Results of Russia’s Real Economy Development after 1991 and Suggestions for Changing its Industrial Policy

Certain sectors of Russian industry declined since 1991 but later returned to growth. Some industries have almost ceased to exist. Among them are the high-tech productions, whose output has become inaccessible to Russia in the world market after the introduction of sanctions in 2014. It seems necessary to expand and pinpoint the industrial policy measures for the successful development of all the economic sectors required for Russia.

Development of the real sector of the national economy in market conditions

Since 1991, the trends in the real sector of the Russian economy have been determined. For most of them, the 1990s were a period of decline, but then many started to grow. At the same time, some industries have failed to recover in market conditions after they lost in competition with foreign producers. Figures 1-5 show different options for the development of industries after the transition to market conditions.

Figure 1. Crude oil production in the USSR and Russia (million tons)

Source: The graph was built by the author on the basis of 2003 and 2017 Statistical Yearbooks of Roskomstat (Russian Statistics Committee).

The oil industry experienced a substantial decline. Meanwhile, after its privatization, partial access of foreign investments, entry to the world markets as a seller and buyer of equipment, and support of the government, it overcame the recession and became one of the drivers of the national economy.

Figure 2. Passenger car production in the USSR and Russia (thousand automobiles)

Source: The graph was built by the author on the basis of 2003 and 2017 Statistical Yearbooks of Roskomstat.

The automotive industry experienced hard times in the 1990s, many local manufacturers left the market and ceased to exist. Foreign investments allowed the industry to revive and re-equip at the price of shifting to the low-level localized production from imported components.

Privatization in agriculture did not produce the expected results since it was not the small farmers who received support for their development, but rather large enterprises, though in terms of increasing agricultural production the results were impressive. The Russian grain production now is not only sufficient for the domestic food consumption, but it also provides sufficient forage for the livestock industry along with being an important export industry.

Figure 3. Grain production in the USSR and Russia (million tons)

Source: The graph was built by the author on the basis of 2003 and 2017 Statistical Yearbooks of Roskomstat.

Figure 4. Russian tourists traveling abroad (thousand people)

Source: The graph was built by the author on the basis of 2003 and 2017 Statistical Yearbooks of Roskomstat.

In market conditions, the service sector has grown. In addition to the fully privatized trade industry and public catering, a completely new industry has been created. It is the thriving international tourism, which satisfies the increasingly sophisticated consumers.

Figure 5. Production of CNC metal-cutting machine tools in the USSR and Russia (thousand units)

Source: The graph was built by the author on the basis of 2003 and 2017 Statistical Yearbooks of Roskomstat.

In this context, a frightening picture is represented by some branches of mechanical engineering, which has practically ceased to exist. Figure 5 shows the production dynamics of only one type of modern engineering products. These are the CNC-based machine tools, one of the most advanced mechanical products in demand by the market. After 1995, their production does not exceed several hundred units per year, while in the USSR such equipment was produced on the scale of many thousands.

The production of metal-cutting machine tools in Russia fell by more than 36 times from 1970 to 2011. The production of the CNC-based machine tools was at its highest level in 1990, and it plummeted by 83.5 times in 2011; the forging and pressing machines production dropped 17 times since 1980.

The modern Russian economy is highly dependent on the imports of the means of production and components. As emphasized by the authors of the report prepared at the Institute of Economics of the Russian Academy of Sciences in 2012[1], the scientific and technological potential of the Russian economy grossly degraded during the radical socioeconomic reforms. However, the report emphasizes that since the 2000s, some losses were compensated and the economy was still capable of a modernization breakthrough. The latter is impossible without a new industrialization, including the recreation of a complex of industries to secure economic growth largely on the national basis. The latter circumstance has become particularly evident in the past two years.

[1] Russia on the Way to a Modern Dynamic and Efficient Economy. Edited by Academicians A.D. Nekipelov, V.V. Ivanter, S.Y. Glazyev, Moscow, 2013 (*in Russian*).

At the same time, the degree of wear and tear of fixed assets in the material production, which determine the country's production potential, is extremely high and continues to increase (*see* Table 1).

Table 1. Depreciation of fixed assets by types of economic activities as of the end of the year (%)

	2010	2013
All fixed assets	**47.1**	**48.2**
by economic activities:		
agriculture, hunting, and forestry	42.1	42.7
fishing, fish farming	64.7	64.4
extraction of minerals	51.1	53.2
manufacturing	46.1	46.8
production and distribution of electricity, natural gas, and water	51.1	47.6
construction	48.3	50.0
transport and communications	56.4	56.5

Source: Russian Statistics Yearbook 2014. Federal State Statistics Service, M. 2014.

The industry has production assets that were installed previously and are currently very outdated. Most of the necessary equipment has been destroyed. Almost all industries require significant investments and replacement of the outdated equipment. The basis for the closure of production in many machine-building branches remaining from the times of the USSR was the assumption that the equipment produced in the USSR and then in Russia was in many respects could not match the quality of the foreign-made. It was assumed then that the imports would satisfy the needs of the Russian industry. Some industries including metallurgy and automotive industries were indeed substantially renovated on the basis of imported equipment. As a result of prioritizing the imported machinery, Russia currently does not have industries that are important from the point of view of the level and quality of manufacturing of the means of production, and the outlook for further modernization of the machine-building industry and other industries is uncertain.

Russia's technological risks under sanctions

In recent years, there have been at least three trends that make it necessary to take a fresh look at the results of sectoral policies in Russia. Firstly, the economic sanctions imposed by the West in 2014; secondly, the slowdown in Russia's economic growth; and thirdly, a new industrial revolution began in the world and based on the widespread use of robotics and artificial intelligence.

If we consider the economic implications of the sanctions imposed by the West on Russia in 2014, we can divide those into financial and technological ones. The political and financial sanctions had an immediate effect while the technological ones are of a delayed nature. Below we will primarily rely on the EU documents, which are detailed in a number of European Commission directives[2]. The US sanctions can also be analyzed on the same basis[3]. They differ from the European sanctions in that they rather focus on particular legal entities.

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[2] Measures targeting sectoral cooperation and exchanges with Russia ("Economic" sanctions) http://europa.eu/newsroom/highlights/special-overage/eu_sanctions/index_en.htm

[3] Press Center Announcement of Expanded Treasury Sanctions within the Russian Financial Services, Energy and Defense or Related Materiel Sectors 9/12/2014 https://www.treasury.gov/press-center/press-releases/Pages/jl2629.aspx

Although the financial sanctions have their own effects, they also reinforce the technological sanctions since the financial constraints make it difficult to fund Russian companies and provide loans, including those intended to purchase new equipment. As for the set of the sanctioned industries, they include the export-oriented oil and gas sector along with high-tech industries related to the national defense. Meanwhile, the importance of the technological sanctions is much wider as due to a limitation of the dual-purpose (defense and non-defense) goods, the unsanctioned non-defense industries are deprived of an access to modern equipment and components. The restrictions apply to the provision of services, delivery of components, and the production of relevant products in Russia.

Since practically all countries of Europe, the USA and Canada, Australia, New Zealand, and Japan have joined the sanctions, and these are the countries manufacturing goods or components necessary for Russia, it is difficult to circumvent these sanctions.

The technological sanctions are targeted and selective. Machine-building products can consist of hundreds and thousands of parts. The sanctions apply to supplies of components that are essential for the products' efficiency, while the wordings of the restrictions are too general and allow interpretations.

While the restrictions on the oil and gas industry hamper geological exploration and development of new fields, which is not particularly relevant in conditions of declining oil prices, the restrictions on dual-purpose products negatively affect the more urgent programs of modernization of the Russian industry.

The EU document on dual-use goods[4] contains a number of sections ranging from radioactive materials and equipment for their enrichment, and aerospace technologies – which practically do not affect internal programs as Russia has appropriate technologies – to more sensitive technological categories such as materials processing, electronics, computers, telecommunications, special materials and equipment for their manufacturing, laser systems, avionics, and marine technologies.

The category of materials processing, which is the most important not only for the defense, but also for the non-defense industries, includes a wide range of products used in the mechanical engineering. These include relatively simple but high-quality products including bearings and hearths used in melting metals, bolts and valves for hydraulic and pneumatic systems. Banned are the supplies of the controlling and measuring tools, machines for metal processing, ceramics and composite materials, milling tools, and welding equipment. The group includes numerical control machines, industrial robots and remote manipulators, non-ferrous metallurgy and chemical industry equipment, equipment for biological materials, industrial equipment software, process flow documentation, and machine-building production lines, chemical industry and non-ferrous metallurgy. Thus the restrictions apply as to individual and critically important products and to the fundamental technologies.

[4] EUROPEAN COMMISSION Brussels, 12.10.2015 C(2015) 6823 final COMMISSION DELEGATED REGULATION (EU) …/... of 12.10.2015 amending Council Regulation (EC) No 428/2009 setting up a Community regime for the control of exports, transfer, brokering and transit of dual use items

For the equipment there are specifications, there is no complete ban, simple products and technologies are allowed to be sold to Russia, though everything required for up-to-date modernization production is prohibited.

The slowdown in economic growth in the Russian Federation began before the introduction of sanctions. It is largely related to domestic economic processes in the country, including the absence of production of the means of production. Practically all modern equipment has to be imported and the import substitution depends on imports. For example, to minimize imports of consumer goods the manufacturers in Russia have to import equipment for producing inside the country. In the current conditions of ongoing technology changes, the choice of equipment for long-term investments requires a profound understanding of such changes.

Robotics: the current situation and outlook for the world and Russia

In present conditions, a complex of technologies uniting various devices called ‘robots’ develops to such an extent that practically all countries of the world, including Russia, will be positively or negatively affected by this process.

Industrial robots

The first industrial robot was invented in 1959 in the USA. It weighed two tons, operated with high precision, and was controlled by software recorded on a magnetic drum. General Motors used an industrial robot in car manufacturing in 1961. Since 1967, industrial robots are in use in Europe.

Sweden became the pioneer. In 1969, first industrial robots came to the Japanese market and in 1971, the first national association of robotics was established in Japan thus creating a solid basis for the country's success in designing and operating the robots. 3000 industrial robots[5] were in operation worldwide in 1973. In 2015, their number was 1.664 million[6]. (*see* Figure 6)

Figure 6. The global fleet of industrial robots (thousand units)

Source: The graph was built by the author on the basis of Global robotics industry: Record beats Record! 2013: 179,000 industrial robots sold - 2014: Continued increase expected. http://www.ifr.org/news/ifr-press-release/global-robotics-industry-record-beats-record-621/ and World Robotics 2015. Industrial Robots. International Federation of Robotics. http://www.worldrobotics.org/uploads/tx_zeifr/Executive_Summary__WR_2015.pdf

There are no reliable statistics on the number of the installed and newly sold robots. The very definition of the concept of "robot" for different types of devices was agreed at the international level relatively recently, work by definition was in the 1990s, and some definitions were adopted only after

[5] History of Industrial Robots From the first installation until today Milestones of Technology and Commercialization IFR International Federation of Robotics www.ifr.org
[6] World Robotics 2015. Industrial Robots. International Federation of Robotics. http://www.worldrobotics.org/uploads/tx_zeifr/Executive_Summary__WR_2015.pdf

2010. This hampers statistical recording. The available numerical data are estimates given by the International Federation of Robotics, as well as the Ministry of Economy, Trade and Industry of Japan in its analytical materials. Estimates by the International Federation of Robotics as of 2015 are presented in Table 2.

Table 2. Estimated number of industrial robots by countries, as at the year's end (thousand units)

Country/region	2013	2014	2015*	2018**
America, including	**226071**	**248430**	**272000**	**343000**
North America (USA, Canada, Mexico)	215817	236891	259000	323000
Brazil	8564	9557	10300	18300
Other countries of America	1690	1982	2500	1700
Asia and Australia, including	**689349**	**785028**	**914000**	**1417000**
PRC	132784	189358	262900	614200
India	9677	11760	14300	27100
Japan	304001	295829	297200	291800
South Korea	156110	176833	201200	279000
Taiwan	37252	43484	50500	67000
Thailand	20337	23893	27900	41600
Other countries of Asia and Australia	29188	43871	60000	96300
Europe, including	**392227**	**411062**	**433000**	**519000**
Czech Republic	8097	9543	11000	18200
France	32301	32233	32300	33700
Germany	167579	175768	183700	216800
Italy	59078	59823	61200	67000
Spain	28091	27983	28700	29500
Great Britain	15591	16935	18200	23800
Other countries of Europe	81490	88777	97900	130000
Africa	**3501**	**3874**	**4500**	**6500**
All other states***	21070	32384	40500	41500
World in general	**1332218**	**1480778**	**1664000**	**2327000**

* - estimate,

** - forecast,

*** - data not attributed to specific countries.

Source: IFR and national federations of robotics. World Robotics 2015. Industrial Robots. International Federation of Robotics.

http://www.worldrobotics.org/uploads/tx_zeifr/Executive_Summary__WR_2015.pdf

Japan is the global leader by the number of robots in operation. The country started developing technologies before other industrialized countries largely due to the absence in the country of the immigrant workforce providing cheap labor to the United States and Europe. Together with China and South Korea, Japan secures Asia's leading positions in using industrial robots.

The second position belongs to Europe (European Union), which is significantly ahead of North America, i.e., the United States. The review contains no specific data for the United States, but according to the available estimates, the leaders are Japan, China, USA, Germany, and South Korea. The latter two countries are roughly at the same level.

Projections indicate rapid growth of the robot fleet in China making the country an unconditional leader in the coming years. According to the forecast, the United States will catch up and probably overtake Japan. Germany will significantly increase the fleet and be slightly behind South Korea which, in turn, will almost catch up with Japan. Such estimates indicate a certain saturation of the Japanese market with industrial robots and a worldwide trend of the fleet growth in all industrialized countries. The average annual growth rate of the fleet is projected at 12% in 2015-2018. It is much higher than the GDP growth forecasts. Thus, the structural shift in the world economy is obviously in favor of robotics. The authors of the report indicate that risks remain given the macroeconomic situation, a slowdown in the global economic growth, an easing of the need for new equipment including robots, while the urge to automate production remains high making the growth of the robot fleet inevitable.

The largest number of robots per 10,000 people employed in the industry falls on the countries with developed electronic industry. They are South Korea with 365 robots and Japan with 211, followed by Germany with 161 robots and Sweden, 142. These countries have the highest levels of robot utilization due to their wide use in various industries. The fifth position is taken by Taiwan with 138 robots. The high level of robot utilization there is also related to the development of the electronics industry. The outlook for the robot fleet changes is based on the data of its annual growth. (*see* Table 3)

Table 3. Procurement of industrial robots by countries (number of units)

Year	2013	2014	2015 *	2018 **
America, including:	**30317**	**32616**	**36200**	**48000**
North America (USA, Canada, Mexico)	28668	31029	35000	44000
Brazil	1398	1266	1000	3000
Other countries of America	251	321	200	1000
Asia, Australia, including:	**98807**	**139344**	**169000**	**275000**
China	36560	57096	75000	150000
India	1917	2126	2600	6000
Japan	25110	29297	33000	40000
South Korea	21307	24721	29000	40000
Taiwan	5457	6912	8500	12000
Thailand	3221	3657	4200	7500
Other countries of Asia and Australia	5235	15535	16700	19500
Europe, including:	**43284**	**45559**	**49500**	**66000**
Czech Republic	1337	1533	1900	3500
France	2161	2944	3200	3700
Germany	18297	20051	21000	25000
Italy	4701	6215	6600	8000
Spain	2764	2312	2700	3200

Great Britain	2486	2094	2400	3500
Other countries of Europe	11538	10410	11700	19100
Africa	**733**	**428**	**650**	**1000**
All other states ***	4991	11314	8650	10000
World in general	**178132**	**229261**	**264000**	**400000**

* - estimate,
** - forecast,
*** - data not attributed to specific countries.

Source: IFR and national federations of robotics. World Robotics 2015. Industrial Robots. International Federation of Robotics.
http://www.worldrobotics.org/uploads/tx_zeifr/Executive_Summary__WR_2015.pdf

As noted by the authors of the report of the International Federation of Robotics, 2014 (the most recent year with accurately reported data) was a record year in terms of the robot fleet growth rates. Its annual robot sales were 29% up. In terms of its value, the world robot market is estimated in the report at $10.7 billion. The main buyers were the companies producing components for the automotive industry as well as the electrical and electronic engineering industries. China was the leader among the countries. (*see* Figure 7)

Figure 7. World leaders in purchases of industrial robots in 2014

Source: IFR and national federations of robotics. World Robotics 2015. Industrial Robots. International Federation of Robotics.
http://www.worldrobotics.org/uploads/tx_zeifr/Executive_Summary__WR_2015.pdf

Five leading countries accounted for almost ¾ of all robots installed in the world. Sales increased substantially after 2010 when the aftermaths of the global financial and economic crisis were largely overcome and the long-term trend of expandingthe automation and reducing the robot costs was renewed. The average annual growth in robot sales was 17% in 2010-2014. The annual number of robots sold increased by 48% after the global financial and economic crisis vs. the pre-crisis period.

Asia leads both in terms of volume and pace. Asian sales increased by 41% in 2014 vs. 2013, while in Europe – the second largest market – the growth was 5% and in America, 8%. China was #1 among the countries with a 56% increase in 2014. Out of 57096 installed robots, about 16000 were made in China, an increase of 78% compared to the year before. Such high growth rates are partly due to the fact that more Chinese manufacturers began providing statistical information on their sales. Foreign manufacturers increased supplies by 49% to 41100 robots. The growth of the Chinese market is unprecedented. No country in the past had so rapidly increased the robot installation in such a short period of time. A number of industries automated their production in 2010-2014 resulting in a 40% annual increase.

High growth rates in robot procurement were registered in Japan. In the period from 2005 – the year of a record-high level of 44000 purchased robots – to 2013, the purchases kept on decreasing with the minimum of 12800 units in 2009. Since 2013, Japan holds the second place in the world in the number of annual purchases.

The growth of robot installations in the United States is connected to the policy of America's reindustrialization, an increase of automotive production, and, in some cases, to the return of manufacturing to the United States from the overseas.

In the conditions of the overall growth in robots procurement, South Korea experiences opposite trends. In 2014, the manufacturers of automotive components radically increased their purchases while other industries made reductions.

In Germany, in the post-crisis years of 2010-2014 when the automotive industry recovered from a severe recession, the annual robot fleet growth was 9% in the conditions of the industry highly saturated with robots.

The automotive industry is the main consumer of robotics. The number of robots in the industry has increased in all countries since 2010. In 2014, almost 100000 robots were installed there worldwide. This industry accounts for more than 40% of the total number of the installed industrial robots.

The second largest consumer of robots is the electrical and electronic industries, including the production of computers and electronic equipment, radio and television equipment, communications equipment, medical, precision, and optical equipment and tools. In 2014, these industries purchased and installed about 20% of all robots. Other industries are consuming not as many robots, though their potential demand is impressive.

As it is emphasized in the report of the International Association of Robotics, the main reasons for the development of industrial robotics are the pursuit for energy efficiency and appearance of new materials requiring new production technologies along with global competition pressing for the increased production and improvement of the quality of products, growing commodities markets requiring additional production capacities, shortening of the lifecycle of products and increasing variety of goods requiring flexible automation, improved quality of the working environment by use of robots in performing the works that are hazardous, dirty, and tedious for people. Systems of effective interaction between robots and operators are being created to simplify the work of the latter. The issue here is safety and security where measures are being taken to develop international safety standards in this sphere, which will further promote the spread of robotics.

Table 4 illustrates the technological usage of robots with a breakdown of the main areas of their application. Obviously, the elimination of the human factor in welding, soldering, and dispensing guarantees a higher quality of operations due to greater precision and ensures a consistently high quality of operations in general due to the elimination of the factor of operator's fatigue.

Table 4. Global sales of industrial robots by their usage*

Usage and application	2005		2011	
	Number of units	%	Number of units	%
Processing and handling of components	44822	37.3	68540	41.3
Welding and soldering	36567	30.4	47938	28.9
Dosed supply of substances	4999	4.2	6941	4.2
Processing by cutting, polishing, and removal of rough edges	1916	1.6	2333	1.4
Assembly and dismantling	15383	12.8	19531	11.8
Other	14520	12.1	16821	10.1
In total	120100	100.0	166028	100.0

* Excluding packaging robots.

Source: Trends in the Market for the Robot Industry in 2012. July 2013. Industrial Machinery Division, Ministry of Economy, Trade and Industry. Available at http://www.meti.go.jp.

Service robots

Alongside with the industrial robots, the professional service robots are filling new niches though their number is much smaller. 24207 service robots were sold worldwide in 2014 (an increase of 11.5% vs. 2013). The number of industrial robots sold was 229261. 45% of the professional service robots are military robots with the dominance of the drones or unmanned aircraft. Next in number is the mine-clearing robots.

5180 cow-milking robots were sold in 2014, 8% above the 2013 level. The use of robots in cattle breeding is expanding. Robots are being designed for new functions, for example, cleaning livestock sheds. The sales of medical robots have somewhat decreased. These robots are used in surgical operations and treatment. These are the most expensive service robots. Robotized logistics systems were actively developed with the growth of 27% in 2014. 4.7 million robots were sold in 2014 for personal and household use or 28% more than the year before.

Robots are used for patient care in medical institutions of the United States, South Korea, and Japan. In 2013, South Korea designed nursing robot KIRO-M5. It is a compact transport robot (1 meter in height and 80 kg of weight) capable of transporting drugs and other goods. It can sterilize and deodorize the air and give a signal to a nurse when a bedridden patient needs to change a disposable diaper. The robot awakens patients, notifies them on the arrival of meals or on scheduled physical exercises. It can urgently call a doctor. At night, the robot's camcorder allows nurses to monitor patients without visiting them. It also has handles to hold for a walking patient[7].

In the sphere of education, there are robots working with students, in particular, the ones with disabilities. These are anthropomorphic robots resembling people in their appearance. Such robots can work in cafes, exhibitions, and in medical institutions. There is already a machine for making hamburgers.

Robotics development programs

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[7] Korean engineers have created robot-nurse KIRO-M5 (*in Russian*) http://nauka21vek.ru/archives/46520

Japan

In 2015, Headquarters for Japan's Economic Revitalization under the Prime Minister developed a document entitled "Japan's Robot Strategy – Vision, Strategy, Action Plan[8]. The Strategy was developed for the period till 2020 and even till 2025, for certain aspects. Its main goal is the inclusion of robots into all spheres of life in Japan.

The document proclaims "Japan as a Robotics Superpower" and urges to use robots for solving such issues as the aging of the population due to low fertility and high life expectancy. It acknowledges the fact that Europe, the United States, and China are catching up with Japan certain aspects of the development and usage of robotics emphasizing that the country needs to maintain its leading positions in the area.

The Strategy makes a statement about the robotics revolution, describing it within the context of the changing degree of the robots' autonomy as they are becoming information terminals and creating networks. The use of robots in this revolution is expanding from industrial application to use in everyday life.

Japan is aiming to become the innovation hub of the world and be the leader in using robots in everyday life, in the Internet of things where robots are integrated into information networks via the Internet, in designing robots with artificial intelligence and their networking.

As an organizational measure to implement this strategy, Japan plans to establish an organization for putting together the efforts of industry and business, research centers, and the government. The directions of research and

[8] http://www.meti.go.jp/english/press/2015/pdf/0123_01b.pdf

development have been prioritized. These are the key elements of the existing technologies (tactile robot capabilities, their mobility, etc.) and the development of new technologies for a competitive edge in the information society. Next-generation technologies include artificial intelligence, sensor and cognitive systems, new mechanisms and control devices, monitoring systems and technological platforms for integrating the key elements of robotic systems. The new technologies are expected to be especially efficient in the industry and other spheres of the economy and everyday life.

The program has an important feature typical for the Japanese style of management. According to the strategy, the research and development activities should be supported by cooperation and exchange of information between working groups of the researchers. Meanwhile, it is noted that the project participants should be competitive.

As for the use of robots in the industry, the emphasis is on their use in small and medium-size businesses as flagship businesses already widely apply these technologies. Within the industry context, the program envisages the emergence of the next generation of industries where robotics will be feasible and practicable. These are the food, pharmaceutical, and cosmetic industries. The first generation of the automotive, electro-technical, and electronic industries is already saturated with robots. The service sector is considered prospective for using robots as they are expected to increase workforce productivity, which in Japan is lower than in other developed countries.

The program in every detail dwells upon the design, manufacturing, and usage of robots for nursing the elderly and sick. Robots are already specialized as per the use of medical attendance. Technical capabilities will be adapted and developed for medical purposes.

The strategy provides for creating a barrier-free environment for robots by 2020 when they will be widely used in everyday life. To guarantee the safety of people in close interaction with robots, the program envisages for designing a testing system for robots to be used for the above purposes.

The program provides for a timeframe of necessary changes in the legislation (including laws governing provision of medical services with the use of robots and laws governing transport with the use of unmanned vehicles and flying robots). There are also estimates of the investments required to meet the objectives.

In general, this is a national program for maintaining the technological leadership based on the existing achievements. It seems that such goals are feasible and Japan is capable to maintain its technological leadership in the field of robotics, to run a technological revolution in this area, and extend the use of robots to many spheres of human life.

USA

In the United States, the National Robot Initiative[9] was launched in early 2015. It is run by the National Science Foundation with a number of other organizations, including those related to healthcare¸ space research, and development of advanced technical systems for the armed forces (Defense

[9] http://www.nsf.gov/pubs/2015/nsf15505/nsf15505.htm

Advanced Research Projects Agency or DARPA). Unlike its Japanese and European counterparts, this program in a much lesser extent covers the industrial robots and is rather focused on the spheres of government responsibilities, including healthcare, space research, and national defense.

The purpose of the initiative is to support research and development in robotics. In the technical sphere, it has the same goal as in the Japanese program, that is to design co-robots, which are viewed as robots capable of interacting with people and not just replacing them in manufacturing. Similar to the Japanese program, much attention is paid to the use of robots in caring for the sick and elderly, which, given the aging of the population in the developed countries seems quite justified.

The initiative identifies the engineering challenges to be met, including the creation of common platforms for different robot models in order to standardize their production and use, which should lead to a significant reduction of costs of these devices.

The initiative also specifies the goals of the National Space Agency in the sphere of robotics, namely:

- to expand the research capabilities of space missions eliminating the limitations inherent in manned flights;
- to reduce the risks and costs of manned flights;
- to improve scientific and research results of space flight missions;
- to increase the number of unmanned flights carried out by robots;
- to receive a synergy effect from the robotics and autonomy of space flights;
- to improve the autonomy and safety of unmanned aircraft in the Earth's atmosphere.

The published text of the program indicates only the research objectives and protection of the military personnel among DARPA’s objectives.

EU

The EU Robotics 2020 program. Adopted in 2015[10], the Multi-Annual Roadmap for Robotics in Europe aims to unite the efforts of science, industry, and government authorities for the robotics development and world promotion of the European achievements in this sphere. It is an annually updated pan-European roadmap.

The program consists of three blocks: requirements for robotics in various Domains, System Abilities, and Technologies. The selected subject areas are the manufacturing industry, healthcare, agriculture, the use of robots in the civil domain, mining, construction and services, transport and logistics, and robots for household use. Special sections are devoted to the development of flying and marine robots. In the latter case, the program considers a possibility of using robots in developing oil and gas offshore deposits.

The system competencies include the adaptive capabilities of robots, configuration, a possibility of autonomous decision-making, dependence on the operator, the ability to interact with other robots, manipulative abilities, a range of movements, and a possibility of perception and analysis.

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[10] http://sparc-robotics.eu/wp-content/uploads/2014/05/H2020-Robotics-Multi-Annual-Roadmap-ICT-2016.pdf

The technologies are grouped based on their purpose: systems and their components, improving human-robot interaction, mechatronics, navigation and cognitive abilities. Specific requirements and characteristics are defined for each cluster.

In general, the program describes the diversity of the robotics development in Europe. As emphasized in the document, the program is based on the consensus of the robotics community. The roadmap integrates fields of application and technologies. Thus, the EU robotics roadmap has numerous components that can be characterized as a feasibility study for the robotics development in European countries until 2020.

In China, a similar program is aimed primarily at improving the technical level and efficiency of the manufacturing industry. The program should achieve intermediate goals by 2020, and a complete restructuring of the manufacturing industry should take place in 2025[11].

Robotics development in Russia

The Russian machine-building industry is significantly lagging behind the world level, thus affecting the prevalence of robots in the Russian industry. The development of car manufacturing after 2000 stimulated imports of equipment, including robots, so that in the manufacturing industry has a certain number of imported robots.

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[11] China plans to realize intelligent manufacturing by 2025 http://english.cntv.cn/2015/05/22/VIDE1432284846519817.shtml

A serious problem for further spread of robots in Russia was created by the Western economic sanctions. Since practically all robot manufacturing countries including Europe, the USA and Canada, Australia, New Zealand, and Japan have joined the sanctions, it is difficult for Russia to circumvent those sanctions.

The Forecast of Scientific and Technological Development of the Russian Federation until 2030[12] uses the words with the root "robot" 11 times. It is an indication of the importance of the robotics for Russia, though the program is much behind its foreign counterparts in the degree of elaboration.

There are examples of a successful continuation of Russia's cooperation with Western countries in the field of robotics. The Dutch company Lelly supplies robots for milking cows in Russia. This advanced technology is necessary for our country to solve the problem of import substitution in dairy cattle breeding. In 2015, it became quite widespread in Russia. A robotized farm for milking 140 cows was opened in the Kaluga region. We began building a robotized farm for 800 big cattle in the Vologda region, and Lely plans to open an assembly plant for manufacturing 300 milking robots per year in the Kaluga region in 2016[13].

The software development for unmanned vehicles, especially trucks, proceeds with success. The Russian software developers here are matching the level of their foreign peers. Unmanned vehicles may appear in agricultural farms and intraplant territories in the coming years.

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[12] http://base.consultant.ru/cons/cgi/online.cgi?req=doc;base=LAW;n=157978;fld=134;dst=1000000001,0;rnd=0.7845702835934

[13] The Dairynews. December 30, 2015 http://www.dairynews.ru/tags/?tag=523 (*in Russian*)

Possible measures by Russia's economic policy of supplying the means of production

While the negative effect of economic sanctions is visible only in the financial sphere, the potential technological sanctions may become very painful for the development of Russia due to their long-term nature. The already acquired equipment and components will operate for some time, but technological progress may quickly make those morally obsolete.

Russia needs to develop a true import substitution and not just having a production from foreign components on its territory. In practice, this can be a combination of two different approaches. Firstly, it is the expansion of economic mechanisms already working in the military-industrial complex for the production of critical means of production (machine tools and industrial equipment); secondly, assistance to market mechanisms in the development of import substitution in areas where an end user is a person or a household.

The combination of these approaches requires a diversification of economic policy, its reorientation in order to obtain specific economic results in one area alongside with the creation of favorable market conditions for business in the other.

Asian countries as suppliers of machine tools to Russia under Western sanctions: problems and opportunities

The countries of the East are mainly those that do not support the sanctions. The potential suppliers to Russia are the Republic of Korea, Taiwan, PRC, India, and possibly Turkey. A high share of exports in the production indicates a significant specialization of production in this industry, so identifying partners becomes a task for specialists and consumers of the machines. Nevertheless, it is possible to define some basic directions of cooperation between Russia and the potential suppliers of machine tools.

China already exports a wide range of tools, equipment, and machines for the mass Russian consumer. As shown above, China is a major manufacturer of machine tools. It is one of the three largest producers, although its place differs in international and Chinese estimates of the scale of production.

The country has China Machine Tool & Tool Builders' Association, founded in 1988. It currently unites 1,500 participants engaged in the production of a wide range of products ranging from metal-cutting, woodworking machines and cutting tools to measuring instruments, numerical control (NC) machines and industrial robots. The Association has eight commissions to discuss particular problems of the industry and 25 sub-sector associations[14].

Noteworthy is that an Internet search for exporters of machines from China finds about 30 thousand participants of foreign economic activities. China has many well-organized partners for establishing relations in the field of machine tools, who are open to negotiations and assistance in establishing relations with particular manufacturers.

[14] The internet site of China Machine Tool & Tool Builders' Association **http://www.cmtba.org.cn/shtml/20091225154630.shtml**

However, there are certain problems. The quality of Chinese products is very heterogeneous. Products may be of low quality because of poor training or because the product is new to the manufacturer and the production technology is not established. The second problem is the state regulation of the Chinese economy. Bans on the export of certain types of equipment are not ruled out. The third problem is that major producers, whose products may have the necessary characteristics, are oriented to Western markets. For them, sanctions against Russia may result in a banned access to these markets. Fearing such a development, Chinese manufacturers of high-end equipment may refuse to cooperate with Russia.

Similar problems may arise in establishing cooperation with the Republic of Korea. The country supplied Russia with unique and exclusive industrial equipment for the petrochemical industry and participated in the Russian automotive projects. At the same time, the Korean industry is so integrated into the world economy that the fear of sanctions from the West may become an obstacle to establishing its ties with Russia.

Similar is the situation in relations with Taiwan, but the following approach is not ruled out. Taiwanese enterprises are small in size, and it is difficult for the authorities imposing sanctions to track their operations. Re-exports via China with further delivery to Russia can be a working scheme, but it requires establishing private contacts and having special arrangements with the Taiwanese and Chinese businessmen. In addition, important is the position on this matter of the authorities of both Taiwan and China.

Certain connections are also possible with the Turkish machinery manufacturers, though the absence of specialized high-end equipment production may become a limitation here. Meanwhile, some mass segments of Turkey-made machines are optimal in terms of their price and quality as well as the already noted problems of pressure from the West.

For Russia, India can be an interesting partner. The country has a small share of exports in its production while the very scale of production in the machine-tool industry is impressive. India produces three times as many machines as Russia in value and its volume of production is comparable to that of France.

Indian machine-building industry needs machine tools of high quality. This applies to the defense, aerospace, and a number of other industries. The level of engineering personnel in India is quite high.

India has access to Western markets as a buyer of the equipment, but its own exports are not impressive as shown in Table 2. In this sense, India is less vulnerable to the threat of sanctions from the West as Indian companies do not enter the markets of Europe and North America. At the same time, a possibility of receiving orders from Russia can become an incentive for cooperation with it.

Russia may start negotiations with Indian Machine Tool Manufacturers' Association. In general, the friendly attitude of India's political elite toward Russia and the lesser degree of the state interference in the economy than, for example, in China and this factor may become an argument in choosing partners by Russian machine-tool buyers.

The technological level of Indian exports is quite high. About 80% of the exported metalworking and metal-cutting tools are numerically controlled[15]. Russian and Indian companies may establish joint production of machines and fulfillment of specific Russian orders by Indian partners. Therefore, the production cooperation is possible in both India and Russia.

For Russian enterprises, import substitution and non-Western suppliers of equipment are extremely important. According to some foreign experts, the Russia machine-building industry produces only about 10% of what the Russian defense industry needs for implementing the Russian army modernization program[16].

As it was noted at the meeting of the Committee on Machine-Building and Tool Industry held within the framework of the scientific and technical conference at International Specialized Exhibition Technoforum 2014, a threatening situation is that the newest equipment supplied to the defense industry is almost 100% equipped with imported carbide tools. Interruptions in the deliveries will inevitably suspend production and fail the orders of the Defense Procurement Committee[17]. The project Import-Independent Tool aims to solve this and many other problems as it envisages the establishment of high-tech production by combining efforts of many Russian companies under OAO Stankoprom of the State Corporation Russian Technologies (Rostekhnologii), which is created to solve this and several other particular

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15 http://www.imtma.in/index.php?page=3&subid=29

16 Cooper J. Sanctions Will Hurt Russia's Rearmament Plans // The Moscow Times, Aug. 12, 2014. http://www.themoscowtimes.com/opinion/article/sanctions-will-hurt-russia-s-rearmament-plans/505006.html

17 http://www.soyuzmash.ru/activities/zasedanie-komiteta-po-stankostroitelnoy-i-instrumentalnoy-promyshlennosti-sostoyalos-v (the internet site of Russian Machine-Building Union, *in Russian*)

problems. In today's world, almost all countries are involved in trading in machine tools and equipment and all Russia's problems cannot be solved by import substitution. The country needs to look for new partners, including in the countries of the East.

Industrial Policy

The law of 2015 "On Industrial Policy in the Russian Federation"[18] and scientific and technical programs of the Ministry of Economic Development can be viewed as measures to reverse the negative trends. The law provides for a number of actions to stimulate investments in industry and assist businesses in this sphere. Nevertheless, the law seems to be able to help mainly those Russian companies that have more or less guaranteed prospects in the market. At the same time, the import substitution policy in the aspects related to modern technologies, especially in the machine building, should rather focus on guarantees to critically important productions that Russia cannot import and not so much on the market conditions.

Article 22 of the law dwells on the measures for stimulating production in the military-industrial complex that are perfectly applicable to the deployment and support of the critically important civil productions, namely:

1) ensuring the readiness of the organizations of the military-industrial complex to develop and manufacture modern weapon systems, military, and special equipment;

2) creating an industrial infrastructure for producing modern weapon systems, military, and special equipment;

[18] Federal Law No. 488-FZ of the Russian Federation "On Industrial Policy in the Russian Federation" of Dec. 31, 2014 http://www.rg.ru/printable/2015/01/12/promyshlennost-dok.html (*in Russian*)

3) improving the procedures for the placement and fulfillment of the government's defense orders, including the out-of-competition mechanisms for placing the state defense orders (including with a single supplier) and ensuring advance payments for such orders to the organizations participating in the fulfillment of the government's defense orders.

These three fundamentally important positions define the non-market mechanisms to secure critically important productions for the country. They could well be used for the development of the civil machine building and production of industrial equipment also required by the civil industries and not available from imports because of the sanctions. The complex machine-building production has substantial commercial and technical risks and the government bodies are capable of uniting the efforts of enterprises for minimization of such risks. The business will not accept the risks while the state can provide for acceptable conditions for private companies operating in the corresponding industries.

Expanding economic measures and differentiating industries and sectors

The results of Russian real economy development demonstrate that is necessary to define several types of economic policy for the development of certain sectors and advanced development of other sectors.

The first is the support for small and medium-sized businesses involved in services, commerce, and agriculture. Such support has proved its effectiveness and created a stratum of successful entrepreneurs.

The second is the support of major national private companies in the spheres of their effectiveness and success. These include fuel and energy complex, metallurgy, and partly machine building.

The third is the state participation, in a number of cases, in the equity and management of the companies such Gazprom, Rosneft, and in the nuclear industry.

The fourth is the attraction to the Russian industries of foreign capital with the up-to-date technologies, as it is in the automotive industry.

The fifth is the development of the state sector in such industries as the military-industrial complex. This approach seems reasonable in regards to the machine-tool industry and manufacturing of the means of production. Private business will not be able to develop these sectors because of the sanctions and international competition if sanctions are lifted. And if they remain, Russian manufacturers will face competition with companies in Asia and Latin America. In addition, modern production requires a technological and business environment supporting and ensuring cooperation, sales, and procurement of necessary components. This is not the case of Russia. From the business point of view, it is impractical to invest in high-tech industries, though from the point of view of the state, the country needs such products.

Macroeconomic planning is a necessary tool to deal with the issue of what sectors to develop and how. On the way of catching-up development, Asian countries widely used tools of macroeconomic planning. We can admit that the free-market practices proved their effectiveness in the world-leading countries (UK and USA) when there were no precedents for solving the problems of economic development. For catching-up development, planning has proved its effectiveness in the most diverse cultures and economies.

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