Development of the Advanced Manufacturing Technologies: Positioning of Europe in the Future

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Summary. The analysis of the trends of global industrial-technological development has shown the existence of qualitative transitions in technological development, presence of three groups of economies by combination of indicators of technological development, existence of various combinations of support for development of industries in national economies. The EU countries possess one of the leading positions, in particular, Germany. They have high global industrial competitiveness. The instruments of technological development are the instruments of stimulation of small innovative business activation and of own high-tech manufacturing. In Germany will be developed “the Industry 4.0”. However, to forecasts, European economies will cede their positions relatively to the economies of Asian-Pacific region, including of the developing. Already now the European economies cede them in the context of dynamics of some indexes of technological development.

Key words: advanced manufacturing technologies**,** qualitative transitions, European economies, developing economies, manufacturing competitiveness

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. However, the slogan "Buy American", which reflects the search for public support of import substitution [6], was coined in the 1980s to protect the American market from Japanese companies.

In Europe, the begin 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. It seems to be relevant to define what trends and results in the development of advanced manufacturing technologies are typical for European developed economies and how they are positioned relatively other economies.

Achievements and forecasts.

There’re already achievements in the sphere of development of advanced manufacturing technologies. 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 [8]. 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%, and 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%) [5].

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 [1. P. 2].

So, in the USA, to these criteria correspond 50 industries, 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 [1. 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.

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 (it’s related on Great Britain, Poland, Sweden, Switzerland, Netherlands, being present in top-20 nowadays) except for the solid position of Germany and improved rank of the Czech Republic (by three points – to the 20th

place). 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.

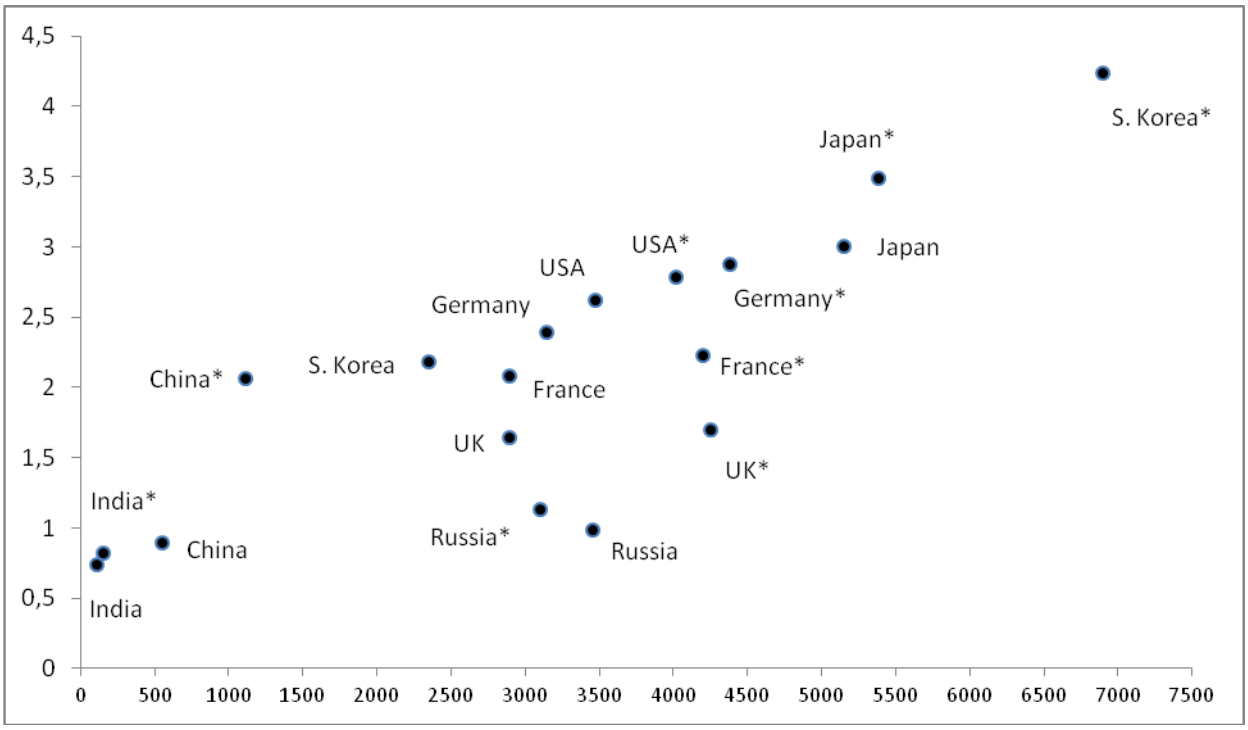
Table 1

Global Manufacturing Competitiveness Index for leading countries, 2016 and 2020 (projected) [2]

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

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. 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) [2], which will be among the 15 leaders by 2020.

In terms of the dynamics of technological development in 2000-2015, the combination of the two most important indicators 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. 1):



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. 1. Changes in R&D expenditure (share in GDP, %) (Y) and number of researchers (per million of inhabitants) (X) in top countries by spending, 2014 and 2000[1]

• the economies that grew the most rapidly: South Korea and Taiwan (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 [2]);

• developed countries that demonstrated moderate growth: Japan, Germany, France, the USA and the United Kingdom. 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

[1] Composed by statistical data of 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).

spending on research. Generally, having strong position today does not guarantee holding them in the future.

• large developing countries that showed growth in at least one of the considered indicators: China, India, Russia.

Instruments of technologies development. It seems to be that not in the last turn the development of technologies is related on demand on them. 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 the most intensively in the periods of the least favorable economic situation" [3]. 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.

It's evident that among developed economies in the context of technologies development the European economies follow after the American. In the rating of the companies of high-tech and industrial sectors represented among the 100 leading companies by market capitalization (46 companies) the USA are the leader in companies' spending on R&D (41 companies out of 100 top). To compare, China occupies only the 12^{th} place (2 companies).

In the European Union at a whole nowadays the mechanism of reindustrialization and technological development is stimulation of activation of small innovative business and own high-tech production. The instruments are:

- strengthening the protection for law on intellectual property, in particular, organization of the service of information support in part of this protection;
- furthering the transformation of industry through development of new goods and services (3D-printing of industrial products);
- simpliflying the access to financing [7].

The most actively technologies will be developed, as the overview has shown, in German economy. The instruments in it served, as the researchers mention, governmental measures for protecting the jobs in the car and mechanical engineering, timely undertaken reforms in labor market and ensuring the moderate growth of the salary [5]. In the German economy, as well as in American, "the industry 4.0" will be actively developed. The key role when forming the German innovative, scientific and educational policy will be got to the Strategy of high technologies development, Pact on the higher school, Initiative on clusters, Pact on researches and innovations. In Germany the high-tech industry of new generation will be developed – the search of alternative energy sources, medical and biotechnologies, production automation and search of resource-saving technologies. The Concept "Industry 4.0" being realized now in Germany is a

concept of reorganization of production systems and of work organization in terms of development of a new form of production automation which is considered under the brand “Digital factory” [4]. On the way to "the Industry 4.0" reflecting formation of an super-modern manufacturing sector, there is an integration of the sector of production and automation to information and communication technologies. "Clever" factories will be grounded which use high technologies arise and at the same time are guided by individual orders [4].

Although, undoubtedly, the strategies of production technologies development will be taken also by growing developing economies. So, China, according to the national program "Made in China 2025", seeks to become the leading technologically advanced nation in the field of industry.

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 [8]. 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.

Conclusion

Therefore, in the transformation of the world industrial-technological landscape, including 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 "hightech" and "low-tech" to the concept of advanced industries);

• presence of three groups of economies identified on the basis of combination of two indicators 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.

The analysis has shown, that there're already the achievements in the sphere of development of advanced manufacturing technologies, and the EU countries possess one of the leading positions, in particular, Germany. They have high global industrial competitiveness. The instruments of technological development are the instruments of stimulation of small innovative business activation and of own high-tech manufacturing. In Germany will be developed "the Industry 4.0". However, to forecasts, European economies will cede their positions relatively to the economies of Asian-Pacific region, including of the developing. Already now the European economies cede them in the context of dynamics of some indexes of technological development.

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