ADVANCED MANUFACTURING TECHNOLOGIES: RUSSIA'S PLACE

I.Dezhina

The development of advanced manufacturing technologies is to become a new trend at the intersection of research, technological and industrial policy. The United States, a few EU countries, and China are leading on the development of new measures and approaches in this field. It was not until recently that the issues of "new industrialization" have been extensively discussed in Russia. All related areas such as science, technological development, and public administration are facing problems. Nevertheless, the research and technological sector has gained experience which may be used, subject to some adjustments though, to help Russia embed into new technological niches.

The development trends in advanced manufacturing technologies (sometimes they are called "explosive" or "breaking-through", thus emphasizing that they change dramatically rather than enhance the entire production pattern) have received an extensive coverage both in developing and developed countries. There is a reason for their being in the spotlight. Advanced manufacturing technologies help create new markets and entire industries, facilitate growth in labor productivity, enhance competition. Additionally, they are often linked with the inception of a new economic order, because they result in mass production phase down, customization of goods, lesser dependence upon cheap labor force, while evolving digital technologies ensure linkage between manufacturing processes. From the technical point of view, new manufacturing technologies are first of all associated with 3D printing, internet of things, new materials, robotechnics[1]. New manufacturing technologies can be better defined as a sum of competencies rather than a list of critical technologies. This is the reason why they are regulated through measures not only within the industrial policy, but also innovation, research and educational policies.

Localization, i.e., localization of new manufacturing facilities next to development and design centers, approximation of research and design departments to manufacturing facilities, is in close relationship with the concept of advanced manufacturing technologies. This is especially typical of the United States which has lost one third of its industrial production over the recent decade because of migration of manufacturing facilities to other countries. This is being regarded as a threat to the national security and, therefore, the localization task was assigned and emphasis placed on creating new institutions (regional hubs) engaged in the development and prototyping[2] which should be coordinated within a network.

The countries whose government is being actively engaged in developing measures of support to new manufacturing technologies have different reasons for being focus of attention. For instance, Germany considers itself the global leader in manufacturing of industrial equipment and therefore the incentive to the development, i.e., increasing competition with the United States, India, and China. Consequently, it is the streamlining of processes (standatization, organization of work, training) and legal and regulatory framework rather than the creation of new entities[3] that is intended to be supported.

At the same time, China is facing the issue of growing labor costs and, therefore, the development of advanced manufacturing technologies is considered as a means of solution. Consequently, the policy is focused on technologies designed to reduce the dependence on labor force.

New manufacturing technologies, regardless of different motives, are in a certain manner defined areas of research and development with a certain level of itemization (*Table 1*). For instance, experts in the United States initially identified 11 key areas which were subsequently itemized up to 135 technologies identified through crowdsourcing[4] in which only private sector representatives were invited to participate[5].

1 See, e.g., section "Advanced Manufacturing" in MIT Technology Review: 2013 Emerging Trends Report. Special Issue. MIT Technology Review. Open Innovations Forum and Exhibition. 2013. P. 51–60.

2 Prototyping is referred to draft realization of the core functionality for analyzing the performance of the entire system. A working system (it may be ineffective, with errors, and incomplete) is created by small efforts at the stage of prototyping. The stage of prototyping must be followed by stages of revising the system's architecture, development, realization and testing the end product.

3 Securing the future of German manufacturing industry. Recommendations for implementing the strategic initiative INDUSTRIE 4.0. Final report of the Industrie 4.0 Working Group. Forschungsunion, Acatech. April 2013.

4 Crowdsourcing is referred to the practice of receiving required services, ideas or content by way of applying for assistance to large group of people, especially the on-line community rather than common personnel or suppliers.

5 Request for Information: Response Summary for the National Network for Manufacturing Innovation. Ed. By Mike Molnar. NIST,

Table 1

SAMPLES OF PRIORITIES IN ADVANCED MANUFACTURING TECHNOLOGIES

The European Union	U.S.A.	China
• New manufacturing processes • Adaptive and "smart" manufacturing systems • Digital, virtual and resource efficient manufacturing • Mobile and collaborating enterprises (network manufacturing and dynamic manufacturing chains) • "Human-centric" production • Customer-oriented production	• Sensors, process measurement and control • Modern design materials, synthesis and processing technologies • Visualization, informatics and digital production technologies • Sustainable manufacturing • Manufacturing nanotechnologies • Flexible electronics production • Manufacturing biotechnologies and bioinformatics • 3D printing • State-of-the-art production and equipment for testing (quality control) • Industrial robotics • State-of-the-art fabrication and interconnection technologies	• New generation IT-industry • Bioengineering • High-performance manufacturing technologies and equipment • Up-to-date materials • Sensors • "Smart technologies" •

Sources: Factories of the Future PPP. FoF 2020 Roadmap. Consultation document. http://www.effra.eu/attachments/article/335/FoFRoadmap2020_ConsultationDocument_120706_1.pdf; Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing. Executive Office of the President. President's Council of Advisors on Science and Technology. July 2012. http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_amp_steering_committee_report_final_july_17_2012.pdf; Княгинин В.Н. Основные тренды в новом поколении производственных технологий. Материалы к выступлению на расширенном заседании рабочей группы Экономического совета при Президенте РФ по направлению «Отраслевая и инфраструктурная политика». Москва, 10.06.2013 г. [Knyaginin V. N. Principal trends in the new generation of manufacturing technologies. Materials for a report at an enlarged session of the work group of the Presidential Economic Council on the 'Sector and Infrastructure Policy', Moscow, June 10, 2013]

Russia is considered nothing but an emerging market for new products in strategic documents of the countries leading in the development of advanced manufacturing technologies. Indeed, since 2010 Russia has been expanding the purchase of manufacturing equipment and is expected to remain a key importer[1].

Furthermore, Russia is assumed to be able to find its own niche for development. The assumption is based on the existing successful ventures in mathematical simulation and development of new materials. Some experts consider biomedicine and IT as potentially beneficial trends for Russia. Russia's development horizon agrees with the global one on the core trends of the development of advanced manufacturing technologies, save for flexible manufacturing (global trends are a decade ahead of Russia), and android robots (Russia is not listed in the technology map until 2030), based on an optimistic forecast of the Center for Macroeconomic Analysis and Short-Term Forecasting (CMASF)[2] (*Table 2*).

Table 2

MANUFACTURING TECHNOLOGIES DEVELOPMENT OUTLOOKS: RUSSIA AND THE WORLD

Technology development horizon	until 2015	until 2020	until 2030
Composite materials	the world, Russia		
Enhancing flexibility of manufacturing lines		the world	Russia
3D designing technologies		the world, Russia	
Internet of things			the world, Russia
Industrial production of carbon nanotubes			the world, Russia
Androids			the world

Source: Мониторинг и анализ технологического развития России и мира, №3, октябрь 2013 г. М.: ЦМАКП, 2013 [Monitoring and analysis of the technological development in Russia and the world, No. 3, October 2013. M.: CMASF, 2013]. http://www.forecast.ru/_ARCHIVE/HT_Mons/2013/2013_q3.pdf

Russia, however, has no at least provisional, coordinated list of priorities in this field, let alone industrial companies crowdsourcing, Nevertheless, the Russian

August 2013. P.3. http://www.manufacturing.gov/docs/rfi_summary.pdf

1 Securing the future of German manufacturing industry. Recommendations for implementing the strategic initiative INDUSTRIE 4.0. Final report of the Industrie 4.0 Working Group. Forschungsunion, Acatech. April 2013. P.69.

2 Центр макроэкономического анализа и краткосрочного прогнозирования [The Center for Macroeconomic Analysis and Short-Term Forecasting (CMASF)]. http://www.forecast.ru/

Government's interest in this has been increasing[1]. Advanced manufacturing technologies have so far been considered within narrow bounds of the industrial policy or targeted measures. For instance, the development of engineering[2] with a focus on creating university-based centers[3] has since recently been given a hypertrophic attention. This is not enough, because higher educational institutions have no competence to establish in-house full-cycle production centers, beginning with engineering and ending with the end product promotion. Additionally, tools related to promoting relationship between the science and its practical applications have been left outside the context under discussion.

However, regulation of the development of new manufacturing technologies is considered largely within the scientific and innovation policy in other countries. From there proceed support measures which countries choose. The following key trends of changes can be distinguished:

1. Technological priorities turn into a point of reference, without being subject to strict financing according to underlined themes (technologies). They are identified not only through a specially arranged expertise or forecast research, but also crowdsourcing. Such priorities are intended to conduct a follow-up monitoring of the development, rather than being used for structuring programs or centers.

2. Consortiums have since recently been gaining popularity as a most common form of supporting the development of new manufacturing technologies. The consist of companies, universities, regional government authorities, service and consulting organizations. Industry plays the leading role, although financing is provided but is not limited to the federal budget. It is companies that provide co-financing which normally accounts for more than a half of the total budget of consortiums.

The following specific features of consortiums are worth mentioning:

- Focus on prototyping and expansion of production.
- Network-based type of interaction.
- Mandatory partnership with research and educational institutions.
- Open-end activity: consortiums are assumed to continue their activity after budget financing is discontinued.

Examples are found in the Institutions established within the framework of the National Network for Manufacturing Innovation (NNMI) in the United States, Factories of the Future which are financed in the EU on the basis of public-private partnership , as well as Catapult Centers in Great Britain .

3. Diagnostic monitoring (or diagnostic follow-up) is conducted during the implementation of initiatives. The key objective of the monitoring is to detect issues and work out solutions to address them, rather than assess the accomplishment of previously formulated goals.

Russia has gained a certain experience in implementing the initiatives which may facilitate the establishment of consortiums in the field of advanced manufacturing technologies. A program of megaprojects – paramount nationwide innovation projects – was initiated as the first experience in 2002. These were major projects implemented by teams consisting of researchers and representatives from the business community. The projects were designed to address the key issues of competitiveness, including manufacturing costs reduction through cost-effective use of resources. Megaprojects were selected largely on the basis of consensus between the researchers and representatives of the business community while their extrabudgetary financing should account for 60%. The megaprojects proved budget efficient on the basis of formal indicators, although there is no system in place to measure their performance. This experience, including project monitoring, may be revised in the context of being used for the development of advanced manufacturing technologies

Technological platforms is a second potential tool though which companies can be mobilized to identify critical areas required for the development of advanced manufacturing technologies. In addition, the European experience in the field of technological platforms shows that they may evolve to consortiums with large companies as leaders.

However, problem aspects are still prevailing, both in science and innovations. First, Thomson Reuters published a review in 2013, in which Russia was not listed in the group of leaders in none of the 100 most promising areas of research[4]. Second, it is not until recently

1 Горбатова А. Технологические метаморфозы. 17.01.2014 г. [Gorbatova A. Technological metamorphoses. January 17, 2014.] http://www.strf.ru/material.aspx?CatalogId=222&d_no=73040#.Ut1iHSdfrIU

2 It is reasonable in part, because the Ministry of Industry and Trade reports that only 2% of Russian companies use engineering. Source: А. Лабыкин. Промышленное послезавтра // Эксперт Online. 17.01.2014 г. [Labykin A. An industrial day after tomorrow // Expert Online. January 17, 2014] http://expert.ru/2014/01/17/promyishlennoe-poslezavtra/

3 A competition among higher education institutions was held in 2013 and 11 winners were selected for the establishment of engineering centers. Sources:. Отобраны проекты по созданию инжиниринговых центров в российских вузах. 21.10.2013 г. [Projects on the establishment of engineering centers in Russian higher education institutions have been selected. October 21, 2013.] http://www.strf.ru/material.aspx?CatalogId=221&d_no=70310#.UuFUjPtfrIU; http://минобрнауки.рф/новости/3719

4 C. King, D. Pendlebury. Research Fronts 2013. 100 top-ranked specialties in the sciences and social sciences. Thomson Reu-

that Russia has just started to discuss the importance of transdisciplinarity, whilst the world is transiting to transdisciplinary research which form the basis of the development of most advanced technologies[1].

The principles of state-financed support of the development of technologies should be subject to a serious adjustment too: it is financing of the production of new samples rather than a system-wide upgrade of technologies[2] that has been in place so far. Moreover, the current policy of "forcing into innovations" in the absence of economic demand for innovations is rather having an adverse effect too. This is why the existing constraints, including the situation with human resources in the Russian science, should be taken into account in establishing a strategy and measures of the development of advanced manufacturing technologies.

ters. April 2013. http://img.en25.com/Web/ThomsonReutersScience/1002571.pdf

1 Под transdisciplinarity is referred to eliminating borders between stand-alone disciplines, integrating methods of different disciplines, emerging of hybrid research areas which, in particular, may facilitate the solution of technically and technologically complicated problems. Source: E. Balcerak. Report Calls for "Transdisciplinary" Research and Collaboration Between Academia and Industry // Eos, Transactional American Geophysical Union, Vol. 94, No. 20, 14 May 2013. P.183. http://onlinelibrary.wiley.com/doi/10.1002/2013EO200003/pdf

2 Княгинин В.Н. Основные тренды в новом поколении производственных технологий. Материалы к выступлению на расширенном заседании рабочей группы Экономического совета при Президенте РФ по направлению «Отраслевая и инфраструктурная политика». Москва, 10.06.2013 г. [Knyaginin V. N. Key trends in the new generation of manufacturing technologies. Materials for a report at an enlarged session of the work group of the Presidential Economic Council on the 'Sector and Infrastructure Policy'. Moscow, June 10, 2013.]