The Changing Role of Universities in Economic Growth

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Abstract: Social and economic evolution is described by numerous wave and cyclic concepts. Nevertheless, at certain historical periods, societies make great breakthroughs known as technological revolutions. Now we are on the threshold of the fourth industrial revolution characterized by a rapid development of such industries, as robotics, artificial intelligence, neuroscience, brain engineering, and 3D printing. Social and economic development always went in parallel with science. However, the role of science in economic processes has been changing throughout time. The focus of the present research is the university as a key actor of economic change. Historically, it is possible to allocate four types of universities by analogy with four industrial revolutions. Under the conditions of the fourth industrial revolution there is a radical shift in the university model. From R&D and technology transfer universities move to creation of intellectual capital. Universities do not simply conduct R&D for business, but also create essentially new industries. Universities become a centre round which new hi-tech enterprises grow. This phenomenon has been entitled an entrepreneurial university, which is considered to be the main actor of entrepreneurial (startup) economy. The research main objective is identification of key factors in the entrepreneurial university success. The authors analysed the Global University Venturing ranking leading universities. The research is not limited to the quantitative data; qualitative indicators are also of great importance. Various techniques to estimate the university entrepreneurial capacity (Reuters, EULP-Entrepreneurial Universities Leaders Program) have been considered, and their comparative analysis has been conducted. The final model is based both on quantitative or qualitative indicators; the model can be used not only for estimation of entrepreneurial capability, but for the development of university strategy as well.

Keywords: knowledge economy**,** technology transfer, the fourth industrial revolution, R&D, entrepreneurial university, startup economy

1. Introduction

At certain moments of history, societies make great breakthroughs known as technological revolutions. They interrupt a steady flow of social and economic evolution; they are always encouraged by an invention (sometimes not one), which sharply shifts the production possibility curve outward. The first technological revolution had an agrarian character. Its moving forces were irrigation and use of domesticated animals (first of all, horses) in agricultural works. The agrarian revolution generated great antique civilizations (Egypt, Mesopotamia, India). The invention of the steam engine at the end of the 17th century had led to appearance of large manufactory works that marked the first industrial revolution. The term “industrial revolution” was introduced in the 19th century by the French scientist Jerome Blanqui (Blanqui 1845). Machines replaced human labour. Having begun with weaving production, revolution covered all industries and came to an end in first half of 19th century with the emergence of modern fabric manufacturing. At the turn of the 19th-20th centuries, the second industrial revolution, which introduced the internal combustion engine, electrification, and mass assembly line production, began. Since then, hydrocarbon resources have become the key factor in not only economy, but all global policy and history as well. The third industrial revolution arose due to invention of the computer, which empowered wide automation of production operations. In 90th of the 20th century, the emergence of the Internet global network marked the entrance of the mankind into the new information era. Rates of scientific and technical progress became determined by the Moore's law, according to which productivity of the processor is doubled every 24 months. Now we are on the threshold the fourth industrial revolution characterized by a rapid development of a variety of industries, such as robotics, artificial intelligence, neuroscience, brain engineering, and 3D printing production. An advance in each of these areas leads to a chain reaction due to the externality effect. However, in the 21st century the mankind is expected to face the most serious challenges in the history. It is essential to note at least two of them. First, the proven oil reserves may come to an end already in the middle of the century. Secondly, the current level of carbon emissions in atmosphere can lead to a catastrophic temperature rise at the end of the century. Therefore, technologies of *green economy* will play an increasingly important role in social and economic development.

Based on inventions and new technologies, social and economic evolution has always gone hand in hand with science. The authors of this research determine the latter as a regular activity aimed at production of new knowledge. However, the role of science and knowledge in economy has been changing over time. Historically,

it is possible to allocate four types of universities by analogy to four industrial revolutions. The first European universities were focused on theology and philosophy; with the advent of early modern period fundamental research began to develop rapidly. The subsequent changes in the social and economic structure of societies brought the issues of knowledge translation and professional training to the forefront. Under the conditions of the post-industrial society, universities became *market consultants* for economic agents on a large scale. Science and business were diverging. A fundamental shift in the university model can be expected under the conditions of the fourth industrial revolution. From R&D and technology transfer, universities move towards creation of the intellectual capital. The university does not simply conduct research on demand for business, but also creates essentially new industries. The university becomes the centre round which new hi-tech enterprises are growing, with new startups constantly appearing. This phenomenon has been entitled as the entrepreneurial university, which is the main actor of entrepreneurial (startup) economy.

Thus, this research is focused on universities as actors of economic growth. Universities are considered in a wide context of social and economic evolution. The main goal of research was to reveal key factors of the entrepreneurial university success. For these purposes, the authors studied 25 leading universities from the *Global University Venturing* ranking. The research methodology was not limited to quantitative data; quality indicators were also given due consideration. Various techniques to estimate the entrepreneurial capability of a university (*Reuters, EULP-Entrepreneurial Universities Leaders Program*) were considered, with their comparative analysis conducted. However, the role of a university in social and economic development cannot be described only in terms of figures and formal rules. Informal restrictions, such as traditions, customs, patterns of behaviour also play important role; usually, their formation is a long process. According to the authors, the analysis of a university in terms of the institutional economic theory is essential here. Therefore, an attempt to model an institutional structure of an entrepreneurial university has been undertaken in the Discussion.

The final model is based both on quantitative or qualitative indicators. It can be used not only for estimation of the entrepreneurial capability, but for development of a university strategy as well. However, the statistical data on universities' entrepreneurial activities is largely insufficient; therefore, this subject requires much further research.

2. Theoretical background

Karl Marx was the first who paid attention to the laws of social and economic development, in particular, its cyclic character. Moreover, Marx directly connected production method (technology) with social formation (institutional structure of society); thus, Marx can be considered as the first institutionalist. Charles Darwin's work became the second development source for the evolutionary economic theory. Thorstein Veblen in his fundamental article estimated applicability of Darwin's evolutionary laws of natural selection to the research of a life cycle of economic agents (Veblen 1898). The following stage in development of the evolutionary theory became the work by Joseph Schumpeter (Schumpeter 1934), who formulated the concept of economic development based on distribution of innovations. According to Schumpeter, any innovation passes three stages in its development: invention, innovation (implementation of the invention by the entrepreneur), and imitation (copying of the innovation by other market players). Many terms introduced by Schumpeter remain applicable today (E.g., *entrepreneurial profit* and *creative destruction*).

In the 20th century, a set of cyclic theories of social and economic development was formulated. Thus, the Russian economist Nikolaj Kondrat'ev advanced a theory of long cycles of economic conjuncture (Kondrat'ev 1925). According to Kondrat'ev's concept, economic development undergoes wavy cycles; every cycle consists of a 24 year-long growth period replaced by a 23-25 year-long recession. In the 80ties of the 20th century, another Russian economist S.JU.Glazyev started to develop a theory of long waves in the form of the technological way concept (L'vov and Glaz'ev 1985). According to this concept, any stage of social and economic development is determined by dominating technology. In 2018, a transition to the sixth technological way is expected to begin, with its characteristic features being nanotechnologies, gelio and nuclear power (Glaz'ev and Haritonov 2009). The author also highlights the importance of the interdisciplinary approach in studying long waves (Glaz'ev 2012).

A number of recognized sociologists in the 20th century studied evolution in terms of social change caused by technological progress. Among them, it is essential to mark the works by Alvin Toffler (Toffler 1980), Daniel Bell (Bell 1973), and Pitirim Alexandrovich Sorokin (Sorokin 1964). On the turn of the century the institutional

evolutionary theory emerged, presented, first of all, by the works of the Nobel winner Douglass North (North 1990) and the monograph of by Richard Nelson and Sidney Winter (Nelson and Winter 1982). This approach united substantive provisions of the evolutionary theory with transformation of economic institutions. The American philosopher and economist Jeremy Rifkin highlighted the role of power technologies connecting the future social and economic structure with development of alternative power (Rifkin 2011). In turn, scientists from the German Cluster of Excellence "Integrative Production Technology for High-Wage Countries" singled out the key features of the new industry 4.0, such as IT-globalization, single source of truth, automation, and cooperation (Schuh et al. 2015).

However, all these theories are primarily devoted to the characteristics and outer effects of various economic development stages, rather than to the mechanism of social and economic transformation. Any change in the economic way is essentially determined by a change in the key factor/resource of economic growth. At the same time, social change is based on the evolution of the basic set of values. Under the conditions of the first industrial revolution, primary production factors were capital and labour; after the second industrial revolution, the main resource of global economic development became hydrocarbons. With the transition to the post-industrial society and economy, information began to play a bigger role. It was not an independent factor or production resource yet; however, it directly influenced utilization efficiency of labour, capital, and natural resources.

With the advent of the fourth industrial revolution, knowledge has begun to play the key role in social and economic development of the mankind. For example, the role of knowledge as a prime factor of production is estimated in the studies of A.I. Tatarkin, the Academician of the Russian Academy of Sciences (Tatarkin and Pilipenko n.d.). However, knowledge is the production factor not in its abstract form, but in the form of the intellectual capital. To put it differently, the economic category *knowledge* means its direct use in the process of public welfare creation. Thus, Cobb-Douglas production function becomes:

$$Q = A \times L^{\alpha} \times K^{\beta} \times IC^{\gamma} \qquad (1)$$

Many researchers consider knowledge economy and knowledge-based society to be major (if not the only) way to solve social, economic, technological, and political issues facing global society (Melnikas, 2011). The author also makes an important assumption about the role of knowledge as a key factor of economic growth in the concept of knowledge economy; at the same time, for the knowledge-based society, knowledge becomes the basic value that encourages social development.

A model of the knowledge-based society was offered by Henry Etzkowitz. The given model is known as a triple helix of university - industry - government (Etzkowitz and Leydesdorff 2000; Etzkowitz 2002). Etzkowitz argues with those researchers who consider a phenomenon of innovative regions (for example, Silicon Valley) to be unique (Etzkowitz and Klofsten 2005). In his opinion, the triple helix model is reduced to concrete mechanisms and institutional conditions. The entrepreneurial university is placed right in the centre of an innovative cluster. This hypothesis has been supported by a number of empirical studies (Acs and Szerb 2007; Reynolds et al. 1994; Glaeser and Kerr 2009; Guesnier 1994). These studies claimed a new type of regional economic system – the entrepreneurial (startup) economy. We determine the notion of the startup economy as an economic structure providing the best institutional conditions for creation of new innovative enterprises. However, this concept is narrower in comparison with those of knowledge economy and knowledge-based society. By creating not solely new enterprises, but wholly new industries, entrepreneurial universities has become key actors of a new-type economy. The issue is how to estimate the entrepreneurial capability of such a university and how to construct a strategic model that will yield similar results in various geographical, social, and cultural conditions.

3. Methodology

Till 2009, *QS-THES*, issued by *Times Higher Education (THE)* together with *Quacquarelli Symonds (QS)*, was considered to be the most authoritative world ranking of universities. According to this methodology, 40 % of estimation relied upon a poll of experts; 10 % - on the opinion of employers; 20 % - on the ratio of students/teachers; 20 % - on the quantity of citation on the employees' publications in Scopus over the last 5 years; 5 % on the shares of foreign students and foreign teachers. The technique was rather arguable; accordingly, in 2009 *THE* signed a contract with a leader in the information industry *Thomson Reuters (TR)*. After brisk discussions on methodology in 2011/12 years, the first release of the *World University Ranking (WUR)* appeared. The methodology includes 13 indicators in 5 directions (Times Higher Education 2015):

- Teaching

- Research
- Citations
- International outlook
- Industry income.

It should be noted that the indicator of industrial profit implies accounting of knowledge transfer; however, its weight in ranking calculation constitutes only 2.5 %.

The company *QS* currently releases its own rating (Quacquarelli Symonds 2014b), with the methodology remaining essentially the same. Besides, *QS* releases rankings in subject categories (Quacquarelli Symonds 2014a); in some countries (for example, Russia), the process of reorientation to these criteria is taking place.

Another recognized world ranking is *the Academic Ranking of World Universities* (ARWU), also known as *the Shanghai rating*. At the heart of its methodology 5 criteria (ShanghaiRanking Consultancy 2015) lie:

- Quality of Education;
- Quality of Faculty;
- Research Output;
- Per Capita Performance.

Performance indicators are generally calculated on the basis of quantity of the Nobel winners; indicators of publications and citations are determined on the basis of *Thomson Reuters Web of Science* and, in particular, quantity of publications in the world most recognized journals *Science* and *Nature*.

The CWTS Leiden Ranking (Leiden University 2015) also takes a data set from *Thomson Reuters Web of Science* for a basis; the indicators are grouped in 2 directions: Impact indicators and Collaboration indicators. Leiden Ranking has a number of specific features of calculation of indicators. Thus, calculation includes not all publications in Web of Science, but only the core publications matching the certain criteria. All indicators have two groups – size-dependent and size-independent. The second group implies a proportion from total quantity of employees of university that allows a relative indicator of the academic performance independently from the size to be estimated. In parallel with the classical accounting of the article quantity (1 article is considered in the list of publications of each of the co-authors; 1 article is considered in the list of publications of university independently from quantity of authors), a share (fraction) accounting is conducted. The second method is considered to be more preferable by the authors of the ranking.

Thus, it is obvious that almost all leading world rankings estimate only academic indicators. At the same time, the mission of an entrepreneurial university as the main actor of the knowledge economy is technology transfer, or knowledge transfer in a wider understanding. The only exception is the *World University Ranking* from *THE*; however, this indicator has a weight of only 2.5 % in calculation. Subsequently, there is an essential need for a joint quantitative and qualitative methodology for estimating universities' entrepreneurial capability.

Global University Venturing (GUV) ranking has made an attempt to estimate the performance of technology transfer offices (TTO) of the leading world universities (Mawsonia 2014). The technique is based on the data on disclosures, patents and licenses, revenues from technological transfer activities, and quantity of the academic startups (spinouts). The ranking is of great practical importance. However, the authors of the ranking recognized that its weakness is statistics: the data is provided by universities; some universities do not provide any information at all. Another ranking also based on the quantitative data is the Thomson Reuters Ranking the World's Most Innovative Universities (Thomson Reuters 2015b). The technique also considers the number of patents; besides, indicators of citations and quantity of articles in collaboration with industry (Thomson Reuters 2015a) are analysed. Thus, *World's Most Innovative Universities* represents an intermediate alternative between the academic and entrepreneurial rankings of universities.

The problem of quantitative indicators is that they show the final condition of a system, failing to reveal the mechanisms of its forming. Therefore, the institutional analysis of entrepreneurial university should be applied. Such an attempt was made in the UK (National Centre for Entrepreneurship in Education and Universities UK 2016), with its methodology being focused on 5 following directions:

- Mission, Governance, and Strategy;
- Stakeholder Engagement;
- Entrepreneurship Education;
- Internalization;
- Knowledge Transfer, Exchange and Support.

According to the authors of the methodology, these indicators influence the academic excellence, quantity of innovations, and competitiveness of a university. The corresponding questionnaire (National Centre for Entrepreneurship in Education n.d.) has been developed.

Table 1 represents the comparative analysis of various rankings.

Table 1: The comparative analysis of various university rankings

Indicator/ Ranking	WUR	QS	ARWU	CWTS Leiden Ranking	GUV	Thomson Reuters	EULP
Data	qualitative/ quantitative	qualitative/ quantitative	quantitative	quantitative	quantitative	quantitative	qualitative
Research Performance	+	+	+	+			
Teaching Performance	+	+	+				
Internalisation	+	+					+
Publications & Impact	+	+	+	+		+	
Knowledge Transfer	+				+	+	+
Entrepreneurial Education							+
Strategy							+

The authors have conducted research on the basis of the abovementioned rankings in three directions. First of all, the results, which are given by various university ranging methodologies, were compared, and possible correlations between the results were determined. Then, the sufficiency of the existing methodologies in terms of the entrepreneurial capability estimation was evaluated. Eventually, an attempt was made to create an institutional model of the university as the main actor of knowledge economy.

4. Results and discussion

Results of a correlation analysis of relationships between various world university ratings and actual values of indicators of effective knowledge transfer are shown in Table 2. The calculation was conducted on the basis of disclosures, patents, licenses, startups, and revenues from technology transfer. The authors studied the relationship between the positions of the university in different rankings (expressed in points) with actual values of the abovementioned indicators. The levels of significance of the obtained coefficients of correlation are exhibited in the next columns.

Table 2: Correlation analysis of various university rankings with knowledge transfer indicators

Indicator	r_QS	t_QS	r_ARWU	t_ARWU	r_THE	t_THE
Disclosures	**0.46804**	**2.33**	0.31322	1.49	0.10075	0.46
Patents	**0.71157**	**4.11**	0.13830	0.64	0.29700	1.41
License	-0.07153	-0.34	-0.10088	-0.48	-0.03475	-0.17
Revenue, mln. $	-0.00312	-0.01	-0.04615	-0.22	-0.22374	-1.09
Startups	0.07651	0.35	-0.01300	-0.06	-0.05040	-0.24
Indicator	r_WUR	t_WUR	r_TR	t_TR	r_GUV	t_GUV
Disclosures	0.36063	1.74	**0.63267**	**2.82**	**0.67961**	**3.82**

Indicator	r_QS	t_QS	r_ARWU	t_ARWU	r_THE	t_THE
Patents	0.32891	1.57	0.18201	0.69	**0.67599**	**3.79**
License	-0.10481	-0.50	0.10300	0.39	0.31057	1.48
Revenue, mln. $	-0.06027	-0.29	0.17572	0.67	0.33183	1.59
Startups	0.00424	0.02	0.29515	1.14	**0.60218**	**3.21**

As is apparent from Table 2, the rankings *ARWU, THE* and integral world ranking (*THE+ARWU+QS*) poorly correlate with the indicators of entrepreneurial activities of the universities; thus, the level of significance of the found coefficients of correlation are below the critical value of *Student's coefficient* equal 2.1 for confidential probability 0.95 and corresponding quantity of degrees of freedom. Moderate relationship (r=0.63267) is observed only at *WUR* ranking with the disclosure indicator, whereas correlation with other indicators is absent. It is important that one of the most authoritative university rankings *QS* reflects the relationship between two indicators of university entrepreneurial activities, i.e. disclosures (0.46804) and patents issued (0.71157); thus, the coefficient of correlation with patents is much greater, and its level of significance is high enough.

The GUV ranking is calculated on the basis of technology transfer indicators; therefore, correlation with the indicators of disclosures, patents, and startups is more than 0.6, and significance levels exceed 3. Nevertheless, no ranking reflects the relationship between the entrepreneurial activity and the number of licenses and revenues from academic entrepreneurship.

An absence of correlation between the results of rankings shows that existing techniques are not interrelated and estimate absolutely different functional areas. Meanwhile, a university is a complex system, and it is essential to consider it in terms of holism. A versatile methodology of estimation is still absent. Besides, available statistical data is not enough. In particular, the authors of Global University Venturing recognized that the ranking is based on the data given by universities. Thus, there are at least two problems. First, not all universities are ready to provide the necessary data (for example, Tokyo, Yale); secondly, the given data may be distorted.

It should also be noted that quantitative indicators estimate only the final condition of a system, failing to reveal the mechanisms of its formation. Moreover, qualitative indicators used in a number of rankings analyse formal university rules, while a number of researchers have reported a prevailing role of informal factors and restrictions in the development of academic entrepreneurship. Thus, Guerrrero et al. have come to the conclusion that such informal factors as attitudes towards entrepreneurship and role models have more value than formal support measures to entrepreneurship or education and training programs (Guerrero et al. 2014). The given approach to the analysis of universities starts with D. North's definition of institutions as formal rules and informal restrictions (North 1990). A number of researchers also consider the institutional theory as the best methodological approach to study knowledge economy (Makarov and Klejner 2007; Popov and Vlasov 2009; Popov 2015).

The existing techniques of university rankings are focused on characteristics and quantitative indicators, while the institutional analysis elucidates internal mechanisms of forming and evolution of entrepreneurial universities. Therefore, we have made an attempt to apply methods of institutional modelling to investigate entrepreneurial universities. The model is based on the thesis concerning the role of a university as the fundamental manufacturer of knowledge. While conducting analysis, it is important not only to describe institutions, but also to provide their correct distribution. We have decided to use two classification features for distribution. First, according to the stages of knowledge generation, all institutions can be divided into production, exchange, distribution and consumption institutions. Secondly, functionally at each of the aforementioned stages, it is possible to allocate institutions of planning, organization, stimulation and control. Table 3 shows the final model.

Table 3: Model of distribution of entrepreneurial university institutions

Functions/ Stages of knowledge generation	Production	Exchange	Distribution	Consumption
Planning	1. Planning of research with (a) short-term (1-2 years); (b) medium-	9. Strategic planning of communications;	13. Curricula;	20. Knowledge transfer strategy;

Functions/ Stages of knowledge generation	Production	Exchange	Distribution	Consumption
	term (2-5 years); (c) long-term (over 5 years) horizon;			
Organization	2. Fundamental research; 3. Applied studies;	10. Academic collaboration; Collaboration with industry; Professional and academic associations;	14. Traditional education and training; 15. Massive open online courses (MOOC); 16. Other forms of open education;	21. Technology transfer; 22. Academic entrepreneurship;
Stimulation	4. Institution of competitive funding of research; 5. Institution of tangible stimulation of the researchers (bonus payments); 6. Institution of intangible stimulation of the researchers (awards, certificates of honor, letters of gratitude);	11. Externalities effect;	17. Institution of tangible stimulation of the teaching staff (bonus payments); 18. Institution of intangible stimulation of the teaching staff (awards, certificates of honor, letters of gratitude);	?
Control	7. The reporting by results of research; 8. The control of target use of the money funds allocated for funding of scientific research;	12. Control of communications;	19. Control of academic processes;	?

It should be taken into account that Table 3 allocates only 22 institutions; in fact, their number is larger. In addition, not all the fields are filled, since the subject demands further detailed research. Nevertheless, we believe this model may serve as a prospective methodological basis. An interested reader is invited to discuss the suggested approach.

5. Conclusions

The fourth industrial revolution is changing both the technological way, and the social and economic structure. Currently, the world is on the threshold of knowledge economy and knowledge-based society. At the same time, global society faces the critical issues of global warming and hydrocarbons deficit. Knowledge has become an independent factor of production and development. Recently, the role of universities in economic growth has changed. Universities are considered to be the main engine of economic development and the key actor of knowledge economy. The modern model of the university as a phenomenon is the entrepreneurial university, which is focused on creation of the intellectual capital. Leading world rankings practically ignore the indicators of knowledge transfer. Entrepreneurial rankings, such as *Global University Venturing* and *Thomson Reuters*, also cannot be considered comprehensive because of the insufficient statistics and accounting of exclusively quantitative indicators. Qualitative techniques (E.g., *Entrepreneurial University Leaders Program*) remain local; besides, it is important to consider not only formal rules, but informal restrictions as well. We consider institutional analysis to be the most promising methodology for investigating modern universities. A first attempt to create the institutional model of a university has been made. Undoubtedly, this subject requires further research; the authors are open for discussion.

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