

Smart Specialization within Industry 4.0 Network Strategies

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Abstract - The article is devoted to the analysis of high-tech sectors development within Industry 4.0 and the features of innovation linkages between them based on network approach. The conceptual base for creating of networks in high-tech sectors based on system integration approach are proposed and the main advantages of given approach are determined. An algorithm for determining the development options for certain inter-sectoral networks, considering the Smart Specialization and international component of national security, has been developed. By empirically examining of Smart Specialization experience a more complete understanding of successful strategies of networked based public policy was proposed.

Keywords – innovation network; strategy; priorities; smart specialization; technology transfer

I. INTRODUCTION

Under the conditions of transition to Industry 4.0 technologies large-scale application, a chain reaction occurs when changes in some industries cause changes in another. In its scale and complexity, this transformation is a qualitatively new phenomenon. These changes affect all nations and regions, and in order to successfully adapt to these transformations, the broadest and deepest targeted coordination of efforts of all forces and agents at all levels of public administration is necessary.

One of the main characteristic features of the transformation of Industry 4.0 deals with the changes in the basic principles of organization: the networks replace the traditional hierarchical structures as a system that allows to increase exponentially the level of connectivity and cooperation of all parts of economy and society (both consumers and producers), ignoring historical spatial and temporal boundaries.

Under these conditions, states are faced with the task of forming the appropriate specific advantages of a systemic nature. Industry 4.0 allows the country to change its role in global economic competition. This is possible with the full application of its existing resource capacity and the application of innovations within the framework of system strategies.

One of the most effective ways to achieve benefits in

Industry 4.0 conditions is to strength cooperation between the business and academic communities in country [1], create innovation spaces based on universities, create mechanisms to promote technological development and strengthen target cooperation between the public and private sectors.

Against this background, the central question that motivates this paper is how Smart Specialization can promote the goals of Industry 4.0 development through the networked based public policy.

II. STUDY OF MODERN TRENDS AND IMPORTANT IMPLICATIONS

We build on this analysis to identify the main ideas and approaches concerning Smart Specialization and its evolution within the modern technological and institutional trends.

The authors of more recent studies have proposed that Smart Specialization should be considered within the development policy and industrial policy [2], which are realized especially through the prioritization of this area of public policy [3].

E.g. in strategic review [4] such points of public policy were proposed:

- identified through, and integrated with, broader capability development, strategic prioritisation and resource allocation processes;
- balanced appropriately between the operational needs of individual agents and broader strategic priorities, as well as between short, medium and long term requirements;
- developed in conjunction with science and innovation community to ensure they are achievable and expressed in manner that is both useful to science and innovation audience and not so prescriptive as to limit novel or alternative solutions;
- risk-informed, evidence-based and developed in logical, transparent and auditable manner.

Given points illustrate an example of system public policy, which is Industry 4.0 characteristic feature.

Smart Specialization within Industry 4.0 study is based on the foresight of emerging technologies and further identification of emerging industries. Such type of analytics deals with the great challenges and opportunities for scholars and policy makers [5].

Study [6] elaborates why and how institutional diversity and integration promote entrepreneurial discovery processes, spillovers and agglomeration effects, and thereby structural change in regions.

Study [8] outlined the links between the policy context, policy design, policy choices and policy intentions were discussed. These approach allows to consider the applied aspects of analysis of policy tools application in technology transfer management within Industry 4.0 conditions [8], using of technological package concept for sector development strategy [9], analysis of strategical aspects of technology transfer in some sectors [10] and technology transfer management policy [11].

One of the main differences between different approaches to Smart Specialization is its scale understanding. Let us now analyze some of them.

Despite the Smart Specialization is considered mainly for regional level in study [12] it is underlined that national level remains important for both social cohesion and economic development. For Smart Specialization the policy challenge for national state is to learn how to foster innovations of Industry 4.0 by the supply- and demand-side repertoires. Although the supply and infrastructure remain critically important, the state needs to do much more to foster innovations prioritization – for example by creating stable regulatory regimes for long term investment

Another approach is given in [13] and includes the internationalization of smart specialization. Its transformation requires not only endogenous knowledge and technology accumulation building but also coupling with international knowledge and production networks.

It is also important to emphasize cross-border regional innovation systems conception and some implications that are important for the selection of innovation policy instruments [14].

The most important challenges are capturing entrepreneurship and knowledge networks, on the one hand, and embedding their complex interrelationship with wider economic mechanisms, on the other, together shaping the impact of smart specialization policies [15].

Cooperation within and between regions emerges as an important determinant of regional diversification [16]. Research [17] explores the policy framework around the concepts of relatedness and knowledge complexity. Authors show that diversifying into more complex technologies is attractive but difficult for European Union regions to accomplish. According to [18] industrial diversification of new industries can be built on similar knowledge base, draw on shared network, important role in knowledge-intensive industries.

Innovation networks in the priorities sectors and their policy support can be studied within the smart experimentation approach, which was considered in [19].

Smart Specialization that make it particularly suited to the problem of sectoral modernisation in the context of a mature economy [20] and connectivity model application [21].

Therefore the objective of this article is devoted to the analysis of high-tech sectors development within Industry 4.0 and the features of innovation linkages between them based on network approach as the component of public policy, based on Smart Specialization.

The following methods were used to determine the role of innovation networks in Smart Specialization to promote the goals of Industry 4.0 development:

- adapted decision-making methods (optimization of performance indicators, which are used to investigate the innovation role of networks);
- methods of innovation systems and intersectoral high-tech complexes strategic development schemes analysis, which are used to develop the main points of Smart Specialization for national innovation strategy;
- methods for searching of innovation ways of development and integrated economic analysis of development policy (are used to develop the innovation partnership strategies).

The fundamental principles of strategical management of institutional dynamics within the framework of development strategies require constant research, as currently the situation in the innovation sphere is constantly changing. This requires focus on identifying pressing problems and determining the prospects of how network approach can help under Industry 4.0 conditions of technological changes.

III. SMART SPECIALIZATION FOR INDUSTRY 4.0

In the context of institutional transformations, let's note that for effective management of resource flows within Smart Specialization strategy, it is necessary to have clear ideas about modern technologies (new trends of Industry 4.0) and the organizational and economic principles of its development. Understanding the specifics of development of Industry 4.0 technologies is necessary for development of innovation strategies, which should be aimed at organizational and resource support of high-tech industries and innovation communications between them.

The idea of current study is based on the hypothesis about necessity to adapt of institutional mechanism for national security ensuring through Smart Specialization strategy. This can be done through the comparison the level of strategical goals protection with the main trends in the innovation area, which can be done as follows:

- openness of innovation processes, strengthening of network processes of intersectoral technology transfer together with the business processes digitization leading to the formation of huge number of organizations & systems, which have significant synergistic potential;

- unique (specialized) innovation systems development, including national and regional, expanding various forms of innovation integration within the active innovation networks;
- innovation networks formation in national innovation system, which is represented as a complex multi-level and multi-sectoral structure.

These tasks are especially important in the conditions of Industry 4.0 forming, which in turn leads to the formation of new organizational framework for development and innovation processes acceleration.

In Fig. 1 we have shown the scheme of Smart Specialization to promote the goals of Industry 4.0, which is based on two-side analytics and evaluation.

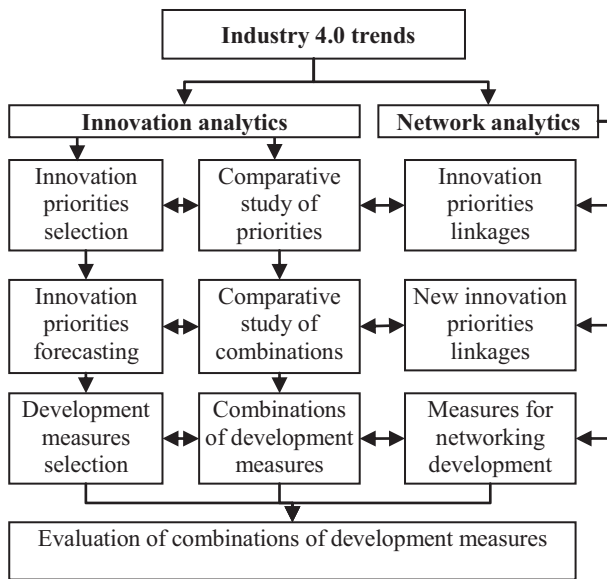


Figure 1. Smart Specialization within Industry 4.0

The elements of given in Fig. 1 scheme are used by many developed countries and corporations for active participation in the fourth industrial revolution. These points are included in the state programs, commercial associations and professional organizations, which aim is eliminating barriers for Industry 4.0 development. In these conditions the main point should be oriented not the classical efficiency achieving, but on adaptability goals (ability to adapt quickly to dynamic markets). This idea forms a new situation of strategic choice, related to redistribution of technology rent and practical planning of innovation-investment processes within the public policy.

Smart Specialization strategy is proposed to consider at such two levels:

1. Management of the technological development within existing sectors and market positions.
2. Designing of new organizational and technological formats for industries and areas of activity development based on innovation linkages.

These levels give possibility to consider national resource base and development priorities and to implement policy with a focus on promising technologies and effects. Thus, the implementation of the objectives of

public policy is implemented by the following managerial and analytical mechanisms:

- identification of areas with the highest priority (current and prospective) and localization of competences (human resources, innovation potential, technological excellence, sectoral opportunities);
- creation of set of organizational advantages (unique organizational concept or development model, special configuration of processes, unique innovation culture, local innovations ecosystem etc.).

For the conceptualization of institutionalization the results of Smart Specialization analytics and, the national innovation system should be considered as a system of state, private and public structures (institutions), as well as national institutions and their interaction with the goal of creating, modifying, transferring and using knowledge and technology.

IV. GLOBAL EXPERIENCE IN SMART SPECIALIZATION

This part of study deals with global experience in Smart Specialization analyzing of priorities based on their importance for nations development and national & international criteria using algorithm for selection. The main aspects of the process of development and implementation of technology strategies are considered.

Through the analysis of innovation systems at macro level decision about the priorities networks in optimization with the aim to improve public policy in science, technology and innovation can be provided. The main techniques and decisions can be considered based on foresight-studies.

Today the competitiveness of nation in global space is provided by innovation technological imperative, which demands modernization of production system according to the requirements of scientific and technological progress and postindustrial Industry 4.0 development. Thus, it is necessary to highlight the priority sectors that are material basis for the functioning of most important areas of human life and ensure the development and implementation of advanced technologies.

In some cases such strategic initiatives have even further importance. World experience shows that the greater the lag in the development of a country, the greater is the role of government in infrastructure development, resource mobilization, identifying priorities, reaching proportions and relationships in national economy and national innovation system. Given the fact that the economy is a selection of best possible, there is a need for effective prioritization of socio-economic, scientific-technical and innovation development.

In several countries despite the existence of national regulatory selection process of priorities, resources for its implementation do not meet the real needs. Also unlike the technologies of choice of priorities in other countries, international criterion of development is not considered, which requires an appropriate organizational and economic security.

Today the main policy issue of countries is integration to the global innovation system for using of its potential and achieving long-term economic growth through innovations. Also the creation of education, research and development system components for the foreign investment through the public-private partnerships is in priority areas.

So our study is based on the idea, that innovation system development requires an interrelated definition of performance indicators and priorities, strengthening of intersectoral coordination, changing of operation principles of development institutions, formation of domestic demand for innovation.

To achieve the aim of the research it was necessary to consider the existing experience of foreign nations in innovation development policy, especially identifying the opportunities in international cooperation and international economic activities, based on the selection of innovation priorities and the development of appropriate system support mechanisms.

All these problems have to be solved within the framework of interaction of national and global innovation systems and as a science and industry compound, which is oriented on providing faster and more efficient management in «science – production» cycle in the priority sectors of scientific and technical progress, acceleration of new idea development and its most effective application in practice (transfer).

The development of each priority is based on system approach of social and economic conditions as a result of integration and cooperation of different agents of innovation system (enterprises, research institutions, industry, society). In this context the effectiveness of coordination at cross-sectoral level and innovation network interaction are proposed to be determined based on competitiveness of production and economic development based on innovations at meso- and micro level. Therefore the main factors (determinants) of Industry 4.0 innovations development, which are considered in the Smart Specialization analysis of national innovation priorities, are follows:

- market and resource factors, including consumer preferences;
- relationship between consumers and producers which is often intense within the national system;
- research system that generates scientific and technological innovations;
- technological interdependence in the country which is most significant in the early stages of innovation processes;
- communication and public policy in different areas (for example, scientific and technological policy and defence researches), as well as the conditions for technological and economic activity (as defined within the framework of the policy) such as legislation and regulation;
- education and training system, developing skills, abilities and competencies required for

innovation;

- national institutions, that support innovations, such as industry and engineering associations.

V. SMART SPECIALIZATION NETWORK BASED STRATEGIES

Support for the development of technologies at the national level is carried out by many industrialized countries of the world: lists of such technologies are approved and maintained at the state level. By empirically examining, we hope to produce a more complete understanding of successful examples of networked based public policy.

The most widespread and most fulfilled practice of such activities in United States, Russian Federation, EU and Japan. In particular, in EU countries, Euclid program were implemented, Germany and Japan are participating in Delphi program with the participation of government, industry and academia to assess the importance and status in broad number of technologies.

Analyzing institutional coordination, we first note the experience of the United States. The key thesis that some technologies are crucial not only for providing combat readiness, but also as an incentive for economic growth, was ensured by the US law passed by the Congress of PL 101-189 (National Competitiveness Act 1989 Technology Transfer Act of 1989; Public Law 101-189). The US Code defines national security objectives to support national technology and industry. It has been established that the policy of US Congress is aimed at reproducing, within a reasonable time, opportunities for development and production of materials and equipment, including technologically advanced systems, in quantities sufficient to prepare for war, state of emergency or mobilization of the Armed Forces in the case of threat to national security.

According to Smart Specialization strategy state support should include a state system for assessing, identifying and monitoring of such technologies. To such a system it is necessary to involve central and local executive authorities, which have the authority in the field of formation and implementation of scientific and scientific-technical policy, industrial, military-technical and military-industrial policy, and policy in the field of military-technical cooperation. Transfer from military to civilian, but now quite often there is a reverse trend.

The most successful model of functioning of the reorientation of the economy to the innovation-oriented model is the Yazma model of Israel. The model envisaged the creation of funds and the further development of 10 private funds with the participation of the state, each with a capital of \$ 20 million or more.

The program was established under the leadership of the Ministry of Industry and Trade of Israel. Funds were required to have at least one Israeli partner and one American or European partner with experience and reputation in the field of venture capital investment.

At the same time, foreign partners undertook to teach Israeli specialists, while the fund itself was managed by an Israeli private asset management company. The sponsored

fund received \$ 8 million from the Yozma Fund, which was 40% of the cost of the project. In case of successful implementation of the project, it was envisaged the purchase by the private investor of a share of the state at the initial cost of the state's investment in the project plus a small income accrued on the state's share. In total, within the Yozma program, 10 venture funds were created, almost all of which were closed-ended. The total volume of high-tech exports increased from \$ 2.2 billion in 1991 to \$ 11 billion in 2000.

US market is characterized by a highly developed investment infrastructure and is by far the largest capital market in the world. The country has a well-developed legislative base, which has more than 80 years of history, uses a wide range of instruments: tax breaks, loans guaranteed by the state loans.

The Small Business Investment Company Program (SBICP) is a unique public-private partnership program, through which, since its inception, more than 100,000 small US companies have been invested in a total amount of \$ 48 billion. The PCIMB Management Company is a privately owned venture capital company licensed by the state to provide venture capital companies with equity or long-term loans. Such a mechanism has been introduced in the United States since 1958 in order to simplify the access of small businesses to borrowed capital. The minimum capital required to set up a company for SBICP is US \$ 5 million, to be provided by individuals, the remaining capital needed for the development of the project, provided by the state in a triple amount through the sale of targeted government securities. Since the launch of the program, since 1958, 46 billion dollar loans and equity investments have been distributed to more than 99,000 small US enterprises. Most of today's well-known holdings started with this program. For example, they are the following: Intel, Apple Computer, Callaway Golf, Jet Blue Airbus. In addition, this program addresses the issues of the labor sphere, in particular, in 2005, 218,000 new jobs were created, all of which were fully occupied by new ones.

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The most famous high-tech clusters in the US are Silicon California, the Boston cluster and the Triangle of Science.

The formation of the first two clusters was not the result of a purposeful government policy, although they benefited from state support, while the last cluster appeared just thanks to this support. The federal cluster policy in the US has historically been minimal and has been implemented mainly through the Administration for Small Business and the Department of Economic Development (EDA) of the Ministry of Commerce.

Basically, the cluster policy was implemented at the state level and, at the first stage, included the identification of a potential cluster by geographic, sectoral and other characteristics, as well as by existing links. At the second stage, work was usually carried out to develop

entrepreneurial potential and business and scientific relations within the framework of the identified cluster, for example, through the financing of joint research, development of standard licensing, coordination of seed funding for small innovation enterprises created at universities. As a rule, the role of the state in the cluster policy was to create a research and innovation infrastructure and to stimulate the development of scientific and business relations in the region, and not to direct financing of companies.

Finland has also built one of the world's most effective investment schemes for innovation development programs, based on the SITRA National Fund for Research and Development (SITRA).

The foundation was founded in 1967 by the state and is currently regulated by the parliament of the country. One of the objectives of the fund is the state support of innovation companies in Finland and other countries, including through direct investments or through a fund of funds. The main component of the success of this program is the optimal interaction between the state, science and private business on the basis of common rules and division of responsibilities. The catalyst for the development of venture capital was the SITRA Fund for Sowing Investment (venture capital fund for start-up projects). The total volume of investments made between 1991 and 2003 increased from EUR 50 million to EUR 420 million.

This experience convincingly indicates the importance of the role of the state in coordinating a number of innovation initiatives in priority sectors.

The research carried out allows us to draw a number of conclusions about the main features of the organization of activities to stimulate demand for Industry 4.0 innovation solutions and products through the Smart Specialization, which can be grouped into such groups:

1. Innovation is not an end in itself, but a means of obtaining a new value for the end customer, new ways of solving social and economic problems of customers. Examples of such tasks include strengthening the competitiveness of small and medium-sized enterprises in the technological sphere (SMBA, South Korea), developing the medical field of "comfortable aging" (HAPPI Healthy aging, France etc.), increasing the competitiveness of enterprises (e.g. RIS-3, France, Ron-Alps region).

2. Stimulating the demand for innovation is a system of measures for building effective interaction of all stakeholders at all stages of the life cycle of innovation product in innovation networks: from identifying and detailing the needs of customers in innovation solutions for public procurement procedures.

3. Stimulating the demand for innovation is not implemented as a set of individual activities, but as systemic actions in the format of projects or programs that cover all or most of the measures aimed at developing and implementing solutions that are needed by end users, as well as popularizing the most effective practices of such policy. In such projects and programs there is always an active coordinating center – the organizational structure

responsible for implementing the key tasks of project or program. We also have investigated that in the most cases a specialized organization is created as a such structure.

VI. CONCLUSION

We opened this paper by noting that institutional mechanism for Industry 4.0 through the Smart Specialization strategy can be considered as matching of cooperation mechanisms with the main innovation trends. The foregoing discussion has attempted to new trends of Industry 4.0 and the organizational and economic principles of its development. Understanding the specifics of development of Industry 4.0 technologies is necessary for development of innovation strategies, which should be aimed at organizational and resource support of high-tech industries and innovation communications between them.

The main factors (determinants) of Industry 4.0 innovations development, which should be considered in the Smart Specialization analysis of national innovation priorities, were discussed. By empirically examining of Smart Specialization experience a more complete understanding of the main points of successful strategies of networked based public policy was proposed. The main features of the organization of various public policy activities to stimulate demand for Industry 4.0 innovation solutions and products through the Smart Specialization were studied.

The study of global experience in Smart Specialization analyzing of priorities based on their importance for nations development and national & international criteria using algorithm for selection leads us to the conclusion that Smart Specialization should be based on network cooperation between the agents from the public and private sectors. The evidence from our studies suggests a variety of factors related to management of network cooperation within the Smart Specialization for Industry 4.0 technologies development.

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