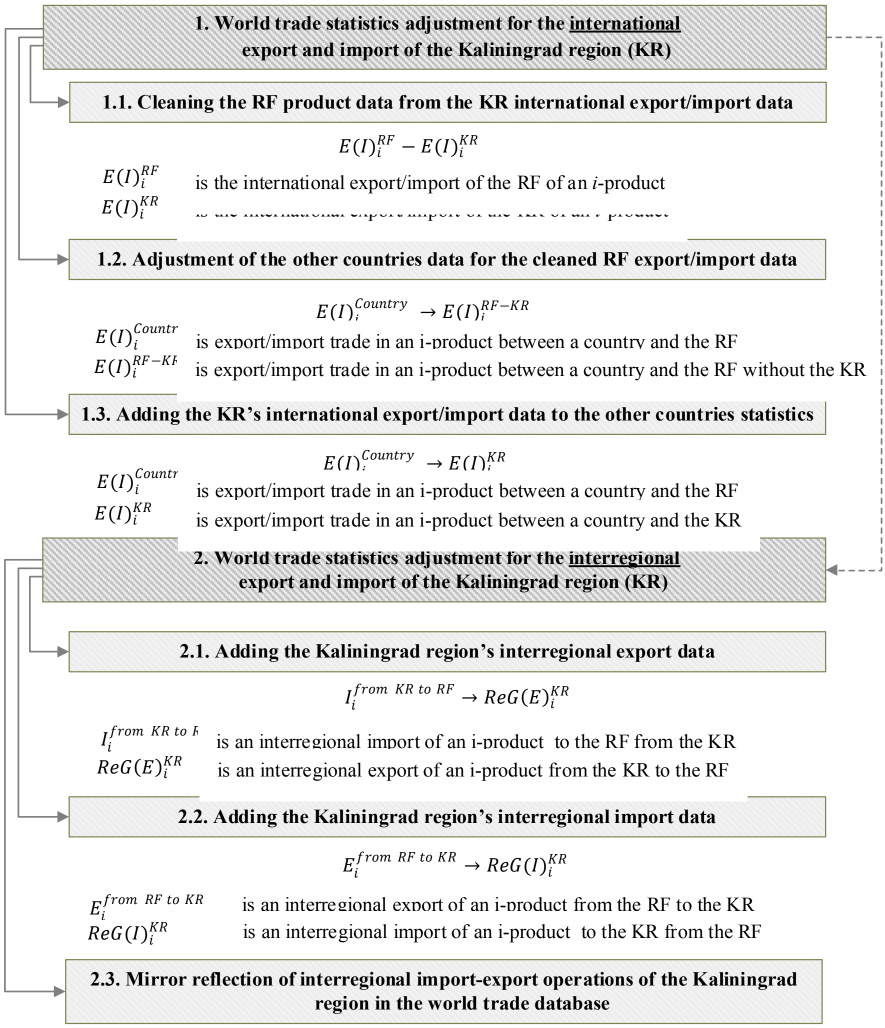


Fig. 2. Algorithm for the inclusion of international and interregional trade flows of the Kaliningrad region into the world trade statistics database

Note: KR — Kaliningrad region.

1. The Kaliningrad region's international trade flows (with every country and on every product) are added to the world trade statistics (at the level of 4 or 6 digits HS-TN FEA). Given that the information is mirrored, the adjustment is carried out both for export and import.

2. Since the region's trade flows were initially included into the RF's export-import operations, it is necessary to "clean" the national data from the Kaliningrad's international export/import volumes (for every country and on every product). In this study, all the product categories for Russia by countries have been adjusted for the Kaliningrad region's import and export volume.

3. The Kaliningrad region's interregional export and import (its trade with the rest of the country, not with its separate regions) are included into the world trade database. This technical solution allows for measuring the prospects of expanding the region's international export portfolio with traded products interregionally.

Special software has been developed to measure the economic complexity at the subnational level. It helped resolve two practical issues: 1) processing of the source export and import databases to measure economic complexity; 2) processing of the auxiliary data on the source export and import databases. There was yet another reason: refinement of Harvard University's downloadable software to correct errors associated with the density calculation.

Codes are open and freely available at: https://github.com/hydrophis-spiralis/regional_economics_complexity.

Analysis of the economic complexity of the Kaliningrad region

The methodology described allowed for analysing the economic complexity of the Kaliningrad region for the period of 2015—2017. The analysed database includes global (1221 product categories), the region's international (743 categories) and region's intranational trade statistics (1028 categories) presented at 4-digit level (HS-code). The calculations are done in volume (tons) and value (US dollars) terms. The results of calculations for 2017 are provided below as an example.

Changing geopolitical situation and growing external threats and risks, as well as the long-term import dependence of the Kaliningrad region's economy determine the relevance of the development of existing and new productive capabilities.

This section presents some results of the analysis of the economic complexity of the Kaliningrad region conducted using the methodology and software developed by a scientific group including the authors of the article. Pilot calculations were carried out for 2017, the period of the latest available global trade statistics.

Figure 3 shows the Product Complexity Index (PCI) for different categories of products (in the HS classification).

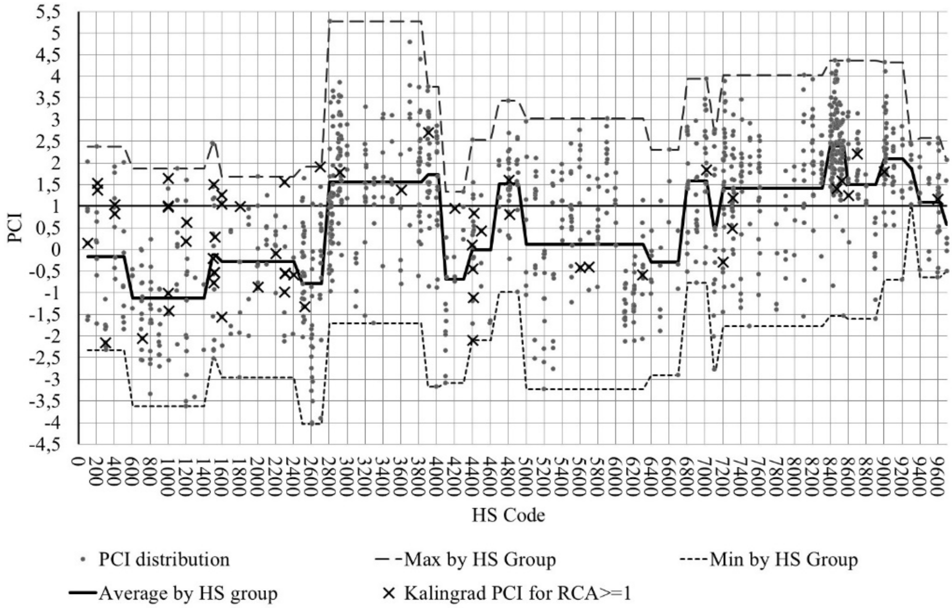


Fig. 3. PCI for each HS product categories in the Kaliningrad region

Note: The letters at the bottom of the graph indicate HS-groups (the codes of the EAEU Commodity Nomenclature of Foreign Economic Activity are indicated in brackets). Groups are delineated by a vertical dashed line as follows: A = live animals; animal products (01—05); B = vegetable products (06—14); C = fats and oils (15); D = prepared foodstuffs and tobacco (16—24); E = mineral products (25—27); F = products of chemical and allied industries (28—38); G = plastics, rubbers (39—40); H = raw hides, skins, leather, and furs (41—43); I = wood, cork, straw (Groups 44—46); J = wood pulp, paper or paperboard (47—49); K = textiles and textile articles (50—63); L = footwear, headgear, umbrellas, sun umbrellas (64—67); M = articles of stone, plaster, cement, asbestos, mica, ceramic products, glass and glassware (68—70); N = natural or cultured pearls, precious or semi-precious stones, precious metals, metals clad with precious metal and articles thereof (71); with the exception of: O = Base metals and products from them (72—83); P = machinery and mechanical appliances, electrical equipment (84—85); Q = vehicles, aircraft, vessels (86—89); R = optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus (90—92); S = arms and ammunition; parts and accessories thereof (93); T = miscellaneous manufactured articles (94—96); V = works of art, collector's pieces and antiques (97).

It is clear that the region should strive to produce goods in those categories where the average PCI is above 1. These are (in order of decreasing PCI): (1) machinery and mechanical appliances; electrical equipment (group 84—85, average PCI=2.4); (2) optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus; clocks and watches; musical instruments (group 90—92, average PCI=2.1); (3) plastics and rubber (group 39—40, average PCI=1.7); (4) articles of stone, plaster, cement, asbestos, mica or similar materials; ceramic products; glass and glassware (group 68—70, average PCI=1.6); (5) products of the chemical or allied industries (group 28—38, average PCI=1.5); (6) pulp of wood or of other fibrous cellulosic material; paper or paperboard (group 47—49, average PCI=1.5); (7) vehicles, aircraft, vessels (group 86—89, average PCI=1.5); (8) base metals and articles thereof (group 72—83, average PCI=1.4); (9) miscellaneous manufactured articles (group 94—96, average PCI=1.1).

The average export volume-weighted PCI for these products (with comparative advantage (RCA> 1)) is 1.79, while the export volume-weighted PCI for all Kaliningrad's products is 1.40

Nevertheless, there is no correlation between PCI and export volume (R^2 = 0.001). The result is solely due to a very uneven export portfolio with 60% of the export value coming from one product category with the PCI of 2.2: Motor cars and other motor vehicles <...> including station wagons and racing cars. Table 1 shows the categories that make up 80% of Kaliningrad's export portfolio.

Table 1

Products comprising 80% of the Kaliningrad export portfolio

Share of total exports, %	Product Category	Cumulative share of exports, %
59.74	Motor cars and other motor vehicles; principally designed for the transport of persons, including station wagons and racing cars	59.74
5.61	Soya-bean oil and its fractions; whether or not refined, but not chemically modified	65.35
3.84	Prepared or preserved meat, meat offal or blood	69.18
3.18	Prepared or preserved fish; caviar and caviar substitutes prepared from fish eggs	72.36
2.22	Wheat and meslin	74.58
2.14	Monitors and projectors, not incorporating television reception apparatus; reception apparatus for television, whether or not incorporating radio-broadcast receivers or sound or video recording or reproducing apparatus	76.72
2.11	Oil-cake and other solid residues; whether or not ground or in the form of pellets, resulting from the extraction of soya-bean oil	78.83
2.04	Ethyl alcohol, undenatured; of an alcoholic strength by volume of less than 80% volume; spirits, liqueurs and other spirituous beverages	80.87

Looking closer at the product portfolio of Kaliningrad we can identify a set of key product categories. This can be done by finding product groups in which Kaliningrad holds a revealed comparative advantage (RCA) and plotting them against the share of the implied capability density (ICD)[7]. The higher the capability density, the more opportunities for the production of more complex products. For the Kaliningrad region, the analysis revealed that the minimum level of ICD required to develop successful export products is only 4.6%, this is quite low comparing to the other territories (Fig. 4).

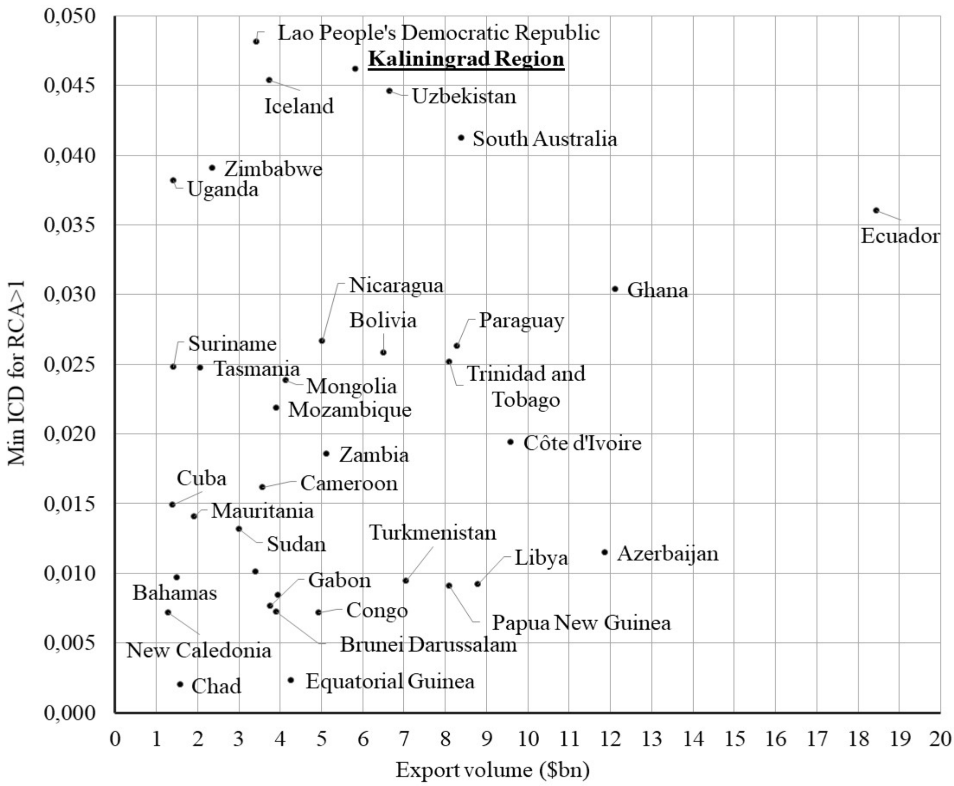


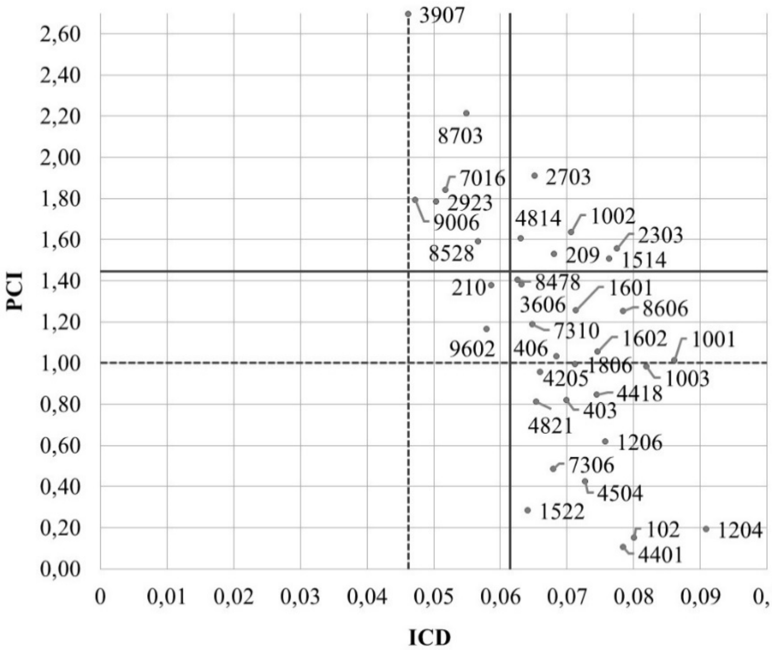
Fig. 4. ICD plotted against total exports for different countries (fragment)

Source: Atlas of economic complexity and authors' calculations

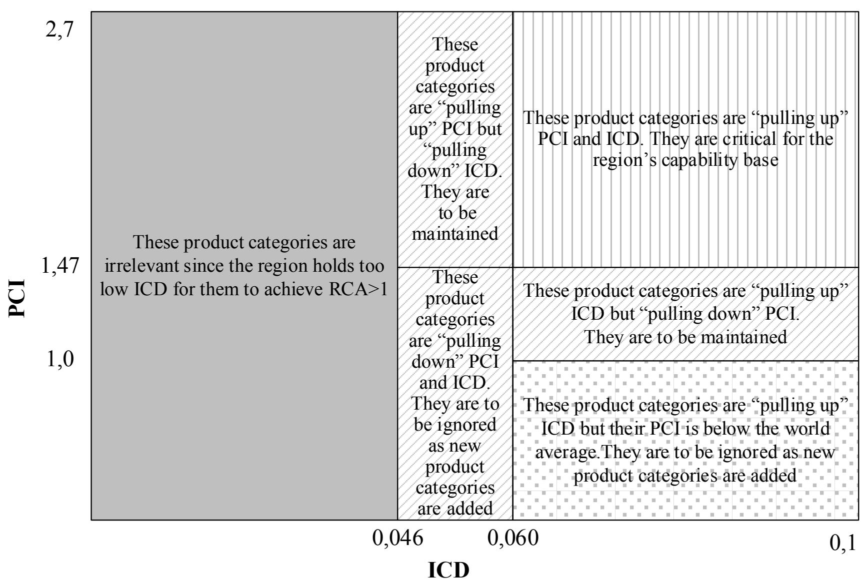
This is an indication that the capability base in the Kaliningrad region is too narrow and too shallow. This means (and empirically confirms) that regional companies operating in higher PCI product categories are dependent on transferred, imported or licensed capabilities from a parent company or from third parties external to the economy.

Another conclusion is that local sub-suppliers to these firms provide non-critical products and services, and are substitutable. The higher the PCI and the lower the ICD (Fig. 5), the larger the risk that the economy will lose this product category, unless it is built around an endowment resource, like a raw material with high transportation costs that is difficult to source on the open market or unless there are inducements provided e. g. tax relief.

[7] *Authors' note:* the concept of implied capability density (ICD) is used, since the density is calculated only for products with RCA>1. The calculation of ICD algebraically corresponds to that of density.



a) calculated values for the Kaliningrad region (part)



b) interpretation of the different spaces

Fig. 5. The part of Kaliningrad’s product space with RCA⩾1 plotted on the PCI and ICD dimensions

Note: lines indicate export volume-weighted average PCI and ICD values. HS codes are used to identify product categories[8].

[8] See Atlas of Economic Complexity — https://dataverse.harvard.edu/dataverse/atlas.

Accordingly, in order to increase the region's competitiveness, the ICD should be approximately twice the current value. To interpret the fragment and product categories in Fig. 5a, it is important to compare them to the zones in Fig. 5b limited by the values on the PCI and ICD scales. Figures 5a and 5b are alike. This paper does not consider the development of specific capabilities required for the production of more complex products, as it is a subject of separate research based on the results of the EC analysis.

The question now becomes if there are any product categories that could be produced in the Kaliningrad region that would increase the average PCI. Fig. 6 shows the result of this analysis. It presents Kaliningrad's product opportunity space plotted on the COG, PCI and ICD dimensions. The dots on the graphs are product categories (HS-4). Quadrants I, II and III differ in the level of complexity of products, the prospects and benefits of increasing their complexity, and priorities for the region.

As Fig. 6 shows, there are no product categories produced in the world that, if produced in Kaliningrad, would have any major positive impact on the absorptive and adaptive capabilities of the Kaliningrad region's existing product space. The main reason for that is the region's narrow and shallow capability base reflected in the low ICD and highly concentrated export portfolio.

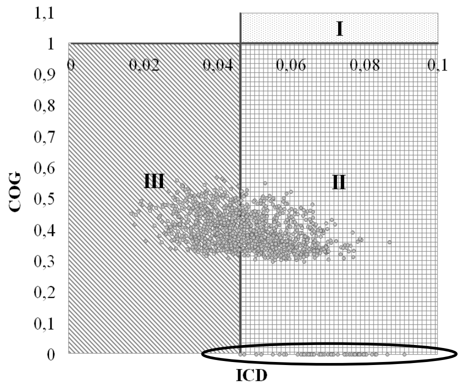
Thus, the results of the study indicate that the current situation in the region in terms of product complexity, as well as its competitiveness and opportunity gain in world trade, is unsatisfactory. Currently, the region produces a limited number of products of low complexity, and the COG is critically low as for all types of products its value is less than 1 (Fig. 6a and b).

However, this does not mean that the desired outcome cannot be achieved, just that it will take time and will require many parallel activity streams.

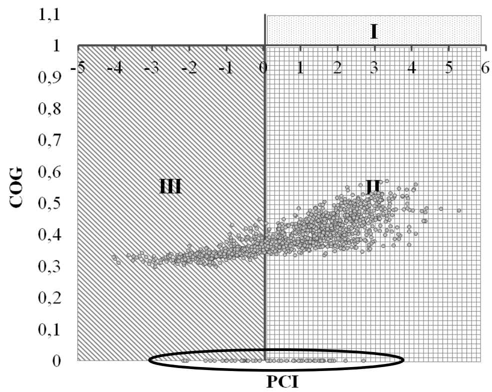
Thus, it is advisable to consider product categories that would provide at least some benefits for the economy if they are successfully (with RCA>1) produced and exported in volume (Table 2).

Based on calculations, Table 2 includes only those groups of international product classification that have COG> 0.5, ICD> 0.046 and PCI> 1. These criteria allow identifying product categories that, if increased, can contribute to the growth of the regional economic complexity, including through the development of related industries (Fig. 5b). Unfortunately, out of the total number of analyzed HS-4 categories, only 14 meet these criteria, and only three of them are presently not produced in the Kaliningrad region.

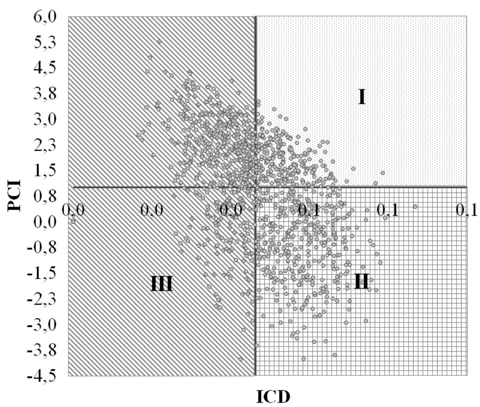
This means that the region would benefit most if, firstly, the competitiveness of the 11 product categories that are already produced is increased so that the corresponding RCA values become larger than one.



a) product opportunity space plotted on the COG and ICD dimensions



b) product opportunity space plotted on the COG and PCI dimensions



c) product opportunity space plotted on the PCI and ICD

Fig. 6. Opportunity space for more complex products

Note: *I* — product categories to focus on; *II* — minor benefits only since COG is less than 1; *III* — there are not enough capabilities for these categories and/or their production will not contribute to the increased absorptive and adaptive capacity of the region. Products in the oval are already produced in the region and their increase in the export portfolio will not affect the absorptive capacity of the economy.

Table 2

Ranking of the attractiveness of the initial product category focus for the Kaliningrad region

Attractiveness*	HS Code	Product Category Product Items	RCA	Export value multiplier to achieve RCA>1
0.7203	8416	Furnace burners for liquid fuel, for pulverised solid fuel or for gas; mechanical grates, mechanical ash dischargers and similar appliances	0.0000	—
0.7177	7326	Iron or steel; articles, n. e.c. in chapter 73	0.0839	12
0.7069	8530	Electrical signalling, safety or traffic control equipment for railways, tramways, roads, inland waterways, parking facilities, port installations or airfields	0.0000	—
0.7046	8607	Railway or tramway locomotives or rolling stock; parts thereof	0.0006	1703
0.7028	8412	Engines and motors; n. e.c. (e. g. reaction engines, hydraulic power engines, pneumatic power engines)	0.8634	1.16
0.6945	8428	Lifting, handling, loading or unloading machinery; n. e.c. in heading no. 8425, 8426 or 8427 (e. g. lifts, escalators, conveyors, teleferics)	0,0004	2406
0.6942	7616	Aluminium; articles n. e.c. in chapter 76	0.1818	5
0.6919	7226	Alloy steel flat-rolled products, of a width of less than 600mm	0.0000	—
0.6858	8516	Electric water, space, soil heaters; electro-thermic hair-dressing apparatus; hand dryers, irons; electro-thermic appliances for domestic purposes; electro heating resistors, not of heading no. 8545>	0.0008	1206
0.6848	9032	Regulating or controlling instruments and apparatus; automatic type	0.0038	263
0.6811	8538	Electrical apparatus; parts suitable for use solely or principally with the apparatus of heading no. 8535, 8536 and 8537	0.0192	52
0.6805	8708	Motor vehicles; parts and accessories, of heading no. 8701 to 8705	0.0010	1036
0.6795	4008	Tubes, pipes and hoses, of vulcanised rubber (other than hard rubber), with or without their fittings (e. g. joints, elbows, flanges)	0.0507	20
0.6640	8441	Machines; for making up paper pulp, paper or paperboard, including cutting machines of all kinds	0.0520	19

Note: * Attractiveness is calculated through the weighted average ratios of PCI, COG and ICD for any product category to their respective maximum value for all products of the Kaliningrad region.

This means that the export value would have to be increased by between 16% for HS category 8412 and a factor of 2406 (!) for HS category 8428. Most of these changes are unrealistic in the short term.

Secondly, the production of HS categories 8416, 8530 and 7226 should be commenced within the region and achieve the RCA>1. This may not be possible in the short term but may be possible in niches within the HS category and over time. It is important to note that before any implementation commences a detailed understanding of the companies active in these sectors must be gained so that appropriate policy interventions and priorities can be identified.

As the economy broadens and deepens its capability base, its absorptive and adaptive capability increases and thereby increases the portfolio of potential product categories that could be produced and exported as well as the benefits that these new products would provide to the economy. The logic is that the more you have the more you can get, and the more you have the easier it is to develop in new products that have not been made elsewhere yet and that are grounded in emerging and converging technologies.

Conclusions

The study allows us to draw several conclusions.

The ongoing structural changes in the economy are the consequence of the value creation paradigm shift resulting from technological development and affecting the micro, meso and macro levels. Economic complexity analysis is becoming increasingly important in identifying key areas for ensuring economic development and future growth, while maintaining and/or increasing the competitiveness of the territory. Assessing local productive capability base of a particular territory allows for selecting industrial strategies according to the criterion of achieving a comparative advantage due to the production of more complex products.

Measuring subnational economic complexity is currently limited due to the underdeveloped methodology. Addressing this issue, the IKBFU research group including the authors of the article, developed methodology and software for economic complexity analysis at the regional level. It was tested on the exclave Kaliningrad region. Specially developed algorithms allowed the authors to create a unified database combining the information (2017) on international and interregional cargo flows from several resources (customs and statistical authorities). It was “cleaned” of transit data, while the Kaliningrad region's trade data were added to the global trade statistics. The study included the calculation of economic complexity indicators and their subsequent analysis.

It has been established that at the moment, the Kaliningrad region has a narrow and shallow capability base resulting in a limited absorptive and adaptive capacity. The indication of this is the low complexity (PCI) of products already manufactured in the region, as well as the low capability density (ICD). This means that, in the product space, new, more sophisticated products are very distant from those already presented in Kaliningrad's export portfolio. Consequently, the amount of capabilities available in the region is not sufficient to switch to more complex products just now. The transition will take a long time and will require comprehensive measures at different levels. The conclusion stems from the low COI and COG values for new export products, as well as the results of interpretation and analysis of different parts of the product space. There are product categories that would provide minor benefits to the economy of the Kaliningrad region, provided they were successfully produced and exported (with RCA> 1). However, their analysis revealed that this will require a dramatic increase in export volume which may only be possible in specific niches within the identified HS groups over time.

The findings of the analysis of the economic complexity of the Kaliningrad region demonstrates its limited absorptive and adaptive capacity leading to the following industrial policy recommendations.

It is imperative that the Kaliningrad region does not lose any of the product categories that make up 80% of the region's export value. This means that there needs to be a continuous dialogue between regional and local government, on the one side, and the companies operating in these product categories, on the other, around how to ensure the continued and strengthened international competitiveness of these companies in a world changing to a more digital and low resource footprint value-creation logic. This dialogue could be informed by technology roadmaps, developed together with the firms, providing a basis for strategic directions in R&D, innovation and consumer/customer acceptance.

Secondly, it is essential to develop and export services linked to these product categories (like intellectual property development sale and licensing, financial services and other business services including architecture, engineering, design, consultancy services etc. as well as software, information & communication technologies). Such services are as, if not more, complex, as economically complex products and hence are major contributors to the absorptive and adaptive capacity of the economy. There are two aspects to this: the servitization of the manufacturing firm itself and the development of specialized service providers.

Thirdly, a policy of attracting companies whose capability would broaden and deepen the region's capability base should be implemented with vigour. Encouragement of new export- and growth-oriented firms (start-ups or spin-outs) grounded in emerging and converging technologies and bringing customers to the region should be a key policy. This will not only require an efficient start-up system around universities but also the activation of new and related value chains.

The results obtained in the course of this study can be used by the regional government to underpin the development strategy and a system of consistent interrelated actions and decisions. They will also be used in further research on structural holes and technological roadmapping in accordance with sectoral strategies and changes in the production structure of the region.

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