Technological systems in economy: problem statement and fundamentals

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Abstract. The study aims to develop and substantiate a single approach to examining a new unit (subject) of analysis, i.e. multisided platforms.

The authors address the phenomenon of technological systems due to dominant trends and dramatic shifts in economy. Firstly, the complexity and the scale of modern technologies result in a number of restrictions (including resource constraints) on their development and application by certain companies. This fact causes the changes in business models of companies and their integration into platforms and other network structures. Secondly, the value of the latest technologies emerges in the context of network interaction. Thus, a network structure is a carrier of technologies. There is also a reverse process unfolding – networks are becoming increasingly widespread due to the global development of digital technologies. On the one hand, this entails the emergence of distributed industries and innovation centers, and on the other hand, this blurs the boundaries of traditional markets and industries. Interactive participation of customers in the product development and production is a key distinguishing feature of digital interaction. Thirdly, under globalization, several companies located in different countries can participate in the creation of the end product. This trend poses the question of the manufacturability of national economies, rather than that of local industries (activities). All these tendencies underlie the changes in the principles of the functioning of the market, which, in turn, transforms the previous ideas about the subjects of analysis, their management and effective organization. We suppose that the main drivers (actors) of economic growth are not individual companies and industries, but cross-company and cross-industry collaboration based on a single technical standard (group of standards). The necessity of searching effective stimuli and mechanisms for scientific and technological development makes the analysis of the nature of technological systems increasingly relevant.

Keywords: technological system, ecosystem, platform, network structure.

I. INTRODUCTION

The objective of taking over leadership in technologies increases the urgency of technological development drivers that lie beyond the scope of intensive production and dissemination of information technology.

Despite the rapid development of digital technologies, humankind cannot be completely virtualized. Material objects manufactured by traditional industries will always be the basis of human life. Surely, digital technologies serve as the basis for the operational transformation of all economic sectors and significantly change business models of industrial enterprises [1]. Current competitive advantages are primarily associated with the ability to quickly respond to changes in the technological landscape and reconfigure their production capacities to changing requirements.

The development of industrial technologies is happening against the background of the massive digitalization of economic processes, customization of production, formation of distributed production models and penetration of digital platforms in all economic sectors. This significantly changes the processes of creating advanced technologies and replacing obsolete ones, as well as the processes of disseminating technologies, which constitutes the essence of the technological development of society [2].

The purpose of the study is to develop a common conceptual-methodological framework that consolidates the provisions of strategic management theories, the ecosystem theory as well as the platform economy, and allows describing the nature of a technological system and, in the future, operationalize this phenomenon.

II. THEORETICAL BACKGROUND

The expansion and deepening of network interaction is the most obvious consequence of the digital transformation of economy. In a broad sense, a network is a group of economic agents that influence each other directly or indirectly [3]. The network groups are formed on the basis of the three core factors – location (geographical), technological and institutional. Modern economic analysis focuses on the identification of one-factor and two-factor groups. One-factor groups include agglomerations (location factor), industries (technological factor) and conglomerates (institutional factor). Two-factor groups embrace economic zones (location and institutional factors), clusters (technological and location factors) and platforms (technological and institutional factors). Three-factor systems have not yet been described in the economic literature, but smart cities are believed to be their prototypes [4]. Tree-factor groups are possible to encompass ecosystems actively debated in the scientific literature as an independent unit of economic analysis. In the narrow sense, an ecosystem is the integration of an industrial cluster, a digital platform and an innovation center (science parks, business incubators) [5]. The concept of ecosystems emerged due to the synthesis of the network and evolutionary theories as the development of the Population Economy of Organizations by Michael Hannan and John Freeman [6]. This line is reserved for Copyright Notice code platform and an innovation center (science parks, business incubators) [5].

The concept of ecosystems emerged due to the synthesis of the network and evolutionary theories as the development of the Population Economy of Organizations by Michael Hannan and John Freeman [6] that is based on the dominance of collective rationality over the individual rationality. This implies that the action optimality can be interpreted differently in terms of an individual company or an industry (a group of firms) at large. Nelson and Winter [7] point out that, along with the adaptation of an ecosystem's participants to each other and to changes in the environment, the development of business ecosystems is associated with the accumulation of technological knowledge. At the initial development stage of the theory of ecosystems, it was assumed that, similarly to the biological, business ecosystems were self-coordinated and decentralized objects. Their generic feature was the spontaneous emergence in that part, where stable self-sustaining relationships arose based on common interests [8]. Ecosystems operate on the principles of collaboration interpreted as "a process in which autonomous actors interact through formal and informal negotiation, jointly creating rules and structures governing their relationships and ways to act or decide on the issues that brought them together; it is a process involving shared norms and mutually beneficial interactions" [9]. In further studies on ecosystems, the main focus shifted from their participants to the nature and dynamics of internal interactions [10]. Ecosystems themselves were regarded as a dynamic combination of multidimensional internal relationships [11]. They embrace economic actors and the environment consisting of technologies, rules of the game, social interactions and culture [12]. Later, Pilinkienė and Mačiulis [13] described entrepreneurial, innovation, industrial, digital and business ecosystems and demonstrated that they could have a marked effect on the sustainability of economic development.

Jacobides [14] categorize papers on ecosystems into three broad groups depending of the unit of analysis – a firm, an innovation or a platform. The first group focuses on studying ecosystems as an economic community of interacting actors and the ways of forming sustainable competitive advantages by a firm, considering the ecosystem's dynamic capabilities [15]. The second group centers on understanding how economic actors interact to create and commercialize innovations. The key issue is the coordination mechanisms between the owner of the focal innovation and the owners of complementary innovations [16]. In a number of studies, a geographical location of an innovative industry-related ecosystem is associated with clusters in their modern sense [17].

The third group of papers concentrates on platform ecosystems which imply technological and digital platforms formed by a core and a network of peripheral firms. The basis for the functioning of a technological platform is a technology organized in the form of technical standards. The firm owning the technology performs the functions of the platform's coordinator, and the peripheral

firms (complementors) are suppliers of complementary innovation adding value to the platform [18; 19]. A digital platform is an integrated information system that serves as the basis for multi-sided user interactions in terms of the exchange of information and values that reduce overall transaction costs, optimize business processes and increase the efficiency of the supply chain of goods and services [20]. Platforms form rapidly developing multi-sided markets [21]. Their special feature is the presence of direct and indirect (cross-side) network effects [22]. Platforms are characterized by not only the absence of a particular location of the participants, but also the presence of a powerful mechanism for formalizing the rules and standards of the functioning of platforms and recording the transactions history through integration of digital technologies. At the same time, there is a discrepancy between the generic feature of ecosystems as a self-coordinated system and the aforementioned innovation, platform and business ecosystems having a certain element acting as the coordinator, mediator and concentrator. Platforms and innovation ecosystems are likely to be a special case of the ecosystem approach, and the conceptualization of business ecosystems is linked with the evolution of ideas about a wider set of relations of a modern firm, covering not only cross-organization networks, but also actors outside the industry. However, there is a distinctive feature common to all ecosystems, i.e. the value is created only through the interaction between the ecosystem's participants.

Thus, in the context of digitalization, the special part is given to the network forms of interaction and there is a need for in depth studies on platforms and ecosystems. According to Balatsky [23], today's economy is the economy of digital platforms.

III. TECHNOLOGICAL SYSTEMS IN ECONOMY

Similar to industries, platforms demonstrate the property of geographical distribution and are localized near the single technical standard. The competition between technical standards translates into the competition between technological platforms, which essentially makes the researcher explore the micro-level and the issues of modifying the methodology of analysis of industry-specific – or more precisely, platform-based – markets. Platforms have the properties of horizontal integration. Thus, both industries and platforms are flat horizontal structures.

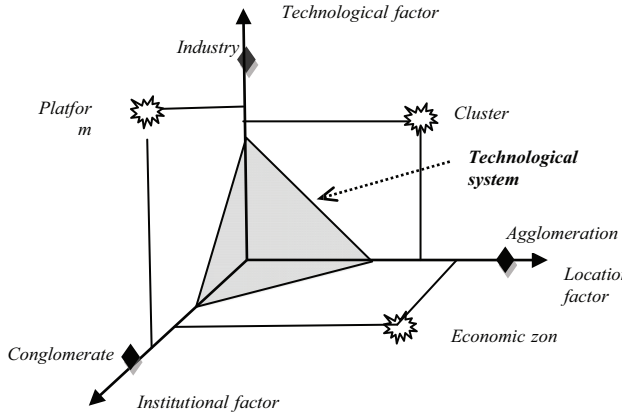
Vertical integration is a group of organizations that cover the entire production chain from the initial to the final technological stages. The structure of vertically integrated formations is rigid, inflexible and insensitive to the dynamics and uncertainty of the environment. There emerge gradual processes of decentralization and disaggregation of these market giants [24] that have become ineffective in the age when the core competitive advantage is not possession of material assets, but the possibility of their temporary use and quick reconfiguration in response to changes in the external environment [25].

It is reasonable to anticipate that the interactions between economic actors will be reshaped from vertical or horizontal – but still flat – two-dimensional structures to the multidimensional space and that both end and intermediate consumers will be involved in these interactions. Customization of production implies the possibility of customer involvement at various production stages, which allows the enterprise to produce a product adjusted for individual consumer demands. Customization is strongly supported by the development of complementary technologies and the creation of digital twins of complex industrial products. Here, we arrive at an important conclusion: when forming demands at various levels of production, the customer affects primarily the technology. If the consumer is not an end but intermediate user, then we are talking about the mutual agreed improvement in technology by manufacturers engaged in different industries.

Multidimensional network space of consumers and manufacturers involved in online interaction makes it more urgent to the revise the processes of creating and spreading technologies. However, it is even more important to seek points of technology application. Due to intensive convergence of technologies, the subject of analysis can no longer be applicable to industries in their traditional sense, i.e. a group of enterprises and productions similar in manufactured products, technology and satisfied needs. The merger of technologies results in the merger of industries over time. In addition,

technologies are disseminated within the network, which causes the diversified interdisciplinary interaction and the emergence of technologies that cannot be included in any particular industry.

Based on the typology of network entities founded on the formation factors, it is possible to assume that there exist three-factors systems referred to as technological systems (see Figure Technological system as a three-factor network structure)



Technological system as a three-factor network structure

A technological system is not a new type of independent network entity, but rather a new unit of analysis of structures formed as a result of the integration of traditional industrial enterprises and high technologies. Technological systems can be regional, national or global. Their fundamental features are the formalized institutional coherence and common technical standards. When it comes to traditional manufacturing, it is required to consider the location factor optimizing the costs of the basic resource industries. These fundamental characteristics allow differentiating technological systems from hard-formalized ecosystems. Structurally, a technological system can include technological and digital platforms, vertical structures, individual organizations and structures.

Thus, digitalization accelerates the spread of technologies and makes multidimensional non-hierarchical ties between economic actors more relevant. The advent of technology is gradually becoming more and more non-stochastic in nature, which means an increase in the path dependence of technological development. The rise and development of technologies do not result from activities of a firm or a platform, but from integrated interaction of the participants within the technological system. Industry is declining in importance, since technologies develop in the cross-industry space and are introduced amid distributed production.

IV. CONCLUSION

The current stage of technological development is characterized by the global expansion of network interactions accompanied by advancement in digital technologies. The advent of technologies is no longer associated with individual companies, but moves into the multidimensional space of interactions between various economic actors. A discrete examination of industries, technological platforms, vertically integrated structures, etc. does not provide a system-wide idea of the processes of technological development. At the same time, there is no interpretation of the concept of a technological system as a unit of analysis. This allows posing a question about the necessity for shifting the research focus towards technological systems.

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