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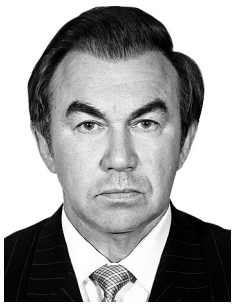

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Managing the Development of Advanced Manufacturing Technologies Under Transformation of the World Industrial Landscape[1]

The paper justifies the specifics of the turning point in the world technological development and indicates the arising opportunity for Russia to change its positioning in the global economy. It demonstrates the role of the advanced manufacturing technologies as an important factor behind new industrialization and maintaining global competitiveness of an economy. The paper describes peculiarities of the modern world technological development and holds a comparative analysis of the level of manufacturing competitiveness, research potential and support provided to industrial and technological development in a number of countries. The authors detect main trends in the transformation of the world technological landscape, including in the context of management of the manufacturing technologies development by the leading technologically advanced countries.

JEL classification: F00, L60

Keywords: manufacturing technologies development; new industrialization; global manufacturing competitiveness; landscape of world technological development; research potential of economies; support for industrial-technological development.

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Introduction

The process of the new industrialization is one of the most pronounced and actively discussed trends in the world economy. The developed countries are characterized by the so-called policy of reshoring, which is being currently implemented by the USA [4; 11; 12]. However, the slogan "Buy American", which reflects the search for public support of import substitution [3], was coined in the 1980s to protect the American market from Japanese companies.

In Europe, the commencement of the industry revival after a long-propagated era of post-industrialization was marked by the communiqué "For the European Industrial Renaissance" published by the European Commission in January 2014, which envisaged an increase in the industry's share in GDP of the EU countries from 16 to 20% by 2020. There are already some achievements. Half of the top 10 nations with the most industrial robots per 10,000 employees belong to the European Union. Of the 22 countries with an above-average robot density, 14 are located in the EU[1]. The third place in the world is taken by Germany, where the national industry preserved better than in other European economies: the share of manufacturing in the structure of GDP is 22.4%, while the output of industrial products has increased by 23.5% over the past fifteen years (for instance, in Italy it has decreased by 11.1%) [6]. At present, in Europe, the general mechanisms of development include stimulation of small innovative businesses and creation of its own high-tech production [4].

As for developing countries, the experience of China deserves particular attention, where it was possible to combine the national trends of the East (in mental sphere) and the best achievements of the West (in innovative sphere). According to the national program "Made in China 2025" PRC seeks to become the leading technologically advanced nation in the field of industry.

Extensive experience of carrying out accelerated industrialization during the Soviet period can be described as a "Russian model of industrialization". Nowadays, in relation to the Russian economy the term "new industrialization" is applied the most often [2; 5; 10].

Taking into account the increased attention to new industrial development in national economies, which involves the use of new technologies, it seems quite relevant to identify the main trends in managing the development of advanced manufacturing technologies in the context of the changing world industrial landscape.

Methodological approaches to identification of peculiarities of the world industrial and technological development

According to S. A. Tolkachev, in modern conditions "reducing costs per unit of output due to enhanced division of labour and increased economies of scale cease to become the determining factor in geoeconomy. Global value chains are subject to de-globalization, regionalization and localization" [11]. In this regard special attention is drawn to new industrialization, which, as treated by Ye. G. Animitsa, Ya. P. Silin, N. V. Novikova, is a set of long-term technical and technological processes, enabling quantitative and qualitative modernization of industry, physical infrastructure, R&D, preparation of specialists [10. P. 16]. Economists highlight the importance of both vertical and inter-industry integration. For instance, S. S. Gubanov argues that the law of vertical integration is a criterion behind progressiveness of a socioeconomic system of any country in the world. Modern economic system is as much progressive, as it is vertically integrated and able to maintain inter-industry interactions. What is not vertically integrated and not organized in the form of inter-industry value chains is certainly imperfect [5. P. 15].

While examining the cycles of world economic development V. Klinov states that "basic innovations that opened the way for the development of new sectors of production occurred

[1] World Robotics Report 2016. International Federation of Robotics Fund. Available at: https://ifr.org/ifr-press-releases/news/world-robotics-report-2016.

the most intensively in the periods of the least favourable economic situation" [8]. This way, in the USSR during the post-war period large-scale high-tech projects were implemented. At the same time, the government provided conditions for active formation and interaction of auxiliary industries, research and educational institutions around new industrial productions, what raised the level of general and technical culture, improved territorial development, and sustainability of the entire socioeconomic system [2].

In the conditions of the global economic and financial crisis, declining world commodity prices, as well as strained global economic relations, we can also speak of a period of unfavorable economic situation, when highly demanded innovations create additional opportunities for scientific and technological development of a country [9. P. 26; 7. P. 21].

Modern technological development features three important qualitative transitions:

- from manufacturing as "production using human physical efforts" to "brainfacturing" as intellectual production, or "production using human intellect";
- from B2B, B2C to M2M and IoT concept (the Internet of Things);
- from the concepts "high-tech" and "low-tech" in the 20th century to the concept of advanced industries in the 21st century.

The Brookings Institution establishes the following criteria to refer to an industry as an advanced:

- an industry's R&D expenditure per worker must fall in the 80th percentile of industries or higher, exceeding 450 US dollars per worker;
- the share of workers in an industry whose occupations require a high degree of STEM knowledge (Science, Technology, Engineering and Math) must also be above the national average, or 21% of all workers [13. P. 2].

Together the two thresholds identify 50 industries in the USA, of which 38 are manufacturing, and the rest represent sector of services closely related to the industry. The advanced industries sector employs 80% of the nation's engineers; performs 90% of private-sector R&D; generates approximately 85% of all US patents; and accounts for 60% of the US exports. One new job in the sector creates up to 16 additional jobs in other sectors [13. P. 3].

Therefore, the indicated peculiarities of the world technological development are of a fundamentally new, comprehensive and long-term nature, which allows the countries directing special attention to this issue so as to secure their leading positions in the world economy.

Comparative analysis of advanced manufacturing technologies development by country

The development of advanced manufacturing technologies determines the global manufacturing competitiveness. The three leading countries in the 2016 Global Manufacturing Competitiveness Index (GMCI) are China, the USA, and Germany (table 1). In the forecast for 2020, the leaders will remain the same, though the USA will push China from the first to the second place. The composition of the five leaders in 2020 will not change much as well, yet India will edge out South Korea and move from the 11th position to the fifth. It is noteworthy that the ranks of the European countries are going to deteriorate except for the solid position of Germany and improved rank of the Czech Republic (by three points). However, the positions of some developing countries are likely to become better, particularly, the ranks of Malaysia (13th place) and Indonesia (15th place) will grow by four points. Of the 15 leading countries in 2020, ten are located in Asia Pacific, three are from North America (the USA, Canada, Mexico) and only two originate from Europe (Germany and the United Kingdom, though the rank of the latter will deteriorate by two positions). At this, there is a direct correlation between a country's rank and its high-tech export. The countries, where high-tech exports account for more than a half of the total exports, are believed to improve their positions: Germany (53%, +5), the USA (58%, +3), Japan (55%, +2), the United Kingdom (58%, +9). The ranking of China and India, having the share of high-tech exports of 42% and 43% respectively, is expected to fall by one and three positions.

Table 1

Global Manufacturing Competitiveness Index rankings by country, 2016 and 2020 (projected)

2016			2020 (projected)			
Rank	Country	Index score	Rank	2016 *vs.* 2020	Country	Index score
1	China	100.0	1	+1	United States	100.0
2	United States	99.5	2	–1	China	93.5
3	Germany	93.9	3	–	Germany	90.8
4	Japan	80.4	4	–	Japan	78.0
5	South Korea	76.7	5	+6	India	77.5
6	United Kingdom	75.8	6	–1	South Korea	77.0
7	Taiwan	72.9	7	+1	Mexico	75.9
8	Mexico	69.5	8	–2	United Kingdom	73.8
9	Canada	68.7	9	–2	Taiwan	72.1
10	Singapore	68.4	10	–1	Canada	68.1
11	India	67.2	11	–1	Singapore	67.6
12	Switzerland	63.6	12	+6	Vietnam	65.5
13	Sweden	62.1	13	+4	Malaysia	62.1
14	Thailand	60.4	14	–	Thailand	62.0
15	Poland	59.1	15	+4	Indonesia	61.9
16	Turkey	59.0	16	–1	Poland	61.9
17	Malaysia	59.0	17	–1	Turkey	60.8
18	Vietnam	56.5	18	–5	Sweden	59.7
19	Indonesia	55.8	19	–7	Switzerland	59.1
20	Netherlands	55.7	20	+3	Czech Republic	57.4

Source: 2016 Global Manufacturing Competitiveness Index Report Highlights. Deloitte. Available at: https://www2.deloitte.com/global/en/pages/manufacturing/articles/global-manufacturing-competitiveness-index.html.

As for Russia, its position in the ranking worsened; after holding the 20th place in 2010, the country ranked just the 32th in 2016. It is a common trend for all BRIC countries: India fell from the second to the 11th place, Brazil changed its position from the fifth to the 29th (Fig. 1).

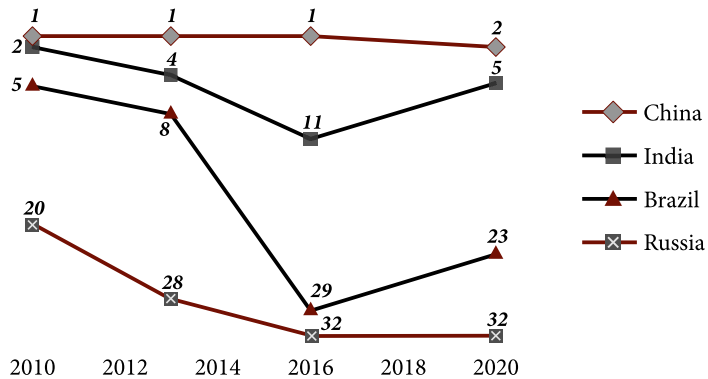


Fig. 1. BRIC ranks in Global Manufacturing Competitiveness Index rankings, 2010–2020[1]

[1] 2016 Global Manufacturing Competitiveness Index Report Highlights. Deloitte. Available at: https://www2.deloitte.com/global/en/pages/manufacturing/articles/global-manufacturing-competitiveness-index.html.

However, we can see the rise of MITI-V (the "Mighty 5"): Malaysia (+4), India (+6), Thailand (the same 14th position), Indonesia (+4), Vietnam (+6) (table 2), which will be among the 15 leaders by 2020 (table 1).

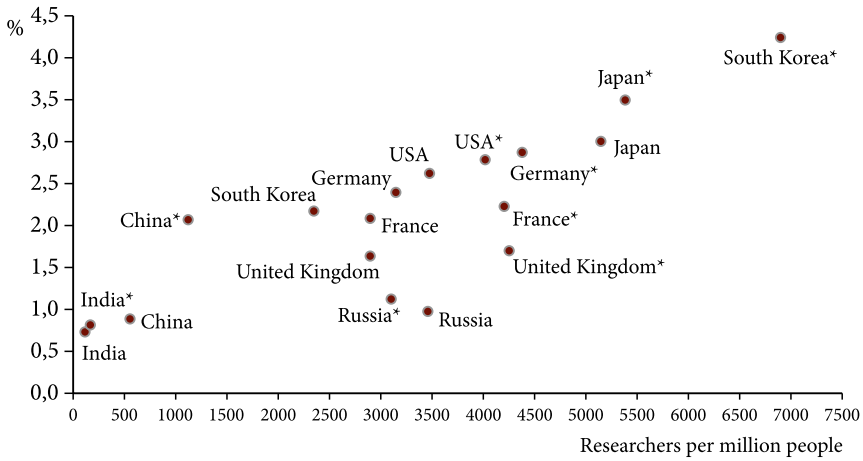
Table 2

MITI-V ranks in Global Manufacturing Competitiveness Index rankings

Country	Malaysia	India	Thailand	Indonesia	Vietnam
2016	17	11	14	19	18
2020	13	5	14	15	12

Source: 2016 Global Manufacturing Competitiveness Index Report Highlights. Deloitte. Available at: https://www2.deloitte.com/global/en/pages/manufacturing/articles/global-manufacturing-competitiveness-index.html.

In terms of the dynamics of technological development in 2000–2015, the combination of the two most important indicators of efficiency of national technological development, namely R&D expenditure as a percentage of GDP and number of researchers per million people allows identifying the following groups of the economies (Fig. 2).



Notes: no (*) indicates 2000; (*) indicates 2014 or 2015. The number of researchers is for 2014 [except for the USA (2012) and India (2010)], and R&D expenditure (% of GDP) is for 2015 [except for India (2011)]

Fig. 2. Changes in R&D expenditure and number of researchers in top countries by spending, 2014 and 2000[1]

- South Korea and Taiwan are the economies that grew the most rapidly: in 2000–2013 their spending went up from less than 2% of GDP to well over 3%, whereas the number of researchers per million people rocketed from 2, 500 to 6, 000 people.
- Japan, Germany, France, the USA and the United Kingdom are the developed countries that demonstrated moderate growth. Their comparatively small increases indicate that the level of development of financial and human research potential is already high, therefore it is not easy to augment it substantially. Moreover, the United Kingdom experienced a decrease in relative spending on research. Generally, having strong position today does not guarantee holding them in the future.
- China, India, Russia are large developing countries that showed growth in at least one of the considered indicators.

[1] Source: UNCTAD (http://data.uis.unesco.org/Index.aspx?DataSetCode=SCN_DS&popupcustomise=true&lang=en#), OECD (https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm) and World Bank statistics (http://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS).

Comparative analysis of national policies for industrial-technological development

Speaking about the global experience of supporting industrial-technological development, we cannot but mention the leadership of the USA, particularly expressed in the fact that out of 100 leading companies judging by market capitalization 54 are of American origin. Narrowing the focus of attention (within these top 100 companies) to companies of high-tech and industrial sector (46 companies out of 100) does not change the status of the American economy as the absolute leader (24 companies out of this number). In addition, the USA are the leader in companies' spending on R&D (41 companies out of 100 top), followed by Japan (25 companies). To compare, China occupies only the 12th place (2 companies). The USA also ranks the first according to the government expenditure on R&D, which is achieved due to allocation of budgets to public research institutions, universities and national laboratories. The USA were the first to address the issue of new industrialization. In 2013 the plan of reviving the American manufacturing industry was formulated. Besides, there was established the program for accelerated creation of jobs and innovations in advanced manufacturing industries **[3. P. 43]**.

In such context, the comparative analysis of policies used to support industrial development in the leading countries seems to be of high relevance. Taking into account the always present limitations of resources (intellectual, financial, material, etc.) it is not possible to tackle the issue of resources' most efficient distribution and the necessity of concentrating the available funds on potential breakthroughs. If stating that this policy should pursue along with the development goals, some socioeconomic goals, including securing employment in traditional sectors, we can conditionally correlate: social goals with the block of traditional sectors, economic goals with competitive sectors, development goals with "venture" sectors. Admitting the choice between these types of sectors we can obtain a number of possible combinations of support for their development. Support of all three types is in place in the case of China's comprehensive support. The option of assisting to competitive sectors describes the South Korea's case, which, for instance, is the world leader in the robot density per 10, 000 workers (more than 500) with the world average equaling 68 and Russia's two in 2015[1]. The third comes Germany, which adopts the policy of developing traditional for it and competitive industries (machine-building and others). The case of Japan represents a successful combination of support provided to competitive and venture industries.

Such kind of policy is specifically addressed within the Eurasian Economic Union (EAEU). This way, Kazakhstan implemented the State program on accelerated industrial-innovative development for 2010–2014, which encompassed subprograms on the machine-building development, assistance to technological modernization, investment attraction, and export promotion. Currenty, the Program "Productivity–2020" is being run, which aims at modernization of technologies and industrial cycles **[1. P. 59–60]**.

In the Russian economy, the leading role in supporting the development of advanced manufacturing technologies is assumed by the project of the National Technology Initiative detailed and supported by already created road maps and allocated budget funds according to some future markets. Within the Initiative there were specified 11 priority directions, which are now transformed into and supported as projects. The new vector of the industrial policy of the Ministry of Industry and Trade of the Russian Federation in the long term presupposes, along with the existing specialization of the country in the world market, four or five global strategic roles.

[1] World Robotics Report 2016. International Federation of Robotics Fund. Available at: https://ifr.org/ifr-press-releases/news/world-robotics-report-2016.

Conclusion

Therefore, in the transformation of the world industrial-technological landscape, including in the context of managing the development of advanced manufacturing technologies in national economies, the following main trends can be detected:

- existence of three main qualitative transitions in technological development (from physical to intellectual production, from B2B to the Internet of Things, from the concepts "high-tech" and "low-tech" to the concept of advanced industries);
- presence of three groups of economies identified on the basis of combination of two most important indicators of efficiency of national technological development, namely R&D expenditure as a percentage of GDP and number of researchers per million people: economies that demonstrated rapid growth (Asian countries); developed economies with moderate growth; large developing countries that showed an increase in at least one of these indicators (Russia included);
- use of possible combinations of support for development of three important types of industries: traditional, competitive and venture.

Russia's ability to take maximum advantage of the chance to overstep the advanced production and technological boundaries will depend on a concerted effort of all participants of the process to run "the most important socioeconomic mega-project, the implementation of which will ensure the rise of the national economy at the next upward long wave of economic growth" **[10. P. 17]**.

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Управление развитием передовых производственных технологий в условиях изменения мирового индустриального ландшафта[1]

Ю. Г. Лаврикова, Е. Л. Андреева, А. Г. Тарасов

Обосновываются специфика переломного момента в мировом технологическом развитии и актуальность использования Россией создавшегося шанса для изменения ее позиционирования в глобальной экономике. Показана роль передовых производственных технологий как важнейшего фактора неоиндустриализации и обеспечения глобальной конкурентоспособности экономики. Охарактеризованы особенности современного мирового технологического развития, проведен компаративный анализ уровня промышленной конкурентоспособности, исследовательского потенциала национальных экономик и содействия промышленно-технологическому развитию в экономиках стран. Выявлены основные тенденции в изменении ландшафта мирового технологического развития, в том числе в контексте управления развитием производственных технологий в ведущих технологически развитых странах.

Ключевые слова: развитие производственных технологий; неоиндустриализация; глобальная промышленная конкурентоспособность; ландшафт мирового технологического развития; исследовательский потенциал экономик; содействие промышленно-технологическому развитию.

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