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ARTICLE

Knowledge: From Ethical Category to Knowledge Capitalism

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ABSTRACT

In the post-industrial economy, the efficiency of scientific knowledge generation becomes crucial. Researchers began to interpret knowledge as a factor of economic growth in the second half of the 20th century; since then, within the theory of economics and management, various approaches have been developed to study the impact of knowledge on economic growth and performance. With time, the focus of knowledge-based theories shifted from corporate management to macrosystems and economic policy. The article describes the main stages in the development of socio-economic concepts of knowledge and analyzes the theoretical and methodological aspects of each approach. The authors have also formulated the critical problems in the analysis of the economic category of knowledge at the present stage and suggested ways of overcoming them. The article may be of interest both to researchers and to practitioners in the sphere of corporate strategies and economic policy.

KEYWORDS

knowledge management; intellectual capital; knowledge economy; economics of scientific knowledge; Triple Helix; Quintuple Helix

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Introduction

The category of *knowledge* was first introduced into scientific circulation in ancient Greece. However, initially, this term had an exclusively philosophical or ethical meaning. Socrates considered knowledge a source of virtue, and his disciple Plato interpreted knowledge similarly. Aristotle's interpretation was much closer to the modern understanding of the word, but it would not even have crossed his mind to regard knowledge as a way of developing the Greek economy (in fact, the very concept of economics in its modern sense did not exist at that time). Until Marx's time, practice had been seen as something unworthy of a philosopher. The Christian church even equated knowledge with revelation, and wealth was declared sinful. Everything changed with the advent of the scientific and technological revolution, followed by the industrial revolution. Natural sciences were rapidly developing, and technical inventions were rapidly changing the world. Surprisingly, the economics came to the role of scientific knowledge and technological progress in the development of socio-economic systems only in the second half of the 20th century.

At the present stage of the development of science, knowledge, as well as scientific and technological progress¹, are considered the factors of economic growth, regardless of school and course within the framework of economic science. However, theoretical and methodological disagreements between neoclassicists, institutionalists, Marxist, and other schools often obscure the very essence of knowledge generation processes and their economic significance. First, it is necessary to trace the evolution of the theory of economic growth. Classical economists from Adam Smith to Marshall attributed higher economic growth rates mainly to the accumulation of physical capital (Marshall, 2013; Mill, 1848; Say, 1836/2008; Smith, 1776/1874). Thus, in the classical theory of economic growth, knowledge was absent as a category.

The economic crisis of the 1920s–30s made economists concentrate on the problems of the business cycle: thus, Keynes (1936) dealt with fluctuations in unemployment and output in determining interest rates and money supply. Harrod and Domar, following the Keynesian model, adopted a constant savings rate and capital intensity ratio when deriving the economic growth formula (Domar, 1946, 1947; Harrod, 1939). Solow's neoclassical growth model included maximizing the profits of producers, who align marginal costs and marginal productivity of factors of production; maximizing utility by consumers, who save a fixed share of their income for future use; the equality between savings and investment, and the replacement of capital and labor (Solow, 1956). Technological progress was an exogenous factor in the Solow model—countries with a higher level of savings had a higher income level. Still, higher growth rates were possible only due to a higher level of technological progress. Lucas (1988), Arrow (1962), and Romer (1990) made the technological

¹ The authors consider scientific and technological progress as a process of implementing scientific knowledge in practice; therefore, in the text we will use the term "knowledge" in relation to both scientific knowledge and scientific and technological progress. In cases where the difference is essential for the study, we will make an appropriate emphasis.

factor *endogenous* by introducing knowledge or human capital into the production function along with physical capital.

Not only is the economic interpretation of knowledge changing, but the new neoliberal paradigm of science and higher education is also emerging. This issue is considered, for example, in the article by Olssen and Peters (2005), and others (Hornidge, 2011; Jessop, 2016). In classical liberalism, the individual is characterized as having an autonomous human nature, capable of realizing their rights and freedoms. In neoliberalism, the state seeks to create not just a person, but a competitive entrepreneur. Education and science in the concept of neoliberalism are interpreted in terms of inputs–outputs, thereby being reduced to an economic production function. The main aspects of the new public management are flexibility (for organizations through the use of contracts), clearly formulated goals (both organizational and personal), as well as focus on results (measurement and managerial responsibility for achievement). In addition, the microeconomic methods of the quasi-market or private sector with their new set of contractual norms and rules replaced the “*ethics of public service*”, according to which organizations were regulated in accordance with the norms and values arising from assumptions about the “*common good*” or “*public interest*”. Consequently, the concepts of “*professional*” or “*trustee*” are considered in the framework of the “*principal-agent*” scheme. The scale of institutional changes at the current stage allows us to talk about a new socio-economic formation—*knowledge capitalism*.

Generally, nowadays, there are four factors² that can shift the production possibility curve to the right without an inflationary gap (arranged in increasing order according to the degree of impact):

- physical capital
- increase in the quantity of the workforce
- increase in the quality of the workforce
- scientific and technological progress

The first factor is functionally dependent on the level of savings and investments. The third and fourth factors are the result of the efficient generation of scientific knowledge, which can be accumulated both in the form of human capital and intellectual property³. Accordingly, the effective generation of scientific knowledge can eliminate structural imbalances and ensure economic growth without inflationary costs. The purpose of this work is to propose a definition of the economic category *knowledge*, based on the comparative analysis of the interpretations of knowledge generation in various socio-economic concepts. Furthermore, we intend to clarify what role knowledge plays in economic processes at the current stage of development and how this phenomenon affects various socio-economic systems.

² The authors deliberately do not consider natural resources as a factor of economic growth in the new economy. On the contrary, the resource orientation of the economy of a country (region) may have extremely negative consequences.

³ An example is the Leontief paradox, which showed the capital intensity of American exports precisely in terms of human and not physical capital.

Processes of Knowledge Generation

The concept of knowledge generation is rooted in Schumpeter (1934), who methodologically separated innovation from inventions. The cycle of scientific and technological activities includes three phases: invention (creating new knowledge)—innovation (implementing new knowledge)—imitation (copying innovation by other market players). Vanderburg (2005) extends this scheme from the perspective of the technology life cycle: invention—innovation and development—diffusion—substitution. It should be noted that the concept of diffusion of innovation has become extremely popular towards the end of the last century (Eveland, 1986; Peres et al., 2010; Rogers, 2003). Lonergan expanded the scope of diffusion of innovation by proposing a repeated cycle of technological, economic and political changes: situation—insight—communication—conviction—agreement—decision—action—new situation—insight, etc. (Lonergan, 1997).

It should be noted that a distinction is made between analytical knowledge (scientific base) and synthetic knowledge (engineering base) (Laestadius, 1998). Science is to explain the global issues of human existence and the world, or to find universal patterns—"truths" (Frezza et al., 2013). Lonergan (1997) further emphasized mathematical and empirical heuristic structures. Engineering/technology aims to meet the urgent needs of man and society (Koen, 2003), to create artifacts. Analytical knowledge more often takes an explicit or codified form (articles, reports, patents); synthetic knowledge exists in a tacit form, it results in new products and technological processes (Popov & Vlasov, 2014). Codified knowledge has a standardized compact form (David & Foray, 1995) and can be delivered over long distances (Foray & Lundvall, 1996); tacit knowledge is sensitive to localization—it is usually transmitted personally. This classification of knowledge came from the work of Polanyi (1962), who wrote about the impossibility of separating the produced knowledge from the personality of the researcher. Moreover, two types of knowledge (explicit and tacit) dynamically interact with each other, which is the basis of the spiral process of expanding existing knowledge. Nonaka and Takeuchi in the mid-1990s created a model for the interaction of explicit and tacit knowledge in the process of knowledge generation in the workplace. This model is known as SECI and will be discussed in more detail in the following section of this paper (Nonaka & Takeuchi, 1995). Individual and organizational knowledge is maximized by translating tacit knowledge into explicit, which can then be interpreted, presented, codified, stored, retrieved, and disseminated (Nunes et al., 2006).

Sociologist Pitirim Sorokin proposed an original interpretation of knowledge generation as an *epistemic process* (Sorokin, 1941). His model included three stages:

- *Mental integration* is the union of two narratives into a single system as an act of creation of the human mind;
- *Empirical objectification* is a means of "delivering" new knowledge to the final recipient;
- *Socialization* is the dissemination of knowledge among individuals through socialization agents.

The latter emphasizes the social context of the utilization and dissemination of scientific knowledge, which makes it similar to the diffusion of innovations and hermeneutics.

Considering the acquisition of new knowledge as a production process, three stages of knowledge generation are traditionally distinguished: generation, dissemination, and utilization (Popov et al., 2009). We proposed to supplement the model with the distribution of knowledge; thus, the knowledge generation cycle consists of four stages: (a) production; (b) exchange; (c) distribution; (d) utilization of knowledge (Kochetkov & Vlasov, 2016). It is essential to draw a line of demarcation between exchange and distribution. In the case of an exchange, we deal with the relationships of one or more economic agents. Distribution implies the free distribution and use of new knowledge by an unlimited circle of economic agents. Distribution of knowledge allows the creation of externalities that stimulate regional economic development. Knowledge-spillovers, in this case, are an exogenous factor in relation to a particular company or industry (Jacobs, 1969, 1984; Porter, 1990).

Knowledge-based Management Concepts

Knowledge Management

Considering the generation of scientific knowledge as a production process, we need to determine the control functions of this process. Without dwelling on the whole variety of management theories, we adhere to the concept of the classical administrative school of management (Fayol, 1949), which distinguishes four main functions of management: planning, organization, control, and motivation. It seems relevant to us to interpret motivation as leadership, respectively, further we will adhere to this functional scheme (planning, organization, control, and leadership).

In the mid-1990s, Nonaka and Takeuchi developed the SECI explicit/tacit knowledge generation cycle (Nonaka & Takeuchi, 1995). The acronym SECI refers to the four-phase cycle of knowledge creation:

- *Socialization*: tacit knowledge is distributed between people through the institution of mentoring, conversations, corporate culture, exchange of experience, etc. Key skill: Empathizing.
- *Externalization*: people begin developing metaphors and analogies to explain the rational meaning of implicitly informed behavior. Tacit knowledge becomes more explicit in the process of developing concepts. In other words, this process can be described as a codification of tacit knowledge. Key skill: Articulating.
- *Combination*: explicit ideas are combined with other explicit ideas in finding dependencies and eliminating redundancy; the culmination of the process is the creation of complete descriptions of processes and procedures for completing tasks. Speaking of scientific knowledge, we mean the formulation of scientific laws. Key skill: Connecting.
- *Internalization*: explicit ideas expand during development. Knowledge is again in the zone of socialization, and the spiral of knowledge cultivation is entering a new round. Key skill: Embodying.

Nonaka and Takeuchi classified knowledge as an asset based on the SECI model into four groups:

- *Routine Knowledge Assets*: tacit procedural knowledge routinized and contained in organizational culture, action, and everyday practice.
- *Systemic Knowledge Assets*: explicit, codified and systematized knowledge stored in documents, databases, manuals, specifications, and patents.
- *Conceptual Knowledge Assets*: explicit knowledge in a symbolic form, including product concepts, brand equity, design styles, symbols, and language. Note that scientific knowledge also belongs to this group.
- *Experiential Knowledge Assets*: tacit knowledge arising from collective experience, including the skills and judgments of individuals, prosocial feelings such as trust and care, as well as motivational resources that fuel engagement, passion, and tension.

The concept of Nonaka and Takeuchi is mainly focused on procedures, which causes difficulties in quantifying the result. In an attempt to bridge this gap, the theory of intellectual capital was developed.

There are a number of terms quite similar to knowledge management. E.g., the term “*cognitive management*” can be found in literature treated as “*the systematic management of processes by which knowledge is identified, accumulated, distributed and applied in an organization to improve its performance*” (Abdikeyev, 2014, our translation from Russian—D. K., I. K.). Based on this definition, we can conclude that the terms “cognitive management” and “knowledge management” are synonymous.

Intellectual Capital (IC)

The concept of intellectual capital was originally used in corporate strategies and had the same theoretical prerequisites as knowledge management, so it is often very difficult to draw a clear distinction between these two theoretical concepts. Brooking (1996) defined intellectual capital as a combination of intangible assets that allow companies to create sustainable competitive advantages. Stewart (1997) defines intellectual capital as “knowledge, information, intellectual property, experience that can be used to create wealth” (Stewart, 1997, p. X). Dumay (2016) replaces “wealth” with “value” for two reasons: (a) the term “value” is used much more often in theoretical studies of intellectual capital and the practice of strategic management than “wealth”; (b) the inputs and outputs of the process of creating intellectual capital cannot always be measured in money. Thus, the question about what constitutes the intangible assets that make up the intellectual capital of an organization is still open for debate.

Traditionally, three components of intellectual capital are distinguished: human capital, structural capital and customer capital (Bontis, 1998; Miller et al., 1999). The first two components are internal in relation to the organization; the third one is external. In relation to the latter, the term “relational capital” (Khavand Kar & Khavandkar, 2013) is often used, which covers all external relations of the company, including market relations, relations of cooperation, power and management.

This approach seems to be preferable, as the company in the process of creating value contacts not only customers, but also suppliers, authorities, and public organizations (for example, in Russian business practice, relations with government structures make up an important part of intangible assets; sometimes they even are the key asset of a company).

The concept of *human capital* goes back to Adam Smith as “*acquired and useful abilities of all the inhabitants or members of the society. The acquisition of such talents, by the maintenance of the acquirer during his education, study, or apprenticeship, always costs a real expense, which is a capital fixed and realized, as it were, in his person*” (Smith, 1776/1874, p. 122). One of the first to use the term “human capital” was Nicholson (1891). Later it was adopted by various authors, but until the end of the 1950s, it did not become a part of the lingua franca of economists. This term was introduced into wide use by Mincer (1958). Schultz (1961) considered human capital as something akin to property, which fundamentally distinguishes this concept from the classical interpretation of labor in economic theory. The publication of the book by Becker (1993) marked the finalization of human capital as an independent research field⁴. The main component of human capital is the knowledge and skills acquired in the process of education, training, and work. However, in recent years, health has been increasingly referred to as a component of human capital (Goldin, 2016), although this indicator is often used in the analysis of macro systems⁵.

Structural and *relational capital* are sometimes referred to as *social capital*, which, in its turn, forms intellectual capital together with human capital. Thus, the typology becomes multilevel. J. Nahapiet and S. Ghoshal (1998) refer to social capital as cognitive capital, which means general cognitive codes (symbols), language and meanings (narratives). This definition is very close to Frolov’s classification of institutions (Frolov, 2016):

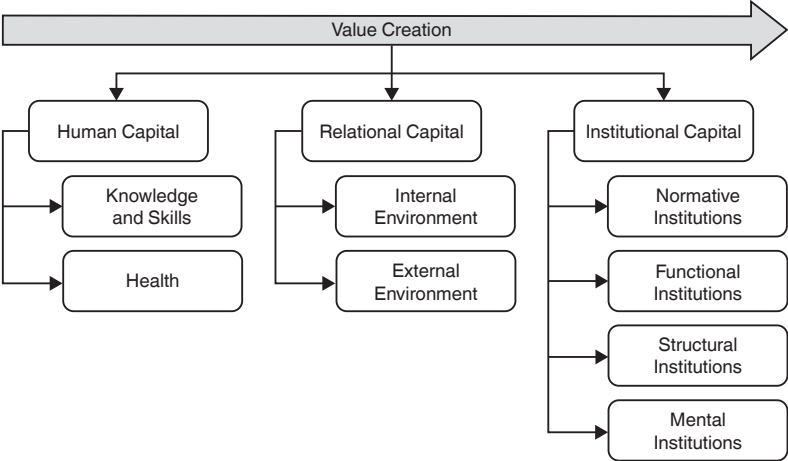
- regulatory—norms, rules, customs, standards, conventions, contracts, etc. (North, 1990);
- functional—status functions and routines (Nelson, 1994; Searle, 1995);
- structural—organizational forms and models of transactions (Scott, 1995);
- mental—collective representations, beliefs, stereotypes, values, cognitive patterns, etc. (Denzau & North, 1994).

Thus, the term “*institutional capital*” seems to be more applicable in this case, because it more accurately describes the essence of the phenomenon (Fig. 1). It is important to note that institutional capital comprises those institutions that directly participate in or contribute to the value creation process.

⁴ However, Becker, by his own admission, was forced to use a long subtitle to defend himself from the attacks of critics.

⁵ On the other hand, firms also take care of their employees’ health, usually by paying for health insurance and sports. It recognizes the importance of employee health indicators in the value creation process.

Figure 1
The Structure of Intellectual Capital



Regarding the process of creating intellectual capital, researchers most often identify combination and exchange (Nahapiet & Ghoshal, 1998). The concept “combination” goes back to Schumpeter: *“To produce means to combine materials and forces within our reach”* (Schumpeter, 1934, p. 65). This concept is also found in the cycle of generating explicit/tacit knowledge of Nonaka and Takeuchi (1995) and in studies of organizational learning (Boisot, 2013; Cohen & Levinthal, 1990; Kogut & Zander, 1992). Combination along with codification is one of the ways of producing new knowledge.

Knowledge exchange can exist both in the external and internal environment of an organization. The processes of internal knowledge sharing are most consistent with the institution of teamwork, which is a form of social interaction based on the unity of goals, objectives, and methods of work performed and built into the organizational context (Kozlowski & Bell, 2003). The most important determinants of a successful team are complementarity of skills (Davis, 2009), mutual assistance (Khatri et al., 2009), and trust between participants (Chiregi & Navimipour, 2016). The exchange of knowledge in the external environment refers to various forms of networking. As an example, we can cite “hybrids” in the terminology of Williamson (1991), who made a methodological transition from the “firm-market” dichotomy to the “market-hybrid-hierarchy” coordinate system.

Recently, researchers have increasingly used the theoretical and methodological apparatus of intellectual capital in the process of analyzing meso- and macro-systems (Bounfour & Edvinsson, 2005). In this case, the process of creating intellectual capital is supplemented by at least two phases—distribution and utilization. As mentioned above, exchange is a closed process in which two or more partners participate. In contrast, distribution is an open process of disseminating knowledge within a certain economic space. Distribution creates positive externalities; therefore, its role for economic growth

is even greater than in the case of exchange. In particular, Marshall (2013) was among the first to identify the role of externalities in economic development; later, Arrow (1962) and Romer (1986) further developed and supplemented the concept; it was finalized by Glaeser et al. (1992). This type of externalities, known in science as MAR (Marshall–Arrow–Romer), is based on the flow of knowledge (knowledge-spillovers). A prerequisite for their occurrence is specialization, as externalities are endogenous to the industry. The concept of J. Jacobs, unlike MAR, implies a diversified economy (Jacobs, 1969, 1984). The flow of knowledge in its interpretation is an exogenous factor in relation to a particular industry, but endogenous in relation to the territory. M. E. Porter subscribed to the same view (Porter, 1990).

The utilization of knowledge in a given territory plays an equally important role in the process of creating intellectual capital. Knowledge can be consumed as part of a product or service of both final and intermediate consumption. In the latter case, a company or another department within the same organization may act as a customer. In the situation of intermediate consumption, knowledge is often transferred in the form of Intellectual Property Objects (IPOs). Thus, the key indicators for the analysis of the intellectual capital of a country, city or region could be easily identified—these are, first of all, indicators of the creation and use of intellectual property objects, the knowledge-intensiveness of goods and services produced, as well as indicators of the health of the population included in the workforce.

It should also be noted that a country (region, city) is not an economic agent, unlike a company, therefore the main task of the government is to create conditions for the accumulation of intellectual capital within a given territory. Accordingly, with reference to the meso- and macrolevels, our definition of intellectual capital of a region (country) is as follows:

The intellectual capital of a region (city, country) is a set of assets, factors, and conditions that determine the production (codification, combination), exchange, distribution and utilization of knowledge in the process of public production in a given territory.

Research and practice in the field of intellectual capital is the subject of a wide range of organizational theories and methodologies, but the theoretical understanding of this matter is still quite limited (Dumay, 2012). Theoretical and methodological pluralism causes a lack of unified approach to the assessment of intellectual capital⁶. This theoretical inconsistency is an obstacle to understanding intellectual capital, possibly explaining the limited use of intellectual capital management and accounting (measurement) methods (Rooney & Dumay, 2016). Thus, most schools, within the framework of knowledge-based management concepts, focus on the description of procedures, but have poor measuring instruments, and most importantly, do not provide a comprehensive theoretical understanding of the role of knowledge in the process of economic growth, which often interferes with their practical application.

⁶ For example, the lack of a unified approach to accounting for intangible assets is a rather serious problem, considered in accounting studies.

Knowledge-Based Economic Concepts

Learning Economy

The distinction between explicit and tacit knowledge has been used in a number of works on the *learning economy* (David & Foray, 1995; Foray & Lundvall, 1996; Lundvall & Borrás, 1997; Lundvall & Johnson, 1994). The learning economy is an economic system in which the ability to learn is critical to the success of people, firms, regional and national economies. Learning is understood not simply as access to information but as acquisition of certain knowledge and skills (Lundvall & Borrás, 1997). Learning as a process is present in both knowledge-based and traditional sectors of economy. The development of competencies in low-tech industries may be more significant for economic growth than in a small number of high-tech enterprises (Maskell, 1996, 1998).

The learning economy is one of the theoretical branches of knowledge-based economy; however, in economics and economic policy, the term “knowledge economy” is more rooted than “learning economy” (European Council, 2000). Nevertheless, the learning economy played an important role in the transition from managerial concepts of the micro-level to the analysis of knowledge generation processes and their impact on economic growth at the macro-level. First of all, this concept has been widely used in regional studies (Maskell & Malmberg, 1999; Morgan, 1997; Storper, 1995, 1997), particularly, in the theoretical concept of regional competitiveness. The discourse of competitiveness at the macroeconomic level goes back to Michael E. Porter. In his influential work, *The Competitive Advantage of Nations* (Porter, 1990), Porter applied his concept of strategic advantage to firms and industries to analyze the competitive position of nations. He argued that the new competitive advantage paradigm had replaced the obsolete Ricardian theory of comparative advantage. Porter’s position was severely criticized, primarily by Paul Krugman (Krugman, 1994, 1996). Nevertheless, the concept of Porter, despite some internal inconsistency and obvious incompleteness, was recognized both among the “new regionalists” (Huggins, 2000, 2003; Malecki, 2002; Maskell & Malmberg, 1999), and political discourse (European Commission, 1999, 2004; DTI, 2003).

One of the most authoritative works on the new paradigm of regional development was published by Morgan (1997). It formulates the following basic principles of a new approach to the development of regions:

- The network paradigm overcomes the traditional state-market antinomy thanks to developed intermediary institutions, such as regional development agencies.
- The convergence of economic geography and innovation studies creates a potentially important new research area that focuses on the *interactive model of innovation*, as well as the role of *institutions* and *social agreements* in economic development.

The network model of innovation and development of the social capital of territories were put into practice in the 21st century, but mostly within the framework of the knowledge economy.

Knowledge Economy

The knowledge economy can be generally defined as an economic system where knowledge is a key factor (or resource) of production and economic growth (Kochetkov & Vlasov, 2016). The term “knowledge economy” was coined by Machlup (1962) in relation to one of the economic sectors and this term immediately found wide application in the corporate sector. Drucker (1970) noted the crucial role of knowledge in the process of creating added value. In the late 20th century, knowledge began to be perceived as a key factor in economic growth. Thurow (1999) provided a set of applied recommendations for achieving a high level of social welfare through the knowledge economy.

It was important to comprehend theoretically the role of knowledge generation in economic growth, to find their place in economic models. The knowledge economy is based to a large extent on endogenous models of economic growth. Romer (1990) introduced into the production process the factor of accumulated knowledge that arises as a result of R&D at universities or research institutes. Stocks of knowledge that exist in the form of constructions, formulae or models are non-rival goods with positive externalities in consumption, since they are freely available. Romer assumes separate production functions for research products, intermediate and final consumption goods, illustrating the endogenous process of technological progress and its impact on economic growth. Workers in the research sector produce new ideas that they sell to firms, which, in their turn, apply these ideas for production of final goods. The productivity of workers in the final goods industries increases when they get the best tools for the job. Thus, economic growth is ultimately the result of the use of human resources in the research sector, such as universities and research institutes. The production function is similar to the Solow model:

$$Y = K^{1-\alpha} (AL_Y)^\alpha,$$

where Y is the level of output, A is the level of technology, L_Y is the volume of labor costs, K is capital, and α is the labor input coefficient of production. The level of technology A is now the result of the workers' efforts in the research sector. The total labor force (L) can be used either in the knowledge sector L_A , or in the final goods sector L_Y :

$$L = L_A + L_Y.$$

Technological progress in endogenous economic growth models equals an increase in research labor:

$$\frac{\dot{A}}{A} = \delta L_A.$$

This definition implies that the increase in the overall productivity of factors of production will be proportional to the number of labor units related to research and development (R&D). With a constant share of labor involved in R&D, technological progress will be proportional to the labor force—the result found in the Romer/Grossman-Helpman/Aghion-Howitt models and many others. Accordingly, higher population growth rates are beneficial, not harmful to economic growth because the economy can attract more people to research and development.

An essential alternative specification of the R&D equation, which, at least on the surface, supports the key results of the Romer/Grossman-Helpman/Aghion-Howitt models without imposing economies of scale, suggests that the increase in overall factor productivity depends on the proportion of research work, not its quantity:

$$\frac{\dot{A}}{A} = \delta \frac{L_A}{L} = \delta s.$$

Eliminating economies of scale is an extremely attractive idea, but nonetheless, it contradicts the foundations of the Romer/Grossman-Helpman/Aghion-Howitt models. The specification without economies of scale is counterfactual, according to which an economy with one unit of labor can produce as many innovations (or at least can generate equivalent growth in the total productivity of factors of production) as an economy with one million units of labor. Besides, both specifications of the model did not find empirical evidence. Jones (1995) showed the possibility of using the average research productivity parameter (the so-called decentralized model) in the model:

$$\bar{\delta} = \delta A^\varphi L_A^\lambda,$$

where $\bar{\delta}$ is the average productivity of research labor, A is the stock of knowledge or technology in the economy, φ measures externalities during the R&D process, λ reflects the possibility that duplication and coincidence of studies at a certain point reduce the total number of innovations produced by L_A units. Accordingly, the growth rate of knowledge is equal to:

$$\frac{\dot{A}}{A} = \frac{\delta L_A^\lambda}{A^{1-\varphi}}.$$

By differentiating this equation, one can find that the technological progress rate g_A is determined by the population growth rate and externalities:

$$g_A = \frac{\delta n}{1-\varphi},$$

where n is the growth rate of labor.

The knowledge economy is an essential part of political discourse, e.g., it initially formed the basis of the regional policy of European integration (European Council, 2000). The decisions of the Lisbon European Council are often regarded as a political failure now because these decisions were not implemented properly and did not produce expected results. Nevertheless, it was these decisions that led to the development of such projects as the European Research Area (ERA) and smart specialization.

The World Bank is evaluating the level of development of the knowledge economy at the global level. Its methodology includes 147 indicators for 146 countries in the following areas: economic indicators, institutional regime, power, innovation, education, gender indicators, and information and communication technology (ICT) (Chen & Dahlman, 2005). Based on these methods, the KAM Knowledge Index (KI) and the Knowledge Economy Index (KEI) were created (World Bank Institute, 2012).

Economics of Scientific Knowledge

The economics of scientific knowledge (ESK) is one of the youngest areas in the heterogeneous field of “Science of Science”. The ESK relies on concepts and methods of economic analysis to study the epistemic nature and value of scientific knowledge (Zamora Bonilla, 2012). The expression “economics of scientific knowledge” was first popularized by W. Hands in a series of works from the 1990s (Hands, 1994a, 1994b). The term itself arose by analogy with the sociology of scientific knowledge (SSK).

The theoretical framework of the economics of scientific knowledge consists of two major theoretical paradigms—optimization and exchange. The former is based on the premise that the search for the best research methodology is the rational maximization of the utility function by the individual (scientist). C. S. Peirce was one of the first scholars to discuss this topic in 1879, less than ten years after the emergence of marginal analysis in economic theory (Kloesel, 1989). The book remained almost unnoticed but was re-discovered almost 100 years later by Rescher (Rescher, 1976). In his later works, Rescher consistently developed Pierce’s ideas (Rescher, 1978, 1989). Another author who tried to apply the cost-benefit rationality to the problems of the philosophy of science was J. Radnitzky (Radnitzky, 1986, 1987).

Another approach to optimization is an attempt to define a specific (“cognitive” or “epistemological”) utility function that should be maximized by rational scientific research. It is a strategy of making decision on the adoption of certain assumptions or hypotheses. Therefore, it is assumed that scientists must solve a scientific problem instead of looking for an alternative solution if and only if the *expected utility* (*EU*) that they receive from the first decision is higher than the expected utility that they will receive from any other solution to this problem. The expected utility of accepting hypothesis *h*, taking into account the evidence *e*, is defined as:

$$U(h,e) = \sum_{s \in X} u(h,s)p(s,e),$$

where *s* are the possible states of the surrounding world; *u(h,s)* is the epistemic utility of accepting *h* if the true state of the world is *s*; and *p(s,e)* is the probability that *s* is a true state, taking into account the evidence *e*. Naturally, the fundamental problem of this approach is the very definition of a utility function (or what is a utility in this case) (Zamora Bonilla, 2012). Levi (1967) and Hilpinen (1968) add the risk-taking parameter to the expected cognitive utility:

$$EU(h,e) = p(h,e) - qp(h,e),$$

where parameter *q* is a measure of the scientist’s attitude to risk: the lower *q* in the researcher’s epistemological utility function, the greater is the tendency to avoid risk.

Numerous economic agents are interconnected, which generates multiple social phenomena that are also studied by economic science. From this theoretical premise, a paradigm of exchange in the ESK was developed. The metaphor of the

scientific market was put forward by Coase (1988), who argued that he did not see the difference between the market for goods and the market for ideas. This approximation allows us to use market analysis methods for epistemological purposes. It should be noted that the theory of market relations in science studies is the subject of heated debate. A number of researchers claim that the more science becomes a market, the less it benefits ordinary citizens (Fuller, 2000).

The ESK is a young⁷ and promising scientific field. However, it stands closer to epistemology than to economics. Despite the use of economic research methods, scientific knowledge, as a rule, is considered in isolation from the actual economic processes.

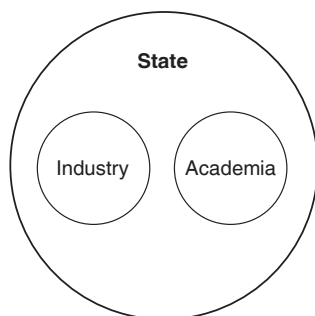
Helix Models

The helix models describe the cyclic process of the development of economic and social systems. The *Triple Helix* concept was introduced at the turn of the millennium (Etzkowitz & Leydesdorff, 2000) and influenced regional development projects in the 21st century. Its structural components were studied by Henry Etzkowitz from the University of Entrepreneurship (Etzkowitz, 1983, 1998), and by Loet Leydesdorff and Peter Van den Besselaar in the field of evolutionary dynamics of science, technology and innovation (Leydesdorff & Van den Besselaar, 1994, 1998).

The Triple Helix implies the interaction of the university, business and government in creating innovation. An important role is played not only by the participants themselves, but also by the type of relationship between them. For example, in the USSR and other countries of the socialist camp, there was a closed model, where the state played the role of supreme arbiter (Fig. 2) in relations between universities and industry—Mode 1 (Etzkowitz & Leydesdorff, 2000). The model is characterized by isolation from the outside world, and the absence of a market mechanism determines the low efficiency of the innovation process. Unfortunately, this model of “bureaucratic innovation” not only still exists in Russia but is also actively stimulated by the state through direct financing mechanisms, tax incentives, and companies with state participation.

Figure 2

An Etatistic Model of University–Industry–Government Relations



Source: Etzkowitz and Leydesdorff, 2000.

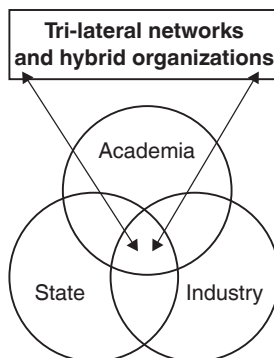
⁷ Excluding the work of C.S. Pierce, but it was invisible to the scientific community for a long time.

Mode 2 of the Triple Helix implies the independence of its participants from each other. Goods and services are acquired from each other on a contract basis for reasons of profit. Thus, mode 2 goes back to the classics of economic theory, the “invisible hand” of Adam Smith (Smith, 1776/1874). Nevertheless, as we know from the further development of economic science, classical political economists did not take into account market failures. Therefore, this theoretical model almost never works well in practice (just as there is no market economy in its purest form).

Mode 3 of the Triple Helix implies the overlapping of institutional spheres (Fig. 3). It is in the overlay areas that redundancy is generated. Generation of redundancy is on the top of information flows (Leydesdorff, 2018; Leydesdorff et al., 2017). The term “*Triple Helix*” is usually associated with this model.

Figure 3

The Triple Helix Model of University–Industry–Government Relations



Source: Etzkowitz & Leydesdorff, 2000.

For this model to function, an “*endless transition*” is extremely important. It is nothing more than an endless process of creative destruction according to Schumpeter. This process stimulates a constant increase in the role of knowledge as a resource in production and distribution (Etzkowitz & Leydesdorff, 2000).

In one of his later works, Etzkowitz also emphasized the exceptional role of the university and state in the period of the change of technological paradigms (Etzkowitz & Klofsten, 2005). The university assumes the roles of creating development forms unusual for common practice (in addition to traditional training and fundamental research). Business is increasingly engaged in self-training and research. The government (in this case, regional authorities) provides support for initiatives through regulatory mechanisms, fiscal policy instruments, and direct funding.

Elias Carayannis and David Campbell expanded the model of the Triple Helix by proposing the *Quadruple Helix*. In addition to the university, business, and government, the fourth helix includes civil society institutions. The authors themselves defined the fourth helix as “*public*” (based on media and culture) and “*civil society*” (Carayannis & Campbell, 2009). Of course, the public is a core element in the knowledge-based society as the main consumer of knowledge.

Knowledge flows permeate all areas of public life. An equally important component is the “knowledge culture”, which includes values and lifestyle, multiculturalism and creativity, the media, universities, and multi-level innovation systems (local, regional, national and global) (Carayannis & Pirzadeh, 2014). Together, they form the “*Creative Knowledge Environment*” (CSE), i.e., a social environment conducive to the creation of new knowledge and innovation. This concept directly correlates with the institutional environment, in particular, with the degree of economic freedom in the country and the type of social contract.

If the Quadruple Helix contextualizes the Triple Helix model in social environments, then the *Quintuple Helix* introduces the natural context of innovation systems. The Quintuple Helix, in full accordance with the interdisciplinary nature of modern scientific knowledge, aims to create and develop conditions for the sustainable development of society, the economy and democracy in the mid- and long term. Carayannis & Campbell introduced the concept of “*social ecology*”, which represented a transdisciplinary field of research for comprehensive solutions to global problems (Carayannis & Campbell, 2010). Thus, while the first three helixes represent the institutional spheres of the innovative development of society, the fourth and fifth helixes contextualize their interaction in social and natural environments.

Discussion and Conclusions

The socio-economic approaches to knowledge as an economic category are summarized in Table 1. The subject-object scheme is the basis of classification.

Table 1
Knowledge-based Socio-Economic Concepts

Theoretical concept/ framework	Key thesis	Subject	Object	Note
1. Theory of economic growth:				
1) Neoclassical Solow Model	The level of technology is a given (exogenous) factor	Economic agents; macro level entities (city, region, country)	Technology level within the production function	The most universal theoretical models; the theoretical basis of the knowledge economy and neoclassical theory as a whole
2) Endogenous Growth Model	The stock of knowledge accumulated in the economic system overcomes the law of diminishing returns		Stock and flow of knowledge within the production function	
2. Knowledge Management	Strategic management of knowledge generation processes creates sustainable competitive advantages	Economic agents	Knowledge generation processes within the firm	One of the most popular and widely used models in the corporate sector; however, the weak point is the lack of a single quantitative methodology for analysis and control

Table 1 Continued

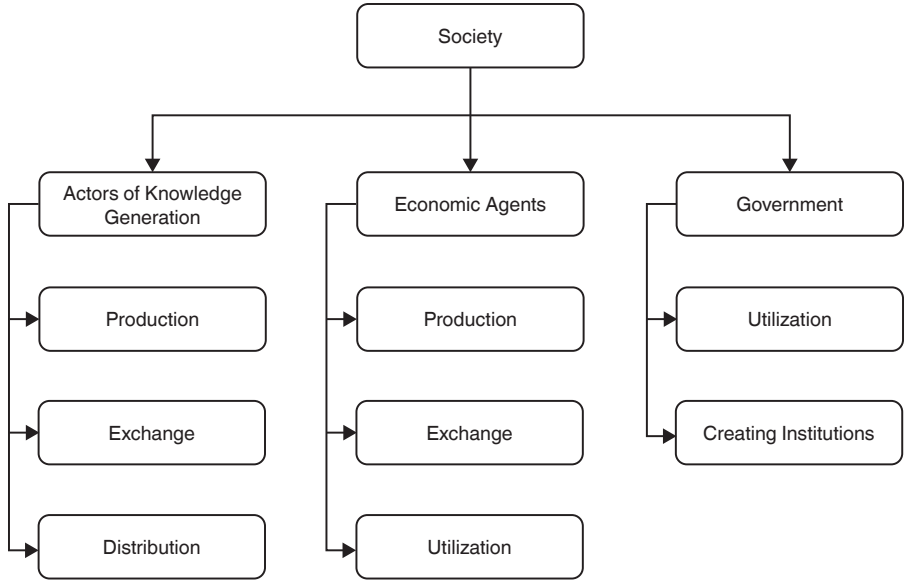
Theoretical concept/ framework	Key thesis	Subject	Object	Note
3. Intellectual Capital	The accumulation of intangible assets creates sustainable competitive advantages	Economic agents; since the 90s. XX century – macro level entities (city, region, country)	Intangible assets (human capital, relational capital, institutional capital)	A more transparent quantitative methodology than in the previous case, however, key indicators remain the subject of discussion
4. Learning Economy	Learning ability is a critical factor in economic success	Economic agents; regions	Learning processes within economic systems	This theoretical concept existed for a rather short period of time, losing theoretical competition to the knowledge economy
5. Knowledge Economy	Knowledge is a key growth factor in the new economy	Economic agents; since the 90s. XX century – macro level entities (city, region, country)	Knowledge generation processes within economic systems	It is one of the most recognized and widely used socio-economic concepts at the present stage of development; based on the theoretical basis of neoclassical models of economic growth; popular in political discourse
6. Economics of Scientific Knowledge	The researchers' decisions in the process of choosing a methodology are similar to maximizing behavior of an economic agent; it opens new possibilities for applying the methods of economic analysis in epistemology	Researcher; research team	Optimization of the function of cognitive (epistemic) utility	A young and extremely promising field of research, which is closer to epistemology than to economic theory
7. Helix models				
1) Triple Helix	Overlapping of institutional spheres generates redundancy	University-business-government	Generation of redundancy and synergetic effect	Influenced most regional development projects in the 21 st century
2) Quadruple Helix	The fourth helix includes civil society institutions	+ public and civil society		Contextualizes the Triple Helix model in social environments
3) Quintuple Helix	Introduces the natural context of innovation systems	+ natural environment		Contextualizes the Triple Helix model in natural environment

Source: authors' own development

The variety of theoretical approaches is historically explainable, but at this stage we need integration. A theoretical understanding of the knowledge economy at the macro-level requires new approaches because the government is neither an actor in the generation of knowledge nor an economic agent. Nevertheless, the government creates conditions for effective generation of scientific knowledge. In our opinion, it is necessary to formulate a new theoretical field that synthesizes the approaches of the knowledge economy, knowledge management and intellectual capital at theoretical and practical levels. The goal of the new scientific field should be the formation of the *theoretical foundations of public administration, focused on improving the efficiency of knowledge generation processes as a factor in economic growth*. Let us call it the theory of *knowledge-based public administration*. This theory is based on two premises:

1. *Functional differentiation of entities in the process of knowledge generation.* The process of knowledge generation includes 4 phases: production (codification/combination), exchange, distribution, and utilization (Fig. 4). The state, not being a direct participant in these processes, performs the essential function of creating the conditions for efficient generation of knowledge within the socio-economic system. These conditions are implemented in the form of institutions created by the government. At the same time, both government and actors in knowledge generation (universities, research institutes) are representatives of society; in other words, they are connected with society by principal-agent relations. In turn, economic agents are part of society, i.e., we can speak about the relationship between the whole and the part.

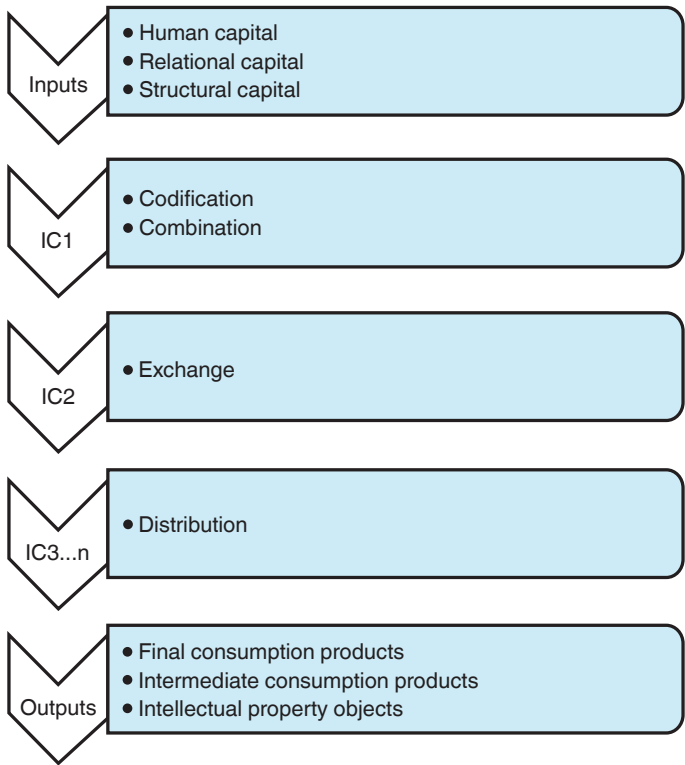
Figure 4
Functional Diagram of the Entities in the Process of Knowledge Generation



For approximation purposes, we attribute knowledge generation actors to the public sector (universities, research institutes); corporate departments (R&D) are economic agents in this diagram. They both produce knowledge and make an exchange on a contract basis. Nevertheless, it is the public sector that disseminates knowledge through various distribution channels, creating positive externalities. The corporate sector, on the contrary, is interested in limiting the effect of externalities through the legal mechanism of intellectual property. Economic agents consume knowledge in the form of final or intermediate consumption products, as well as intellectual property objects. The government is also a consumer of knowledge, but its primary function is to design and implement optimal institutions. It is important to note that the generation of knowledge is a cyclic process, which is reflected in the SECI explicit/tacit knowledge generation cycle.

2. The process of knowledge generation is based on the continuous transformation of intellectual capital. In the description, we followed the process approach: the inputs of the process are human, relational and institutional capital; outputs are products of final/intermediate consumption and objects of intellectual property (Fig. 5). The outputs of one process can become the inputs of another.

Figure 5
The Process of Transformation of Intellectual Capital



If we look at the theory of the knowledge economy through the prism of K. Marx's theory of social reproduction (Marx, 1885/1992), it becomes obvious that part of the country's economy will always be involved in the process of reproduction of intellectual capital⁸. We can state the emergence of a new socio-economic formation—knowledge capitalism. We understand knowledge capitalism as an economic system based on expanded reproduction of intellectual capital and characterized by high mobility of resources and factors of production. Accordingly, one of the important consequences of the transition to knowledge capitalism will be a further decrease in the role of national borders in the global economy, i.e. the process of its de-territorialization. Knowledge capitalism along with the knowledge economy is a template for national policies (primarily, Western countries and “developed” Asia) starting with the reports of the OECD (1996) and the World Bank (1998), which consider education as an underestimated form of knowledge capital that will determine not only the future of the economy but also society as a whole (Guy Peters, 2012).

Intellectual capital has a number of significant differences from physical capital that shape the new formation:

- The accumulated intellectual capital (stock) directly affects the flow of new knowledge. This ability of the system to self-development underlies theories of endogenous economic growth. Knowledge creates the effect of externalities—for example, the knowledge gained in one scientific field creates a cumulative wave in other scientific areas; the same applies to industries. At the same time, the costs of replicating knowledge in comparison with the costs of their creation are negligible.
- The period of renewal of intellectual capital is much shorter than that of physical capital. It can be associated with Moore's law, according to which the chip power doubles every two years without increasing the cost. Accordingly, the business cycle in modern conditions is becoming much shorter.
- The intangible nature of knowledge does not allow us to talk about the complete alienation of the results of scientific work. The process of alienation is affected by such characteristic of scientific work as authorship. Therefore, we can assume that an increase in the share of intellectual capital in products will contribute to a more equitable distribution of income in the future.
- An essential component of intellectual capital is human capital, which has high mobility. Therefore, the task of both firms and the government is not only to create/attract human capital but also to retain it.

It is important to note that here we get a new “paradox of knowledge”. Knowledge is created both through public funds and through private investment. It is impossible to split financial flows within one socio-economic system. Therefore, private business often uses the knowledge created at the expense of all taxpayers to create their own products, including intellectual property. On the other hand, very often inventions of

⁸ Even Adam Smith attributed knowledge and skills to constant capital.

private companies change the world for the better (remember mobile phones). From the global perspective, the private ownership of knowledge, which is supported by the patent law institution, deepens inequalities between countries. This huge topic is beyond the scope of this study, but it is an extremely interesting and promising direction for future work.

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