Russian Coal-Mining Regions Clustering Based on the Analysis of Investment and Innovation Activity

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Abstract. The paper is devoted to the clustering of coal-mining regions of Russia based on the analysis of their investment and innovation activity. The indicators characterizing investment and innovative activity were formed. The group of investment indicators included indicators highlighting the total shares of investment in fixed capital by types of activities related to the extractive and manufacturing industries. To assess innovation activity the total share values of the costs on technological innovations of extractive and manufacturing organizations were calculated. The results of hierarchical analysis fulfilled on the group of investment activity indicators allowed authors to identify four clusters of coal-mining regions. The coal-mining regions were divided into three clusters based on the indicators of innovation activity. Verbalization of the results allows authors to conclude that the most of coal-mining regions are characterized with the following: low/medium level of investment activity in extractive and manufacturing industries; medium level of innovation activity in extractive industries and medium/low level of innovation activity in manufacturing industries. On the whole, coal-mining regions are not able to modify the general «picture» of resource-mineral-raw materials dependency of the Russian economy in the short-term period.

1. Introduction

Nowadays, the export-raw materials model is the core of the Russian economy development. The urgent need for its «transformation» into the innovation model of development took on «chronic» character and the Russian Government has made permanent attempts to transform the export-raw materials model into innovative one using various instruments of economic policy at the federal and regional levels over the past decade. Nevertheless, extractive industries and manufacturing industries producing raw materials and intermediate products with low added-value determine competitive advantages of the Russian economy on a global scale. In the current geopolitical situation as well as within the framework of imposed Western sanctions related to the falling prices for export commodities and restricting access for Russian mining companies to foreign financial markets and technologies the problem of «restructuring» the model of extensive extraction and export of raw materials via its transformation into the model of intensive development based on the integrated exploitation of mineral resources leading to the emergence of positive externalities in the Russian
economy has great importance. In this case, the regions that are rich in natural and mineral resources are the key regions determining the further directions of the Russian economy development [1]. Oil and gas complex of the Russian economy has the crucial meaning, but coal-mining industry is also important from the point of view of the Russian exports as well as for the economies of several regions. Russian coal is exported to almost eighty countries of the world [2]. The total volume of the Russian coal exports exceeded 200 million tons according to the results of the year 2018, and 100 million tons was exported to the West (for example, the share of Russian coal in the European market is almost 40%), and 100 million tons was exported to the East, where the Russian share is 9.3% [3].

We identified 23 regions, in which coal mining is currently operating based on the available data on coal basins in Russia. Domestic coal reserves are mainly concentrated in Western and Eastern Siberia (84%) and in the Far East of Russia (6%), and at the same time Kuzbass coal basin is the largest deposit of coal reserves (56%) as well as Kansk-Achinsk coal deposit (12%), Trans-Baikal region (6%) and Republic of Khakassia (4%) [4].

One may point out the particular importance of the fact that as the previous studies show [5, 6] Russian regions rich in natural and mineral resources are characterized with the development model that can be indicated as enclave dual economy. Enclave dual economy is based on providing privileges and preferences for separate entrepreneurs and owners of large companies and business-groups who affiliated with regional authorities very tightly. J. Stiglitz noted that «economic science focuses on studying the deformation of initiatives as a result of the guaranteeing such privileges and preferences, but it must be said that they have more insidious aspect, i.e. these privileges are usually obtained through corruption and bribery of government officials» [7]. This variant for the development of the regional economy is associated with the formation of a highly productive export-oriented sector (wealth enclaves) that is isolated from the rest of the economy and represented with enterprises, companies and business-groups in the mining and intermediate industries (oil and coal mining industries, ferrous and non-ferrous metallurgy, etc.). Development of this sector does not provide significant incentives for the modernization of the regional economy and its integration into the all-Russian economic space as well as does not create conditions for the development of traditional manufacturing industries and innovation sector of the regional and national economies, and also this sector does not form the demand for human capital involved in high-tech production. Moreover, privileges holding by representatives of wealth enclaves are source of negative externalities associated with the deformation of incentives for entrepreneurs from other sectors of the economy, which are reoriented from creating new added-value to rent-seeking behavior linked with participation in the redistribution of added-value in a highly productive export-oriented sector.

The core of this problem is the situation when persistently preserved enclaves of wealth impede (or completely block) the transition to the development when national integrated economy is formed. National integrated economy provides conditions for the modernization of traditional manufacturing industries, for stimulation of innovation activity of medium and small businesses as well as investment in healthcare and education, research and development (R&D). Sustainable preservation of wealth enclaves in the regions rich in natural and mineral resources increases their resource dependence, locks-in investment flows in a narrow circle of industries producing raw materials and intermediate products, does not allow breaking short vertical value chains linked with the export of these products to the world markets as well as «creates incentives to invest resources in the development of human capital and competencies linked with the extraction of mineral and natural resources, but not with the intellectual activity» [8].

2. Literature review
The problem of resource dependency overcoming and transferring Russian economy to the innovation mode of development has several components. The first one is related to the fact that Russia consists of regions that are extremely different in their social-economic characteristics, which is reflected, for instance, in their uneven economic development, widening the gap in terms of the most important indicators of regional production, incomes and poverty, and the quality of life of the population [9,
The difference of regions in terms of indicators assessing their innovation activity was one of the most significant in comparison with other social-economic indicators. Thus, the gap in the share of domestic research and development costs in the gross regional product amounted 143-148 times, and the gap in the number of advanced production technologies used amounted more than a thousand times [11]. It is important to note that stimulating the development of high value-added industries in regions rich in natural and mineral resources creates an opportunity to weaken resource dependency, go beyond the enclaves of wealth, create new highly paid jobs in the non-resource sector (innovative business, traditional manufacturing), and improve the quality of life of the population.

In this regard, the second component of the problem is the need to achieve the goal of creating favorable conditions for federal and regional actors in coal-mining regions who will be ready to invest resources in the development of high value-added industries. Investment activity stimulation may lead to the emergence of the necessary positive externalities, which will favorably impact on the development of non-resource sector. In this sense, investments in extractive industries have transformational potential. However, there is a destructive side of investment activity in resource-dependent regions. This side is in the fact that investment activity may cause significant economic, social and environmental damage, but not lead to the long-term sustainable development [12-14].

The third component of this problem highlights the need for niches of innovative activity searching in the coal-mining regions. Investment in extractive industries can lead to the resource dependency increasing and the aggravation of «accompanying» problems (environmental degradation, increasing social tensions). Innovation activity stimulation is a way to overcome this problem successfully. Nowadays, innovations are the basic for sustainable, inclusive and «smart» economic growth. A number of studies are devoted to the problem of building sustainable, inclusive and «smart» innovation systems in countries with emerging markets [15-17]. The components of this triad are mutually reinforcing. «Smart» growth is based on knowledge and innovations as well as sustainable growth promotes more resource-efficient, green and competitive economy, while inclusive growth means stimulation of high level employment and ensuring economic, social and territorial integrity of the economy [18]. These components are priority (explicitly and/or implicitly) within the framework of economic policy conducted by the authorities of Russian regions rich in natural and mineral resources. For instance, regional environmental standard «Clean Coal - Green Kuzbass» changes approaches to coal-mining for the regional authorities and the owners of the coal-mining companies as the main stakeholders of the region development [19]. In this sense, the key task for the coal-mining companies is to solve the environmental problems of the region, which are inextricably linked with the problems of the indigenous population of Kemerovo region (Shors and Teleuts).

It is important to note that we did not highlight «dark» side of innovations in the study. However, some researches on this theme show that scientific and technological policies can serve the interests of narrow pressure groups that have significant political and administrative power and can exclude broad interest groups from the process of its development and implementation [20-22]. At the same time, innovations can be destructive [23-25], which means that they only contribute to increasing the resource dependency of coal-mining regions.

The aim of the study is the clustering of coal-mining regions of Russia on the basis of assessing their investment and innovation activity as a way of national integrated economy forming and resource dependency overcoming.

3. Data and methods

The data of 23 Russian regions specializing in coal extraction were used. The data were obtained from official sources of Russian Unified Interdepartmental Information and Statistical System. The following steps were made to analyze investment and innovation activity in coal-mining regions and assess their differentiation. Initially, indicators were formed that characterize the investment and innovative activity of coal-mining regions.

The group of investment indicators included two indicators highlighting the total shares of investments in fixed capital by types of activities related to the extractive industries (first indicator)
and to the manufacturing industries (second indicator). The calculation of the values of the first indicator included the share of investment in fixed capital for the extraction of coal and brown coal and peat as well as in the enrichment and agglomeration of coal. The calculation of the second indicator included the share of investment in chemical and metallurgical production, production of end metal products, in high-tech economic activities, and in the production of machinery and equipment (without the production of weapons and ammunition). The values of the presented investment indicators were calculated for each of the 23 coal-mining regions of Russia from 2013 to 2016. The choice of the chronological framework is justified by the fact that 2013 is the last pre-crisis year for the Russian economy, and 2016 is the last year with statistics available for the authors. It is important to note that the distribution of investment by the years for the region is most often uneven. Therefore, the average values for this period were taken into account as the values of investment indicators for more accurate assessment of investment activity. Table 1 presents the distribution of the values of investment indicators in the studied group of regions.

**Table 1.** Values of the average share of investment by industries in the coal-mining group of regions.

| Region                        | Extractive industries | Manufacturing industries |
|-------------------------------|-----------------------|-------------------------|
| Altai region                  | 0                     | 0,02174                 |
| Amur region                   | 0,00089               | 0,00223                 |
| Jewish autonomous region      | 0,0017                | 0,00031                 |
| Trans-Baikal region           | 0,02223               | 0,02003                 |
| Irkutsk region                | 0,00370               | 0,04550                 |
| Kemerovo region               | 0,43988               | 0,06253                 |
| Krasnoyarsk region            | 0,00305               | 0,16796                 |
| Magadan region                | 0,00014               | 0,00033                 |
| Murmansk region               | 0                     | 0,07533                 |
| Novosibirsk region            | 0,01511               | 0,05015                 |
| Orenburg region               | 0,00012               | 0,03155                 |
| Primorsky region              | 0,01124               | 0,08223                 |
| Republic of Buryatia          | 0,02668               | 0,03552                 |
| Komi Republic                 | 0,03222               | 0,00500                 |
| Republic of Sakha (Yakutia)   | 0,05873               | 0,00024                 |
| Republic of Tuva              | 0,26182               | 0                        |
| Republic of Khakassia         | 0,11027               | 0,07170                 |
| Rostov region                 | 0,01800               | 0,06241                 |
| Sakhalin region               | 0,00903               | 0,00029                 |
| Sverdlovsk region             | 0                     | 0,16943                 |
| Khabarovsk region             | 0,02880               | 0,02377                 |
| Chelyabinsk region            | 0,00014               | 0,23032                 |
| Chukotka autonomous region    | 0,00235               | 0                        |

One may note that in Republic of Tuva and Chukotka autonomous region the average share of investment in manufacturing industries is null. Maximum values of the average share of investment in extractive industries were shown by Kemerovo region, Republic of Tuva and Republic Khakassia as clearly resource-dependent regions. On the other hand, the average share of investment in extractive
industries turned out to be null in Altai, Murmansk and Sverdlovsk regions. Chelyabinsk, Sverdlovsk and Krasnoyarsk regions showed maximum values for the average share of investment in manufacturing industries.

The values of two indicators were calculated to assess the innovation activity of coal mining regions. The first indicator assessed the total cost share of extractive industries organizations on technological innovation. The second one assessed the total cost share of organizations for technological innovation in manufacturing industries. The share of costs for technological innovation in the respective industries was calculated for the time period 2013 - 2016 for each of the 23 regions. The indicator characterizing the innovation activity of coal-mining regions in the extractive/manufacturing industries was presented as the average value for the studying period.

**Table 2.** Values of the average share of costs for technological innovations by industries in the coal-mining group of regions.

| Region                    | Average share of organizations' costs for technological innovation distributed by industries, 2013 - 2016 |
|---------------------------|----------------------------------------------------------------------------------------------------------|
|                           | Extractive industries | Manufacturing industries                                                                 |
| Altai region              | 0                                                                                                       | 0,21718                                                                 |
| Amur region               | 0                                                                                                       | 0                                                                 |
| Jewish autonomous region  | 0                                                                                                       | 0,00119                                                                 |
| Trans-Baikal region       | 0,02731                                                                                                 | 0,01555                                                                 |
| Irkutsk region            | 0,00105                                                                                                 | 0,34691                                                                 |
| Kemerovo region           | 0,09657                                                                                                 | 0,78069                                                                 |
| Krasnoyarsk region        | 0,00031                                                                                                 | 0,06566                                                                 |
| Magadan region            | 0                                                                                                       | 0,01599                                                                 |
| Murmansk region           | 0                                                                                                       | 0,44275                                                                 |
| Novosibirsk region        | 0                                                                                                       | 0,38211                                                                 |
| Orenburg region           | 0                                                                                                       | 0,24127                                                                 |
| Primorsky region          | 0,00013                                                                                                 | 0,10004                                                                 |
| Republic of Buryatia      | 0,00236                                                                                                 | 0,50519                                                                 |
| Komi Republic             | 0,08370                                                                                                 | 0,00046                                                                 |
| Republic of Sakha (Yakutia)| 0                                                                                                       | 0,00131                                                                 |
| Republic of Tuva          | 0                                                                                                       | 0                                                                 |
| Republic of Khakassia     | 0                                                                                                       | 0                                                                 |
| Rostov region             | 0                                                                                                       | 0,35285                                                                 |
| Sakhalin region           | 0                                                                                                       | 0                                                                 |
| Sverdlovsk region         | 0                                                                                                       | 0,39687                                                                 |
| Khabarovsk region         | 0                                                                                                       | 0,59065                                                                 |
| Chelyabinsk region        | 0                                                                                                       | 0,35391                                                                 |
| Chukotka autonomous region| 0,00297                                                                                                 | 0                                                                 |

It is important to note that in more than 65% of the coal-mining regions the average share of organizations' costs on technological innovations in extractive industries turned out to be null. Moreover, in Amur and Sakhalin regions as well as in Republics of Tuva and Khakassia the average share of organizations' costs for technological innovations in extractive and manufacturing industries also turned out to be null. The main paradox is that Kemerovo region (the «coal-mining capital» of
Russia) turned out to be the leader among coal-mining regions with the maximum value of the average share of organizations' costs on technological innovations in manufacturing industries.

4. Results and Discussion

Table 3 shows descriptive statistics of investment and innovation indicators calculated for a group of coal-mining regions. Both parametric and non-parametric statistics were included in the calculation for a more detailed study [26].

| Indicator                        | Average | Median | Minimum | Maximum | Quartile lower | Quartile upper | Standard deviation |
|----------------------------------|---------|--------|---------|---------|----------------|-----------------|--------------------|
| Investment in extractive industries | 0.045   | 0.009  | 0       | 0.440   | 0.0002         | 0.029           | 0.103              |
| Investment in manufacturing industries | 0.050   | 0.032  | 0       | 0.230   | 0.0003         | 0.072           | 0.062              |
| Innovation in extractive industries | 0.009   | 0.000  | 0       | 0.097   | 0              | 0.001           | 0.026              |
| Innovation in manufacturing industries | 0.209   | 0.100  | 0       | 0.781   | 0.0005         | 0.382           | 0.233              |

Analysis of descriptive statistics allows authors to make the following conclusions. Investment activity in extractive industries in the studied group of regions is different. The average value of this indicator is very different from the values of the median and even the upper quartile. One may suggest that the study group contains regions with abnormally high values of this indicator (for instance, Kemerovo region, Republic of Tuva). Distribution of investment in manufacturing industries is more evenly. Similar picture is observed for innovation activity in extractive industries. Moreover, in more than 50% of the regions this activity is absent (median is 0) and the maximum value of this indicator (0.097) is significantly lower than in manufacturing industries (0.781).

Cluster analysis was used to build a typology of Russian coal-mining regions by investment and innovation activity [27-29]. Cluster analysis was carried out according to standardized data (zero, average, unit variance) since the range of variation of the indicators values differs significantly. Division of regions was carried out separately according to the indicators of investment and innovation activity. Initially, hierarchical cluster analysis was used (method of complete-linkage clustering). Hierarchical analysis allowed authors to make an assumption about the number of highlighted groups. Figure 1.1 and figure 1.2 present the results of the regions division based on the indicators of investment and innovation activity.

The studying of the hierarchical analysis results conducted with the group of indicators of investment activity allowed identifying 4 clusters. Regions were divided into 3 clusters based on the indicators of innovation activity. Figures 2.1 and 2.2 present graphs of average values of indicators in various classes of investment activity and innovation activity.
The following division of coal-mining regions was obtained with the level of investment activity. First cluster includes regions with a low level of investment activity in extractive industries and a high level of investment activity in manufacturing industries (Krasnoyarsk, Sverdlovsk and Chelyabinsk regions). Second cluster includes regions with a medium level of investment activity in extractive and manufacturing industries (Irkutsk, Murmansk, Novosibirsk, Rostov and Primorsky regions, Republic of Khakassia). Third cluster includes regions with a high level of investment activity in extractive industries and a low one in manufacturing industries (Kemerovo region, Republic of Tuva). Fourth cluster is represented by the regions with a low level of investment activity in extractive and manufacturing industries (Altai, Amur, Magadan, Orenburg and Sakhalin regions, Jewish autonomous region, Trans-Baikal region, Republic of Buryatia, Republic of Sakha (Yakutia), Khabarovsk region, Chukotsky autonomous region).

The results of dividing coal-mining regions according to the indicators of costs for technological innovation can be described as the following. First cluster includes regions with a medium level of technological innovation costs in extractive and manufacturing industries (Altai, Irkutsk, Murmansk, Novosibirsk, Orenburg, Rostov, Sverdlovsk and Chelyabinsk regions, Republic of Buryatia, Khabarovsk region). Second cluster includes regions with a high level of costs for technological innovations in extractive industries and a medium level of costs for innovations in manufacturing industries: Kemerovo region, Komi Republic. Third cluster is represented with regions with a low level of innovation costs in manufacturing industries and a medium level of innovation costs in
extractive industries: Amur, Magadan and Sakhalin regions, Jewish autonomous region, Trans-Baikal region, Krasnoyarsk region, Primorsky region, Republic of Sakha (Yakutia), Republic of Tuva, Republic of Khakassia, Chukotka autonomous region.

Table 4 presents the distribution of coal-mining regions depending on the level of their investment and innovation activity.

**Table 4.** Clustering of coal-mining regions depending on the level of investment and innovation activity.

| Cluster number (technical innovation costs) | Medium level of innovation activity in extractive and manufacturing industries (cluster 1) | High level of innovation activity in extractive industries and medium level of innovation activity in manufacturing industries (cluster 2) | Medium level of innovation activity in extractive industries and low level of innovation activity in manufacturing industries (cluster 3) |
|---------------------------------------------|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| Cluster number (investment in fixed capital) | Medium level of investment activity in manufacturing and extractive industries (cluster 1) | High level of investment activity in extractive industries and low level of investment activity in extractive industries (cluster 3) | Krasnoyarsk region                                                                             |
| | Sverdlovsk region | Chelyabinsk region | Krasnoyarsk region |
| | Irkutsk region | Murmansk region | Primorsky region |
| | Novosibirsk region | Kemerovo region | Republic of Khakassia |
| | Rostov region | | Republic of Tuva |
| | Altai region | Komi Republic | Amur region |
| | Orenburg region | | Jewish autonomous region |
| | Republic of Buryatia | | Trans-Baikal region |
| | Khabarovsk region | | Magadan region |
| | | | Republic of Sakha (Yakutia) |
| | | | Sakhalin region |
| | | | Chukotka autonomous region |

Clustering of Russian coal-mining regions based on the analysis of their investment and innovation activity showed the following results. Two thirds of the regions (15 of 23) are concentrated in three cells (according to the vertical axis «investment in fixed capital» and horizontal axis «costs of technological innovation»): cluster 4 - cluster 3; cluster 2 - cluster 1; cluster 4 - cluster 1. These cells are generally characterized by low/medium level of investment activity in extractive and manufacturing industries, and medium level of innovation activity in extractive industries and...
medium/low level of innovative activity in manufacturing industries. The situation of Kemerovo region and Republic of Tuva is quite curious because high level of investment activity in extractive industries and low level of investment activity in manufacturing industries, as well as high/medium level of innovation activity in extractive industries and low level of innovation activity in manufacturing industries only reinforce resource dependency of these regions. For instance, richness and diversity of minerals of Republic of Tuva determines largely the prospects for the economic development of the region. At the same time, its main problems are the following: high degree of depreciation of fixed capital, significant investment reduction in the real sector of the economy, low share of investments from private enterprises [30].

5. Conclusion
At the present, Russian economy is predominantly a resource-mineral-r raw materials one, both in terms of the dominant industries structure (extractive and low added-value sectors) and in terms of the export structure (raw materials are crucial export goods). Coal-mining is one of the foundations of the domestic economy. Investment and innovation processes taking place in coal-mining regions could form the prerequisites for overcoming resource dependency. However, as the analysis showed, neither investment nor innovation is the factors to overcome it. Most of the represented regions are characterized with the following: low/medium level of investment activity in extractive and manufacturing industries; medium level of innovation activity in extractive industries and medium/low level of innovation activity in manufacturing industries. Certain territories (Krasnoyarsk, Sverdlovsk and Chelyabinsk regions) showed results that are different from other coal-mining regions, but on the whole they are not able to change the general «picture» of resource-mineral-r raw materials dependency. In other words, coal-mining enclaves of wealth are preserved rigorously and they have insignificant impact (or there is no impact at all) on the development of non-resource sectors of the economy. There are permanent flows of «innovation through investment in the purchase of imported equipment», and not «innovation through local R&D implementation» in these enclaves. In this case, such innovation and investment activities have a destructive potential, which consists in preserving resource dependency and the inability to form a national integrated economy.

References
[1] Kagan E S and Goosen E V 2017 *IOP Conf. Series: Earth and Environ. Sci. 84(1) 163-170*
[2] Tarazanov I G 2019 *Ugol 3* 64-79
[3] Official site of Ministry of Energy of the Russian Federation https://minenergo.gov.ru/activity/statistic
[4] The Mining Landscape (Part One) https://www.worldcoal.com/coal/17102013/the_mining_landscape_part_one_140/
[5] Levin S N, Kagan E S and Sabin K S 2015 *J. of Institutional Studies 7(3)* 92-101
[6] Levin S N, Sabin K S and Rutskiy V N 2018 *Mir Rossii 27(3)* 6-27
[7] Stiglitz J 2003 *Globalization and its Discontents* (Moscow: National Public and Scientific Fund)
[8] *Russia 2025: Resetting the Talent Balance* https://www.bcg.com/Images/russia-2015-eng_tcm27-187991.pdf
[9] Malkina M Yu 2014 *Economy of Region 2* 238-248
[10] Nureev R M 2009 *Terra Economicus 7(2)* 18-42
[11] Ignatov V G 2009 *Terra Economicus 7(2)* 132-138
[12] *Investment in Extractive Industries* (Columbia Center for Sustainable Investment) http://ccsi.columbia.edu/our-focus/investments-in-extractive-industries/
[13] Bebbington A, Bornschlegl T and Johnson A 2013 *Introduction to Development and Change 2* 1-16
[14] Bebbington A 2012 *Social Conflict, Economic Development and Extractive Industry: Evidence from South America* (London: Routledge)
[15] Altenburg T 2009 Building Inclusive Innovation Systems in Developing Countries: Challenges for IS Research *Handbook of Innovation Systems and Developing Countries: Building Domestic Capabilities in a Global Setting*, ed B-A Lundvall, K J Joseph, C Chaminade and J Vang (Cheltenham: Edward Elgar Publishing) pp 33-56

[16] Altenburg T and Pegels A 2012 *Innovation and Development* 2(1) 5-22

[17] Athreye S and Kapur S 2015 Capital and Technology Flows: Changing Technology Acquisition Strategies in Developing Countries *The Handbook of Global Science, Technology, and Innovation*, ed D Archibugi and A Filippetti (Oxford: Wiley) 191-211

[18] *Guide to Research and Innovation Strategies for Smart Specialisation (RIS 3)* https://ec.europa.eu/regional_policy/sources/docgener/presenta/smart_specialisation/smart_ris3_2012.pdf

[19] *Clean Coal - Green Kuzbass* http://kuzbass85.ru/2019/08/23/chistyj-ugol-zelenyj-kuzbass/

[20] Levin S N, Sablin K S and Kagan E S 2017 *J. of Institutional Studies* 9(3) 119-132

[21] Chaminade C, Lundvall B-A and Haneef S 2018 *Advanced Introduction to National Innovation Systems* (Cheltenham: Edward Elgar Publishing)

[22] Soete L 2013 Is Innovation Always Good? *Innovation Studies: Evolution and Future Challenges* ed J Fagerberg, B R Martin and E S Andersen (Oxford: Oxford University Press) 134-144

[23] Baumol W 1990 *J. of Political Economy* 98(5) 893-921

[24] Desai S and Acs Z J 2007 *Jena Economic Research Papers* https://www.econstor.eu/bitstream/10419/25657/1/553834517.PDF

[25] Heilbrunn J R 2014 *Oil, Democracy, and Development in Africa* (Cambridge: Cambridge University Press)

[26] Sidorenko E V 2000 *Methods of Mathematical Processing in Psychology* (Saint-Petersburg: Rech)

[27] Pegat A 2013 *Fuzzy Modelling and Management* (Moscow: Binom. Laboratory of Knowledge)

[28] Mirkin B G 2005 *Clustering for Data Mining: A Data Recovery Approach* (New York: Taylor & Francis Group)

[29] Rodriguez M Z, Comin C H, Casanova D, Bruno O M, Amancio D R, Costa L and Rodriguez F 2019 *PLoS ONE* 14(1) 1-34

[30] *Mineral and Raw Materials Sector of Asian Russia: How to Ensure Social and Economic Useful Effect?* 2015 (Novosibirsk: IEIE of Siberian Branch of RAS)

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