МИРОВАЯ ЭКОНОМИКА И МЕЖДУНАРОДНЫЕ ОТНОШЕНИЯ, 2022, том 66, № 3, сс. 73-80
WORLD ECONOMY AND INTERNATIONAL RELATIONS, 2022, vol. 66, no. 3, pp. 73-80

INDUSTRIAL POLICY PRIORITIES UNDER INDUSTRY 4.0

(World Economy and International Relations, 2022, vol. 66, no. 3, pp. 73-80)

Vladimir B. KONDRAT'EV,
ORCID 0000-0002-7253-7320, v.b.kondr@imemo.ru
Primakov National Research Institute of World Economy and International Relations RAS, 23, Profsoyuznaya Str., Moscow, 117997, Russian Federation.

Vladimir V. POPOV,
ORCID 0000-0001-5299-958X, vlvaspopov@rambler.ru
Primakov National Research Institute of World Economy and International Relations RAS, 23, Profsoyuznaya Str., Moscow, 117997, Russian Federation.

Galina V. KEDROVA,
ORCID 0000-0002-2830-2612, kedrova@imemo.ru
Primakov National Research Institute of World Economy and International Relations RAS, 23, Profsoyuznaya Str., Moscow, 117997, Russian Federation.

Received 07.06.2021

Abstract. The analysis of the fourth industrial revolution outlines the structural changes arising in industries, as described by firm managers, scientists and consultants, as well as the literature on the fourth industrial revolution. It raises the need for new industrial policies, which are discussed in this paper. Structural changes arising in specific industries might have effects on other industries (due to complementarities) and on the whole economic system. Industrial policy must therefore be based on an analysis of productive processes, but also on analyses of the interactions between different productive processes. Favoring structural changes in one sector may have positive or negative impacts on other sectors; it may also impact upon the labour market, changing the skill required in the labour force, as well as wages. We argue that industrial policies are particularly needed when the economy experiences deep transformations, such as industrial revolutions. The advent of digital globalization is primarily driven by the technological progress induced by the fourth industrial revolution, but we believe that industrial revolutions are the result of complex transformations of the economy, the society and culture. We define industrial policy in a broad manner, as a set of actions aimed to favor structural changes in industries and orientating industrial development in specific directions. Such actions regard innovation, trade, intellectual property rights and antitrust; they also regard labour, because firms cannot upgrade or be created if they do not find the human capital they need for their operations. Looking at providing appropriate human capital means considering social policies, labour contracts and measures to favor the participation in the labour force. It also means considering education and training, because they determine the types of skills people will be able to develop.

Keywords: Industry 4.0, industrial policy, global value chains, circular economy, reverse logistics, reshoring, digital infrastructure, regional disparities.

About authors:
Vladimir B. KONDRAT'EV, Head of Centre, Dr. Sci. (Econ.), Professor.
Vladimir V. POPOV, Senior Researcher.
Galina V. KEDROVA, Researcher.

DOI: 10.20542/0131-2227-2022-66-3-73-80

The Fourth Industrial Revolution radically changes the nature of the economy and society as it covers an increasing number of traditional industries. Technological progress has changed the production nature in various sectors of the economy and has led to significant market transformations. The nature of the industrial policy is also changing as it is difficult to draw a clear line between the industrial and non-industrial sectors in an era of increasingly close integration of industrial production and digital technologies.

In this article, industrial policy is understood as a set of any state actions that are directly or indirectly aimed at improving the conditions for various industries and industrial companies, as well as prospects for their development. Government initiatives in this area include the creation of favorable legal, infrastructural, social, and financial conditions to maintain the important role of industry in the economy and its high competitiveness in foreign markets.

NEW TECHNOLOGIES AND THE NATURE OF PRODUCTION

The term "Industry 4.0", as it is known, was first introduced in Germany in the early 2000s by the Federal Government to promote the modernization of the country's manufacturing industry, primarily by the introduction of digital technologies, the Internet of Things, and automation [1]. The main motive was to support engineering, mechanical engineering, equipment manufacturing, and the automotive industry, export-oriented, where Germany had a strong competitive advantage.

The Industrial Revolution associated with Industry 4.0 offered digital technologies and automation capable of reformatting the role of new generation equipment in production both within the enterprise itself and between other participants in supply chains. The production process in such a system is transformed due to cloud computing, the Internet of Things, and automation [2]. These technologies are able to connect production across the entire value chain on a global scale for the development of customized products with no defects, using universal equipment, short modification cycles, and low inventory levels [3].

New technologies can seriously change the business models of companies and contribute to unique solutions that require joint innovations of the client and the company [4]. Companies, especially large ones, actually become hubs in spatial and industrial systems, linking local specialized suppliers and the global value chain on different continents.

It is expected that these technologies can radically change not only the organization of production and the balance between capital and labor but also the workplace and the production environment. The role of such technologies was first noted in the economic literature devoted to the importance of General Purpose Technologies (*GPT*) and Key Enabling Technologies (*KET*) in the late 1990s – early 2000s. *GPT*, in fact, are those technologies that can be used in different sectors of the economy and market segments. *KET*, on the other hand, become platforms for diversifying the competencies of companies, or, in other words, turn out to be interdisciplinary to the extent that their application is capable of creating technologies that can be used in various fields [5].

New technologies form the so-called smart production with three key characteristics. First, it is servitization, that is, the symbiosis of traditional production and services. Second, smart manufacturing allows filling market niches with personalized and individualized products. Such products are produced in small batches or in the form of unique items that require joint innovation or even production from customers and consumers[1]. Finally, intelligent manufacturing is changing the structure of product supply chains through deeper integration of local and global elements. Innovative companies often choose suppliers at the place of production, but are focused on demand both near and far from it.

The Fourth Industrial Revolution and breakthrough technological changes are reshaping global value chains. There are five main trends that arise in connection with the development of Industry 4.0: 1) technological upgrade of value chains; 2) creating shorter production and sales links; 3) reorientation of production to the domestic economy, or reshoring of production; 4) the emergence of small-scale intellectual productions combining digital and "artisanal" competencies; 5) localization of production near sales markets [6].

Approaches within the framework of Industry 4.0 open up great opportunities for the creation, renewal, and expansion of enterprises and organizations. This is caused by the nature of Industry 4.0, when new technologies cannot be considered specific to any sector of the economy and can be used in different industries. Giants such as Google or Apple, serving billions of users, are increasingly using digital opportunities to enter various value chains, such as, for example, the production of self-driving cars or personal mobility services (rental of electric scooters, bicycles, electric skateboards, etc.).

As for shortened value chains and the transfer of production (reshoring) to the country of origin of transnational corporations (TNCs), the introduction of digital technologies radically changes the technology and the way products and processes are developed. Thus, chain participants are no longer limited by geographical location, which gives manufacturers greater flexibility in choosing the location of production sites and promotes the optimal placement of production and organization sales [7].

Additive technologies provide companies with greater flexibility in choosing production locations. Now, when choosing the location of new facilities, the use of special equipment and local labor is much less important. Demand in local markets and their size are becoming more significant factors [8].

[1] As an example, one can cite the activities of Shapeways, a company founded in Denmark in 2007, but based in the USA. This company offers 3D printing services, its customers can independently design their own production and create files for 3D printing.

FEATURES OF THE NEW INDUSTRIAL POLICY

European experts identify four key areas of industrial policy aimed at preparing companies for the upcoming changes in the structure of global value chains, as well as facilitating and encouraging reshoring. These include: development of European and International standards; development and implementation of intelligent and flexible production systems; strengthening and development of regional clusters and supply chains; improvement of specialists' qualification skills [6].

The development of appropriate standards for digital and communication technologies is a crucial factor in their dissemination and development. It simplifies the connection of new equipment regardless of the manufacturer and digital service provider, eliminating the problems associated with the development of innovative technologies.

The development of smart production systems has a fundamental impact on the reformatting and reorganization of global value chains. Intelligent production systems are interdisciplinary in nature. In this regard, the persons defining the new industrial policy are in close contact with representatives of different links of the value chains, which helps to timely identify problems, develop and disseminate intelligent flexible technologies and practices.

As is well known, industrial clusters are characterized by "joint (cooperative) competition", when companies within a cluster cooperate and compete at the same time. The advantage of clusters for regional companies is their ability to combine into value chains. As a result, various regional, national, and international stakeholders, such as TNCs and local companies, universities, research institutes of the public and private sectors, cooperate, achieving a synergistic effect leading to a common economic benefit.

The Fourth Industrial Revolution creates conditions for the further development of such strengths of the cluster as interconnectedness, cooperation, common standards, etc. In this regard, industrial policy should promote the development of existing and the growth of new clusters and strengthen the links between old and new participants in value chains and networks.

A fundamental requirement in assessing the expected consequences of the Fourth Industrial Revolution for global value chains is the development of special qualification skills of personnel necessary for the implementation of technology and practices of Industry 4.0. A fundamental requirement in assessing the expected consequences of the fourth industrial revolution for global value chains is the development of special qualification skills of personnel necessary for the implementation of technology and practices of Industry 4.0. These skills depend on both the public and private sector, and within regional clusters on the close interaction of industry, higher, secondary special education and local government. All this ultimately determines the success of regional clusters' adaptation to the changes that Industry 4.0 brings [9].

As for reshoring, experts believe that within the framework of the new industrial policy, it is necessary to focus on promoting the development of new skills and competencies to launch the next generation of production processes instead of returning the "old" production associated with unskilled jobs that were previously outsourced abroad [10].

The capabilities of material infrastructure will be an important factor in the introduction of new technologies in Industry 4.0. A number of economists define such infrastructure as basic, necessary for the functioning and survival of the economy. This includes transport and electricity networks, sewerage, and waste disposal systems [11]. There are also broader requirements for infrastructure, which is necessary to increase readiness for the new challenges of Industry 4.0 [12].

At the same time, many experts note that the introduction of Industry 4.0 practices may be associated with high risk, since technological changes occur very quickly and are associated with untested technologies. Management requires pooling resources and risk sharing, as well as the development of joint ecosystems with the participation of the public and private sectors. There is a need to introduce innovations within the framework of multi-level management that can be integrated at the regional, national, and global levels. Such structures can become so-called living labs, where multinational companies and startups can interact and benefit from each other's competencies.

The successful introduction of new technologies largely depends on the digital infrastructure, so its development becomes the focus of industrial policy. The level of digital capabilities varies greatly depending on the region and country, which creates a certain "digital gap". There are many factors that may cause such a phenomenon: differences in the degree of human capital development, institutional structure and policy, infrastructure, and access to finance.

The need for high-speed and reliable communication access of users to the 5G infrastructure, (the

development of high-speed Internet) is in the first place here. It is assumed that by 2025, the total volume of Internet traffic, for example, in the UK may increase by 95 times compared to 2005, and mobile data traffic will grow annually by 25–42% [12]. The explosive growth in demand is caused by changes in the organizational and social environment and the growing interconnection between companies, consumers, and connected devices. This leads to the development of new business models, the emergence of new participants in value chains and contributes to the steady development of virtual global markets and jobs.

There are a number of key aspects that need to be taken into account when developing a new industrial policy for digital infrastructure projects. First, it is necessary to finance the experiments and testing, as well as the introduction of digital infrastructures in order to reduce risks. Second, industrial policy should contribute to increasing the speed of traffic, providing coverage and sufficient bandwidth for data transmission in the volumes, speed, and reliability necessary for business and society, while ensuring a balance between availability and consumer costs. The third direction is interregional coordination of interfaces and international standards. Further, the evolution of digital infrastructure should be in line with the improvement of "digital education", which implies the development of certain skills, labor mobility, and an inclusive environment that guarantees the expansion of social groups having access to the digital economy.

The development of appropriate skills and educational potential is an important factor in the successful transition of manufacturers to intelligent production. The BRICS Business Council stated at the time that high rates of technological development in the manufacturing industry increasingly led to "qualification gaps", which means that the qualifications or professional skills of personnel do not meet new requirements. Many manufacturing companies consider the lack of talent and the necessary qualifications of employees a serious barrier limiting their ability to implement technologies and practices of Industry 4.0 [13].

The prevalence of digital technologies in the workplace dramatically changes the structure of demand for employee competencies, so employers are interested in staff having a broader knowledge and understanding of technologies and production methods.

The introduction of technologies and practices of Industry 4.0 leads to the elimination of some jobs and the simultaneous creation of new ones. It generates a serious risk of polarization in the labor market. In this regard, the new industrial policy requires not only the identification of the needs for the necessary skills but also the creation of an appropriate infrastructure for continuous retraining of personnel.

Closed-loop economy, or *circular economy*, is becoming an important element of industrial policy. This economy can be considered a business strategy aimed at saving resources. This is a departure from the traditional, linear economic model, which is based on a take-make-consume-throw-away pattern [14]. A model: "sharing, renting, reuse, repair, upgrade and recycling" is being implemented instead. The main characteristic of the circular economy is the sale of access rights, not property rights, which allows companies to make a profit without increasing waste disposal costs.

The automotive sector has been at the forefront of changes in consumer behavior. For example, in the UK, the distance traveled per year by personally owned cars decreased by about 20% by 2000 compared to 1995, which was the peak. Stable growth of car rental and membership in automobile clubs was observed. For example, in the database of the well-known company Uber, there are more than 40 thousand drivers and 3.5 million users in London alone. Similarly, the number of auto club members in the UK has grown from 32 thousand in 2008 to 245 thousand in 2018 [15].

The lack of a clear strategic plan at the state level remains a limiting factor for the development of a circular economy. In particular, the transition pace of the UK automotive industry from internal combustion engines to electric motors is limited by the uncertainty of existing and planned regulatory requirements, as well as the reduction in the scale of government incentives for the purchase of electric vehicles [16]. These incentives and infrastructure projects remain the main factors determining the spread of electric vehicles. In Hong Kong, the reduction in government support led to a drop in sales of electric vehicles from more than 2 thousand units in 2016 to just 89 units in 2018 [16].

The need to raise public awareness about the circular economy and its advantages has become another important feature of industrial policy. Many consumers believe that recycled goods have a lower consumer value, which becomes one of the main factors hindering the development of a closed-loop economy. Industrial policy, along with educational institutions and businesses, should solve this urgent problem by encouraging a change in social norms and the perception of acceptable social models.

The existing industrial infrastructure is considered the main limiting factor in the development of a circular economy; therefore, the main problem of industrial policy is the development of reverse logistics infrastructure. Reverse logistics involves collecting used goods and waste, transporting them, and sorting them according to their final destination, that is, restoration, repair, reuse, or recycling [14].

Currently, the reverse logistics infrastructure in European countries is in its infancy, since the costs of its creation do not recoup. This is partly due to the insufficient scale of collection and sorting of obsolete goods, the costs of which are often too high due to geographical dispersion.

Industrial policy should promote the development of reverse logistics infrastructure by encouraging the activities of economic structures collecting goods at the end of their life cycle by local and national consolidation centers, where they will be sorted and then redelivered to producers or processors. It is desirable to include reverse logistics requirements in the value chains even at the stages of product development.

REGIONAL ASPECTS OF THE NEW INDUSTRIAL POLICY

TNCs, acting as key players in decision-making on innovation, investment, labor, placement, and organization of production, do not act in isolation, but are embedded in regional production systems [15]. Unless new technologies affect all parts of the value chain, the incentives for economic growth provided by the Fourth Industrial Revolution will not be implemented in practice, especially in local production systems, where small and medium-sized companies play an important role.

Small companies and local production systems can become hubs where innovation and exploratory research complement large-scale production. Therefore, one of the most important questions of industrial policy is how new knowledge can be integrated into existing clusters and industrial areas built into local production systems [15].

The scale and complexity of the problems created by the Fourth Industrial Revolution determine both the need and the possibility of developing new approaches to regional industrial policy, where the following can be distinguished:

– support for industrial policy as a process of identifying emerging opportunities and ways to overcome emerging problems;

– search for new forms of technology policy for the introduction of new technologies in various sectors and regions;

– measures for professional development and retraining of personnel;

– supporting small and medium-sized businesses and providing access to finance;

– support for reshoring while global value chains will undergo a transformation.

Breakthrough innovations often require interdisciplinary collaboration. According to experts of the Organization for Economic Cooperation and Development: “Necessary knowledge comes from a wide range of participants, and different types of activities are rarely available within only one organization therefore it is important to support the creation, dissemination and use of many types of knowledge and types of cooperation” [17]. In order for this “mixing” to happen, an open environment of cooperation is needed, built on long-term relationships and trust. This, in turn, requires well-developed institutions capable of developing such cooperation in the process of knowledge dissemination.

The new industrial policy will be able to “repopulate” production ecosystems in old industrial areas when global value chains are transforming and opportunities for small-scale production are appearing. However, what is meant here is not attempts to return to the traditional labor-intensive activity, but attracting companies within the framework of production reshoring policy, intensively engaged in Research and Development (R&D), as well as producing non-standard products.

Although reshoring does become real, its actual logistics can be quite complicated. The possibility of obtaining benefits from reshoring in developed countries will depend, among other things, on the qualifications of employees, innovation potential, the availability of a supply chain base, support services and the role of institutions, which can be seen, for example, in the experience of the United States and Great Britain.

It should be emphasized that the Fourth Industrial Revolution goes different ways in various economy sectors and in various countries. Industrial policy is designed to combine technologies, identify, develop and disseminate those key ones that play the role of “general-purpose” in production and services, making them accessible to all enterprises.

Concerns about the risk of a “digital gap” that may arise between regions of the same country, as well as between different countries and between rich

and poor segments of society, began to be expressed in publications about the impact of technological changes on the strengthening of socio-economic imbalances [18].

There are many factors that can cause such a gap. These are different levels and rates of human capital development, differentiated infrastructure capabilities, and institutional structures, as well as differences in policy, access to finance and culture.

For example, European companies face more serious problems than US companies in terms of access to finance. According to a number of experts, there is generally no risk capital in the EU, which allows creating new and innovative companies, especially during periods of technology change. This is reinforced by the lower risk appetite of European companies compared to American ones.

An important problem for the EU's industrial policy is that technological changes can consolidate the current development trajectory for individual regions and ultimately deepen the existing digital gaps. The gap between the countries of Northern Europe, on the one hand, and Southern and Eastern Europe, on the other, becomes obvious if one looks at the share of companies in the EU countries using information and communication technology specialists. Data on the level of automation and digitalization of the production process show similar trends.

As a result, the new industrial strategy should take into account industry trends and identify new opportunities. It is also extremely important to analyze the export potential of key sectors that can be used in the context of "smart specialization". Such an approach requires regional industrial development strategies, promotion of "connected diversification" using the achievements of the Fourth Industrial Revolution. First of all, these strategies should take into account the need to combine various but related actions in the region via end-to-end technology platforms of Industry 4.0 (for example, via "living labs" or digital demonstration centers). In addition, they determine the potential for regional diversification due to various industrial, educational, and institutional structures associated with specific regional development trajectories [10].

However, in order to transform the potential of the region on the basis of "connected diversity", expand and update its industrial structure, diversify into new related activities, industrial policy should encourage the "crossing" of industrial sectors both among themselves and with the service sector and with new technologies. This process can occur by knowledge transfer mechanisms between related and unrelated industries. For example, by attracting businesses from unrelated industries, because it increases the likelihood of successful policies, as well as contributes to regional diversification.

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The promotion of labor mobility between related and unrelated industries is extremely important for the success of industrial policy in the context of Industry 4.0, as it promotes the transfer of knowledge and can lead to new options for their recombination, increasing the level of human capital. Industrial policy should promote the dissemination of new technologies by institutional intermediaries and support collective research cooperation with partners from related and unrelated sectors [19]. Other necessary elements of the future industrial policy are: the development of new skills and competencies of employees, a constant process of retraining and advanced training as the Fourth Industrial Revolution develops; providing small and medium-sized companies with access to sources of financing for the introduction of digital technologies; motivating companies, industries, and regions to move to new segments of global value chains as they transform; using the capabilities of reshoring in the framework of the growing localization process; encouraging targeted investments in infrastructure for the introduction of new technologies.

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ПРОМЫШЛЕННАЯ ПОЛИТИКА В УСЛОВИЯХ ИНДУСТРИИ 4.0

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КОНДРАТЬЕВ Владимир Борисович, доктор экономических наук, профессор,
ORCID 0000-0002-7253-7320, v.b.kondr@imemo.ru
ИМЭМО им. Е.М. Примакова РАН, РФ, 117997 Москва, ул. Профсоюзная, 23.

ПОПОВ Владимир Васильевич, старший научный сотрудник,
ORCID 0000-0001-5299-958X, vlvaspopov@rambler.ru
ИМЭМО им. Е.М. Примакова РАН, РФ, 117997 Москва, ул. Профсоюзная, 23.

КЕДРОВА Галина Васильевна, научный сотрудник,
ORCID 0000-0002-2830-2612, kedrova@imemo.ru
ИМЭМО им. Е.М. Примакова РАН, РФ, 117997 Москва, ул. Профсоюзная, 23.

Статья поступила в редакцию 07.06.2021.

Дается анализ концепции новой промышленной политики в условиях Индустрии 4.0, интеграции промышленного производства и цифровых технологий. Рассмотрена роль государственных инициатив по созданию правовых, инфраструктурных, социальных и финансовых условий для поддержания важной роли промышленности в экономике и ее конкурентоспособности на внешних рынках. Представлены главные направления промышленной политики: разработка европейских и международных стандартов; развитие и внедрение интеллектуальных и гибких производственных систем; адаптация региональных кластеров; совершенствование квалификационных навыков и компетенций специалистов; мотивирование фирм, отраслей и регионов для перехода в новые сегменты гло-

бальных цепочек создания стоимости по мере их трансформации; расширение доступа к источникам финансирования; поощрение целевых инвестиций в инфраструктуру; использование возможностей решоринга в рамках нарастающего процесса локализации; внедрение экономики замкнутого цикла и реверсной логистики.

Ключевые слова: Индустрия 4.0, промышленная политика, глобальные цепочки стоимости, экономика замкнутого цикла, реверсная логистика, решоринг, цифровая инфраструктура, региональные диспропорции.

DOI: 10.20542/0131-2227-2022-66-3-73-80