Institutions of Scientific Knowledge Generation in Regional Economic Systems

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Abstract: The institution of the university comprises one of the most important actors within national, regional or metropolitan economic systems. Typically, metropolitan universities are seen in terms of components of the respective national economic system. However, the object of our research is the institution of the regional university, which is defined in terms of a regional economic actor. There are various models for analysing the impact of universities on the regional economies. Several studies have studied this phenomenon in terms of providing employment, increasing expenditures and exporting educational services to other regions. However, in emphasising the role of universities in regional economies within the knowledge economy, most contemporary researchers consider the university as a major producer of scientific knowledge. Different "helix" models and models of university engagement are constructed in the context of this position. In order to overcome problems concerning terminological and methodological diversity, we propose to employ an institutional approach to the analysis of economic phenomena. Institutions are understood as comprising a set of formal and informal norms, as well as the mechanisms required to implement their conformance with these norms. The aim of our study is the development of a typology of institutions of scientific knowledge generation according to the different phases and stages of scientific production. In order to avoid an artificial gap in the subject-object relation, we analyse the problem on the basis of the methodological unity of actors, stakeholders and institutions, as well as their interactions with the environment (natural, political, social, economic and cultural). For the classification of institutions, several dimensions were referred to: the stages of knowledge generation (production, exchange, dissemination and consumption); management functions (planning, organisation, control and motivation). The model of circulation of explicit / tacit knowledge SECI developed by Nonaka and Takeuchi for the corporate sector is also thought to be relevant in this connection. On the basis of this model, we have identified the institutions of socialisation, externalisation, combination and internalisation of knowledge. The results of the study will be used in the further analysis of case studies of universities, both in Russia and elsewhere.

Keywords: Russia, knowledge generation, higher education, economic institutions, institutional configuration, classification, SECI, explicit knowledge, tacit knowledge

1. Introduction

Under the conditions of the post-industrial economy, the processes of knowledge generation, formation of intellectual capital and implementation of intellectual property objects in manufacturing acquire a special significance. Thus, the key role of the university as the main producer of knowledge results in it being seen as one of the main actors within the corresponding economic system. The university not only affects the environment, but it is also being influenced itself. In order to determine the mechanisms of mutual influence, it is necessary to isolate the mechanisms for scientific knowledge generation. From this perspective, it is extremely difficult to analyse the capital's higher education institutions: on the one hand, they exploit the resources of the whole country; on the other, they affect the national economic system as a whole. Therefore, we have chosen the object of our study regional universities, the relationship of which with the local economic systems is more obvious.

Higher education can contribute to the economy of the region in different ways including employment, increased consumer spending and revenues derived from outside the region at the expense of students and visitors to the university (Florax, 1992a, 1992b; Barklays Bank, 2002; Charles and Benneworth, 2002; Hill, 2004). However, the most important role of the university as a subject of the regional economic system is its generation of knowledge, which is the most important resource in the knowledge economy (Department of Trade and Industry, 1998; Batterbury and Hill, 2005). A currently recognised model of university's contribution in this respect was introduced by H. Etzkowitz (Etzkowitz and Leydesdorff, 2000; Etzkowitz, 2002; Etzkowitz and Klofsten, 2005); this model, known as "triple helix", is based on the partnership comprised of university-

business-government. Subsequently, additional elements were appended to the model: civil society and public institutions (Carayannis and Campbell, 2009) and environmental and ecological institutions (Carayannis and Campbell, 2010). S. Hill developed a model of university engagement in the regional socio-economic system (Hill, 2005) based on several dimensions including education, research, knowledge exchange, public relations, community-based research, and flexible learning.

From the point of view of our research, it is important to note that researchers distinguish between analytical knowledge (scientific base) and synthetic knowledge (engineering base) (Laestadius, 1998). Science is intended to explain the global issues of the existence of Man and Universe, to find universal laws or "truths" (Frezza, Nordquest and Moodey, 2013). Lonergan (1997) additionally singles out mathematical and empirical heuristic structures. Engineering/technology is aimed at meeting the actual needs of man and society (Koen, 2003), i.e. creating artefacts. Analytical knowledge often takes an explicit or codified form (articles, reports, patents); synthetic knowledge exists in an implicit form resulting in new products and technological processes (Popov and Vlasov, 2014). Codified knowledge has a standardized compact form (David and Foray, 1995) and can be shipped over long distances (Foray and Lundvall, 1996); implicit knowledge is sensitive to localization being transmitted personally. This classification of knowledge came from the works of M. Polanyi, who highlighted the impossibility of separating the knowledge produced from the personality of the researcher (Polanyi, 1958). In this case, two types of knowledge (explicit and tacit) dynamically interact with each other, becoming the basis for the spiral process of expanding existing knowledge. Nonaka and Takeuchi in the mid-90's created a model of explicit and tacit knowledge interaction in the process of knowledge generation in the workplace, known as SEKI (Nonaka and Takeuchi, 1995). Individual and organizational knowledge is maximized by transforming tacit knowledge into explicit, which can be later interpreted, presented, codified, stored, retrieved and disseminated (Nunes et al., 2005).

However, a unified methodological approach to analysing the impact of regional higher education systems on economic growth has not yet been developed. The variety of the terminology and indicators used in studies hampers the research process, taking it away from what, in our opinion, is the key problem: namely, an identification of the institutional mechanism of the impact of higher education on regional socio-economic systems. The aim of our work is to develop a unified theoretical and methodological platform on the basis of an institutional approach to the analysis of economic phenomena, with a subsequent classification of the impact institutions. The results of the work are important both for future theoretical and applied research, and for decision-making in the field of regional economic and educational policies.

2. Model of Institutional configuration

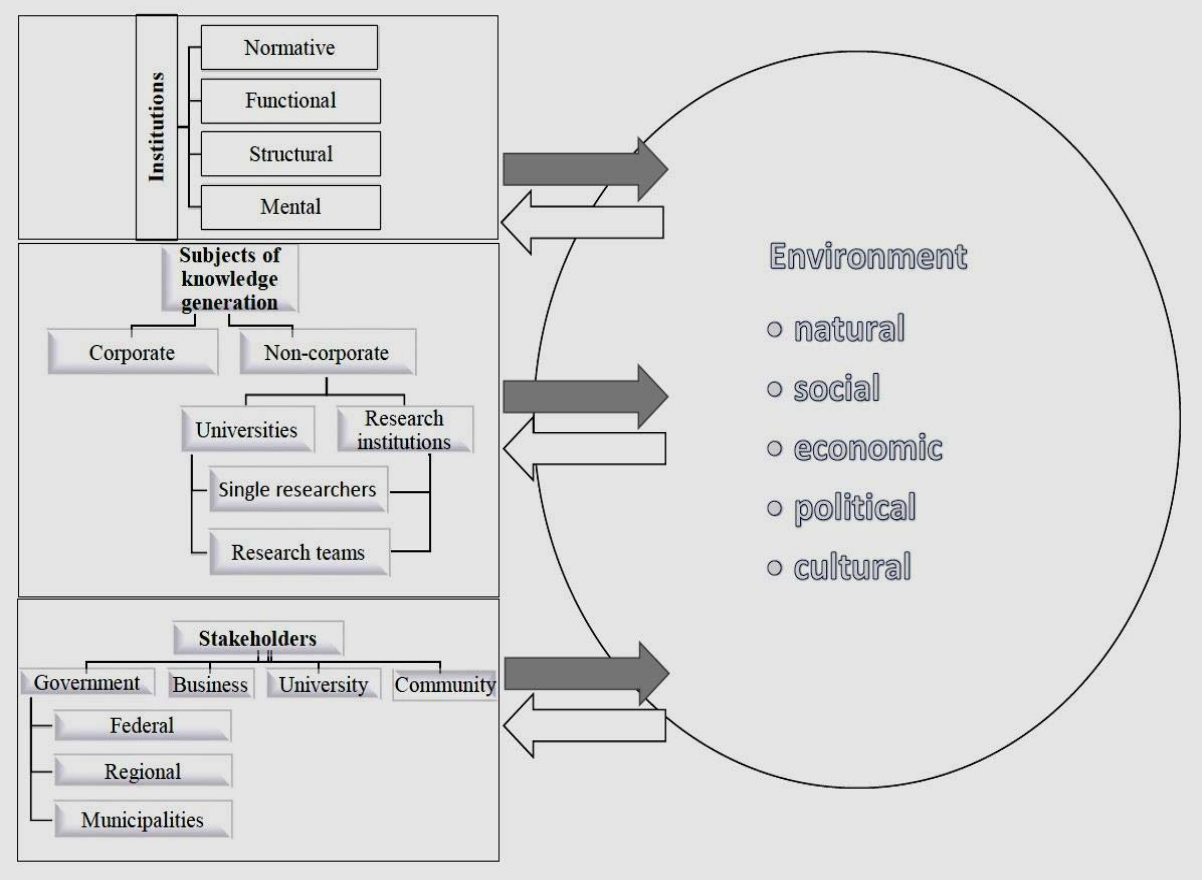
The theoretical and methodological basis of the study is the model of institutional configuration, by which we mean "models of interaction of institutions and their stakeholders in a specific economic space" (Frolov, 2016). This concept considers institutionalisation in terms of the unity of interaction of subjects, i.e. categorical and relative social groups, and factors – i.e. institutions. Such an approach overcomes the artificially created discontinuity of the subject-object relationship in traditional institutionalism. At the same time, Frolov's proposed model conflates the stakeholder with the subject of knowledge generation, which does not seem entirely justified. The subject of knowledge generation can be an individual scientist or a collective, i.e. a group of researchers united by a common goal (project). This may be a research team (permanent or temporary), a university, a research institution or a research and development unit in the corporate sector.

The stakeholder map includes universities, regional governments and municipal authorities, business, and public structures. In summary, the main stakeholder in the knowledge generation process is society as a whole. Universities (and sometimes corporate sector entities) can act both as actors and stakeholders. The problem of Russian practice is that the absolute majority of universities are subordinated to federal structures, thus comprising a "foreign body" in the regional configuration. This greatly complicates the transactions of interaction between the university, business and the region. As for the individual researcher, the alienability of the product of his labour (knowledge) is the subject of a discussion that goes beyond the scope of this study. Nevertheless, taking into account the economic direction of our work and the fact that the scientist in most cases has the status of employee, we will treat the scientist as an actor (not stakeholder) of knowledge generation within the framework of further analysis.

As a structural element of the analytical model, the environment also manifests itself a multidimensional phenomenon. As a minimum, we can distinguish between natural, social, economic, political and cultural-historical dimensions. Each of these dimensions influences both the actors and institutional system within the configuration. Thus, institutional configurations are spatially specific; in other words, individual for specific countries and regions.

We understand institutions in the sense assigned to them by D. North, i.e. as a combination of formal norms, informal constraints and coercion mechanisms (North, 1990). A similar definition of institutions is given by Hall and Taylor (1996), who defined institutions as formal and/or informal procedures, routines, norms and customs embedded in the organisational structure of the polity. The last two decades of the 20th century saw the emergence of historical institutionalism within the framework of the new institutionalism (Bulmer, 1994; March and Olsen, 1994, 1996; Hall and Taylor, 1996; Pierson, 1996; Bulmer and Burch, 2001; Bulmer et al., 2001; Peters, 2001), in which the formation and evolution of institutions was examined in historical terms as a means of explaining how institutional environments affect differences in development.

From the functional point of view, any institution has an input, output and control parameters; in other words, we can represent the institution as the simplest dependence y = f (x). In turn, according to the type of subject-object interaction, institutions can be classified into 4 types (Frolov, 2016): normative – norms, rules, customs, standards, conventions, contracts, etc. (North, 1990); functional – status functions and routines (Nelson, 1994; Searle, 1995); structural – organisational forms and models of transactions (Scott, 1995); mental – collective representations, beliefs, stereotypes, values, cognitive schemes, etc. (Denzau and North, 1994). A graphic representation of the institutional configuration model is shown in Figure 1.



Source: authors' own development.

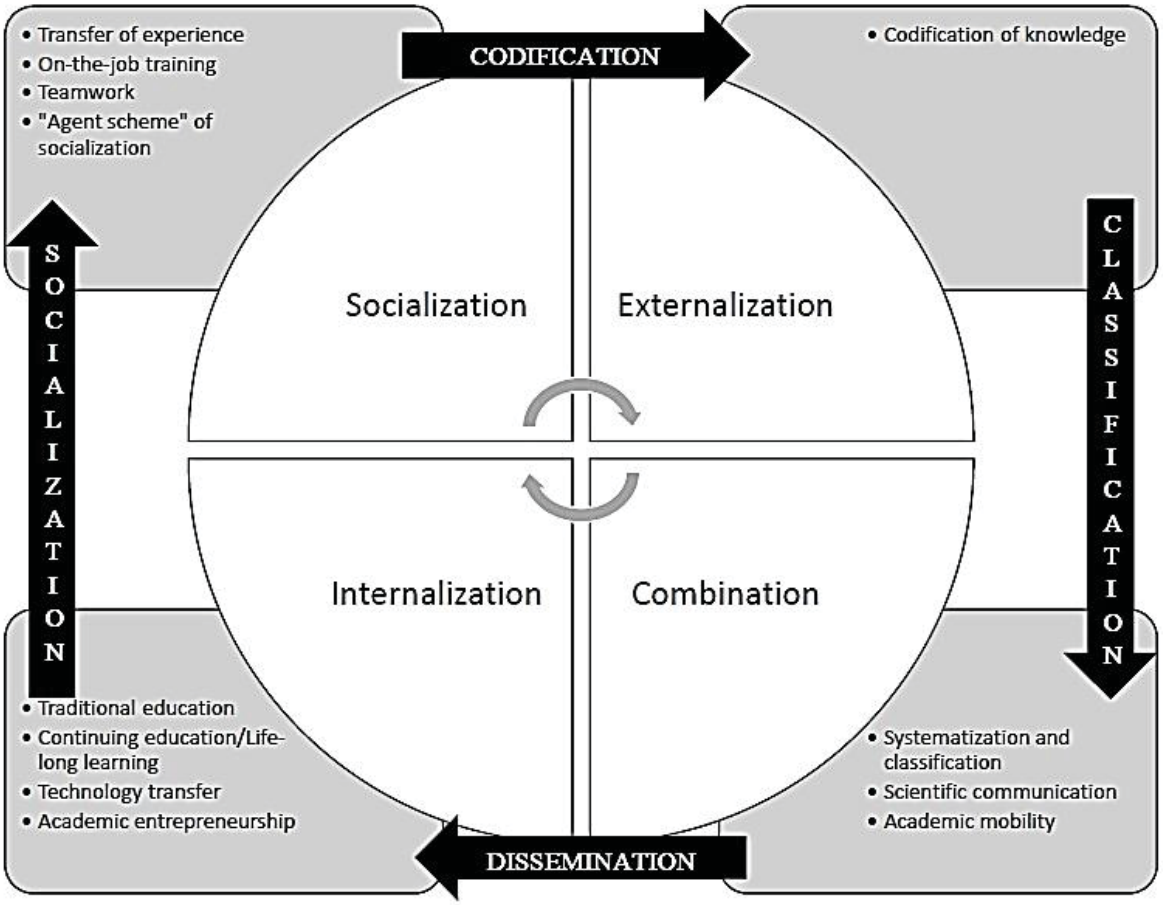
Figure 1: Institutional configuration model of scientific knowledge generation

Frolov emphasises that institutions are exogenous to the subject, but endogenous in relation to the system as a whole. In our opinion, this statement is valid only if the object of analysis is an individual (researcher). If we are talking about a collective actor, then there will be both exogenous and endogenous institutions. Considering the versatility of the notion of knowledge, the problem of classification arises. We propose to use the explicit/tacit

knowledge generation cycle (SECI model) to solve this problem. Here, we apply the corporate knowledge management model developed by Nonaka and Takeuchi (1995). The application of this model in the non-corporate sector seems highly promising because it fully reveals the mechanisms of mutual influence of universities and the environment.

3. Institutions of explicit/tacit knowledge generation

The explicit/tacit knowledge generation cycle is based on the widely adopted knowledge management SECI model (Nonaka and Takeuchi, 1995). The SECI acronym denotes a four-phase knowledge creation cycle. The model was developed for the analysis of knowledge generation at the micro level; however, it can be successfully used in theoretical constructions of the meso and macro levels, in our opinion. A graphical representation of the model is shown in Figure 2.

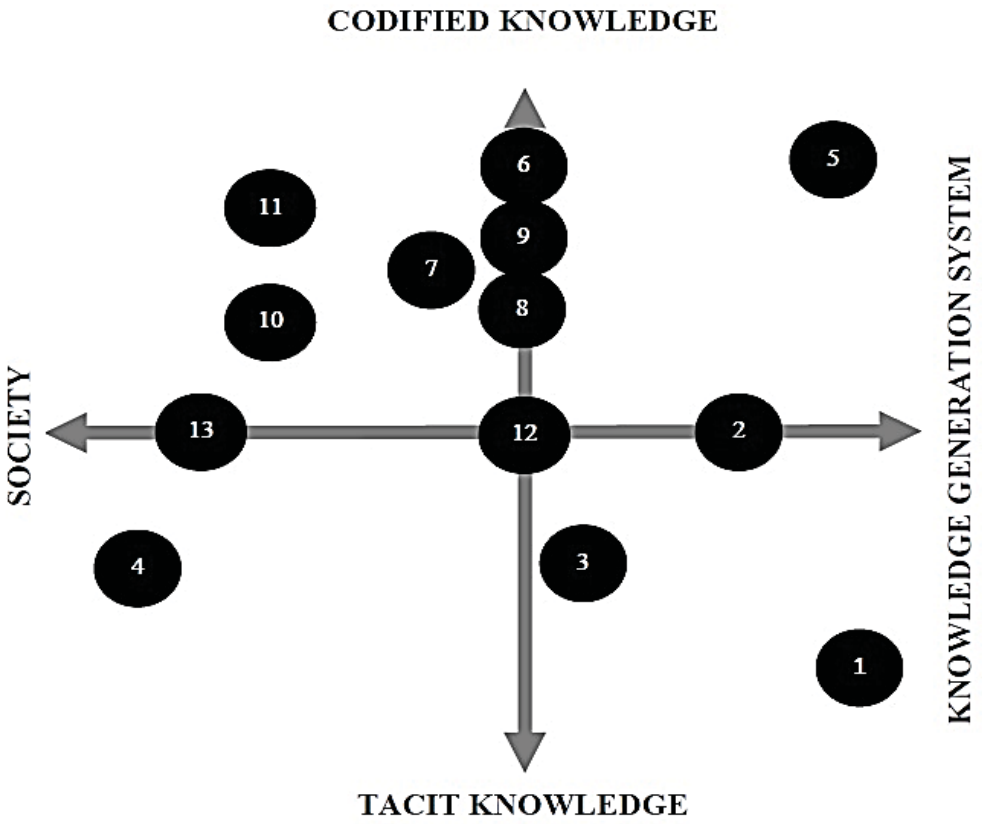


Source: authors' own development.

Figure 2: The explicit/tacit knowledge generation cycle

During the cycle, knowledge makes a transition twice from one state to another (from tacit to explicit and vice versa) as a result of processes of codification and dissemination. This transition can in some ways be compared with the phase transition in physics. Thus, these processes are exogenous both in relation to the society and to the system of scientific knowledge generation. In turn, the processes of classification and socialisation are endogenous in relation to the knowledge generation system and society, respectively. As a result of the complete cycle, the generation processes are restarted, but at a different level. Thus, the process of scientific knowledge generation can be characterised as spiralling.

For the purposes of the typology, we can single out institutions of scientific knowledge generation in terms of their proximity to the knowledge generation system/society, and also by the form of storage and transmission of knowledge (codified/tacit) (Figure 3). "Proximity" in this case means a subjectively perceived distance between objects, similar to the cognitive distance between actors in organizational behaviour.



Source: authors' own development.

Figure 3: Typology of institutions of scientific knowledge generation:

1 - Transfer of experience;
2 - On-the-job training;
3 - Teamwork;
4 - Socialization of scientific knowledge;
5 - Codification of knowledge;
6 - Systematization and classification;
7 - Scientific communications;
8 - Academic mobility;
9 - Traditional education;
10 - Continuing education;
11 - Electronic education (including online);
12 - Technology transfer;
13 - Academic entrepreneurship.

3.1 Socialisation

Socialisation is by its nature an interdisciplinary phenomenon, which complicates the unified definition of this term. In particular, we allocate humanistic concepts of socialisation (E. Fromm, A. Maslow, and A. Giddens), cognitive theory (J. Kelly), behaviourism (B.F. Skinner), phenomenology (M. Weber, G. Zimmel, C. Rogers), structural functionalism (A. Comte, G. Spencer, E. Durkheim, P. Sorokin, T. Parsons, R. Dahrendorf, Z. Sikevich), interactionism (C. Cooley), and many others.

From an organisational perspective, Nonaka and Takeuchi treat socialisation as a form of knowledge transfer having a tacit form (Nonaka and Takeuchi, 1995). It implies exchange of experience and creation of knowledge, as well as sharing of mental models and technical capabilities. The key to acquisition of tacit knowledge is practice. Without any joint experience, people have difficulties in projecting the process of thinking from

someone else's perspective. The value of knowledge increases during the process of its dissemination (Sawhney and Prandelli, 2000; Alavi and Leidner, 2001). Despite the fact that it is extremely difficult to extract the experience of one person and transfer it to another, conversely, the organisation loses knowledge gained from experience, training and teamwork (Prichard et al., 2000). Thus, we can articulate the following organisational institutions of socialisation:

- *Transfer of experience.* This institution functions through discussions, meetings and exchange of experience. The most important mechanism for the transfer of personal experience is the institution of mentoring, which is designed, on the one hand, to prepare a young specialist for the performance of his or her functional duties, and on the other hand – to introduce him or her to the organisational culture and ensure the adoption of corporate values. As applied to the academic environment, A. Johnson recommends finding a good mentor (not a job supervisor, but a person who does not have a direct interest in the work of a particular specialist or in the results of his research) (Johnson, 2011). Transfer of previous personal experience can be also attributed in this category of knowledge transfer mechanisms. For example, if a person is employed in a higher education institution with previous experience in business, he has already some skills in the field of project management, marketing, finance, which he can use in research or teaching.
- *On-the-job training.* This includes various forms of trainings and workshops. As a rule, such activities are held in small groups; this format provides close psychological contact, due to which there is an effective acquisition of knowledge in a tacit form.
- *Teamwork.* By "team" we mean teams that exist to perform relevant organisational tasks, having one or more common goals, interacting socially, demonstrating the interdependence of tasks that support and manage the boundaries of their activities and are built into the organisational context that establishes these boundaries, sets constraints for the team and affects the exchange with other units in a broader organisational context (Kozlowski and Bell, 2003). Teams usually consist of people with complementary skills and create synergy through coordinated efforts, which enables each member of the team to maximise their strengths and minimise their shortcomings (Davis, 2009). Khatri, Brown and Hicks (2009) argued that team members should learn how to help each other, help other team members realise their true potential, and create the environment that empowers everyone to go beyond his limitations. Thus, team members share their knowledge when they trust their partners (Chiregi and Navimipour, 2016), and when they feel dependent. The sense of dependence and trust is correlated with the frequency of communication, perceived value of the project and experience (Park and Lee, 2014). Besides, Yuan et al. (2009) highlighted that the project obligations also have a direct impact on the dissemination of explicit knowledge and mutual trust (Aghdam and Jafari Navimipour, 2016), but it does not directly affect the exchange of tacit knowledge. It should be also noted that Huang and Huang (2008) found that expected external rewards negatively affect the attitude of people to the knowledge exchange. The processes of dissemination of knowledge in the tacit form are much less subject to the influence of human resource management technologies than in the case of explicit knowledge (Chuang, Jackson and Jiang, 2013); so, here the main role is played by the function of leadership in the team.

Nevertheless, the phenomenon of socialisation takes place not only within the organisation, but also in a broader social context. Scientists, as individuals, are an integral part of society; they disseminate knowledge in the tacit form through personal communications as well as explicitly through publications and reports. P. Sorokin has written about "empirical vehicles of delivery", which are used in the social process of knowledge dissemination headed by agents of socialisation. In addition, he noted that thousands of produced texts and artefacts were not socialised, i.e. were not used by anyone other than the authors themselves (Sorokin, 1941).

3.2 Externalisation

Externalisation refers to process in which tacit knowledge becomes explicit and acquires the form of metaphors, analogies, concepts, hypotheses or models. When the links between phenomena are inappropriate, inconsistent or inadequate, such inconsistencies and missing information contribute to reflection, discussion and interaction between people. Externalisation is manifested in the process of creating concepts generated by a dialogue (including internal) or collective reflection. Sources in this case are unstructured data – facts, opinions, attitudes, i.e. data typically obtained during field research (interviews, surveys, questionnaires, etc.). Over time, sources evolve; e.g. in the recent decade, more attention has been paid to the analysis of social networks (Schreck and Keim, 2013; Anderson et al., 2015), especially in the field of marketing (Nicholls, 2012) and policy studies (Sobkowicz, Kaschesky and Bouchard, 2012; Ceron et al., 2013). The output of the process of externalisation and

its performance indicator is explicit (codified) knowledge in the form of publications in peer-reviewed scientific journals, monographs, intellectual property objects, reports, etc.

Here we should note that the main performance indicator for universities is exclusively publications. The quality of publications is estimated through citation rates; at the same time, citation has a fairly large time lag (2-5 years). Therefore, the journal indicators are used most often; particularly, the impact factor available on the Journal Citation Reports. In our opinion, this is not entirely justified, because this indicator shows the quality of the journal, but not of the published articles - even the most prestigious journals have a certain percentage of uncited papers. Thus, the existing system of indicators leads to significant disparities in the development of science.

3.3 Combination

Combination refers to the process of classification of concepts, through which a knowledge system is generated. Persons exchange and combine knowledge through various means of scientific communication. Reconfiguration of information, which is done through the classification, addition, combination and categorisation of explicit knowledge, can lead to new knowledge. The combination process has similar outputs to the externalisation process, but the main source in this case will be information resources (full-text, abstract, statistical resources, databases of scientific and technical information, etc.). The question of the impact of the use of databases on publication remains open and requires additional research. Possible indicators for evaluation here are the same as in 3.3.

An important tool for systematization and classification of concepts is scientific communication. Here we specifically talk about internal professional communications: researchers exchange ideas at conferences, symposiums, exhibitions, etc. Such exchanges, on the one hand, enable generation of new scientific knowledge based on the combination of the existing one, and on the other facilitate promotion of new ideas in the scientific community. With the development of information and communication technologies (ICT), virtual communication tools are increasingly used.

One of the most important institutions of scientific communication is academic mobility, which overcomes cultural social, and political barriers between scientists from different countries and regions as well as creating a global scientific space. Switzerland, where 57% of scientists are foreigners, is the country having the highest share of foreign researchers. In Canada, Australia, the United States, Sweden and the UK, between 30 and 50% of researchers are foreigners; in the Netherlands, Germany, Denmark, Belgium, and France – from 10 to 30%; in Brazil, Spain, Japan, Italy and India – less than 10%. Switzerland and India are among the countries having the highest share of researchers who move to work in other countries (Dessibourg, 2012). Unfortunately, there is also a downside to the process of globalisation for developing countries, which is expressed in a "brain drain". For example, Russia has lost 800,000 scientists during the period that began in 1991 (Shorich and Filatova, 2017), representing a serious threat to the country's development. However, the brain drain phenomenon exists not only internationally; within the country there is also a tendency to outflow of specialists from regions to the capital. Unfortunately, there is no precise data relating to this problem.

3.4 Internalisation

Internalisation involves the transfer of accumulated explicit knowledge to the external environment, where it is utilised and transformed back into a tacit form. Thus, the cycle of generation of explicit/tacit knowledge goes into a new circle. The main tool for knowledge internalisation is vocational education, which can be implemented both in the traditional form (traditionally higher education on campus) and in "flexible" forms (foundation degrees, continuous professional development, distance technologies, massive open online courses – MOOC). E-learning can both complement the traditional methods of teaching and act as an alternative to them. E-learning demonstrates significant growth rates around the world; in Russia, this trend was expressed in the creation of the National Platform for Open Education (Bystrova et al., 2015). The specificity of this platform is that it offers not only self-education courses, but also provides credits that are taken into account when students study the curricula at the universities participating in the project.

Quantitative indicators (graduates, higher education programmes, continuing education programmes) cannot give a complete picture. We can consider higher professional education as the main "business process" of the university; therefore, we need criteria of efficiency for its analysis and evaluation. The fact is that the "cost" of

a student (i.e. the cost of his training) may differ significantly, as well as performance indicators. In our opinion, the key indicator of the process of vocational training is the demand for graduates, which shows the success of the university and its graduates in a real economy. This picture is incomplete without the indicators of the average salary of graduates. Wages are the most objective criterion for the demand for knowledge and skills obtained in the course of training in a particular institution.

In addition, internalisation can be realised through the processes of technology transfer, i.e. licenses for the use of patents and academic entrepreneurship. Licenses are a good indicator of the demand in the real economy for scientific developments taking place within the university. Academic entrepreneurship implies the direct commercialisation of knowledge through university spin-offs. The university can generate not only enterprises, but also entire industries. Thus, in determining the future contours of the economy and society, the university acts as a leader. Indicators of the entrepreneurial activity of universities are analysed in the framework of innovative university ratings, such as Global University Venturing and Thompson Reuters Most Innovative Universities. Nevertheless, a unified methodology for the integrated assessment of the university's activities is currently lacking; most universities and government agencies are guided by classical rankings that take into account only publications and performance of education, sometimes internalisation (Kochetkov and Larionova, 2016). This approach leads to significant disparities in the development of science. For example, in Russia, the number of licenses for their use of intellectual property can be counted on in single digits (Kochetkov, Larionova and Vukovic, 2017). Proceeding from this, we insist that both indicative planning and evaluation of universities should be conducted in terms of holism. A list of planning items and indicators for monitoring is given in Table 1.

Table 1: The indicative planning model

Phase of knowledge generation cycle	Type of acquired knowledge	Institutions	Indicators
Socialisation	Tacit	Mentoring Open discussions Transfer of experience On-the-job training Teamwork	Number of mentors and mentees performance indicators Open events Number of training sessions and workshops for employees Number and staff of research groups
Externalisation	Explicit	Scientific publication Intellectual property objects	Articles in peer-reviewed scientific journals Monographs Patents
Combination	Explicit	Scientific communication Academic mobility	Participation in conferences Participation in exhibitions Virtual scientific communication (e.g. ResearchGate, Academia.edu) Use of information resources
Internalisation	Tacit	Higher vocational education Part-time education Continuous professional development E-learning Technology transfer	Demand for graduates Demand for part-time and continuous development programs Use of electronic forms in traditional education MOOC Licenses for the use of intellectual property Academic entrepreneurship

4. Conclusions

In a post-industrial economy, the university is a key actor of the regional economic system. Its contribution to the prosperity of countries, regions, and cities is conducted in the form of scientific knowledge generation.

For the analysis of the interaction of universities and regional economic systems, we suggest using the model of regional institutional configuration, which is based on the methodological unity of actors, stakeholders, institutions and the environment. The methodological basis of the analysis is the tool of historical institutionalism.

A serious challenge for the researcher is the classification of institutions for scientific knowledge generation. The typology referred to in this article is based on the SECI corporate model of knowledge management, which enables isolation of the institutions of socialisation, externalisation, combination and internalisation of knowledge. In addition, a number of indicators have been formulated that can be used within the framework of statistical analysis in the future.

The results are suitable for application in the course of further theoretical and applied research of regional systems of higher education. It is possible to apply the models and concepts proposed in the article within the framework of federal and regional policy in the field of higher education, as well as planning of partnerships of the "triple helix" type of university-business-government. In our opinion, only an institutional approach to the analysis and modelling of economic phenomena can overcome the "path-dependency effect" in the development of different countries.

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