UDC 338.47:330.322.1 (477)

Maryana Melnyk
D.Sc. (Economics), Professor,
State Institution «Institute of Regional Research named after M. I. Dolishniy of the NAS of Ukraine»
4 Kozelnytska Str., Lviv, 79026, Ukraine
mar.melnyk@gmail.com
ORCID ID: http://orcid.org/0000-0001-8869-8666

Ewa Korcelli-Olejniczak
D.Sc. (Social-Economic Geography), Associate Professor,
Department of Urban and Population Studies,
Institute of Geography and Spatial Organisation,
Polish Academy of Sciences
Twarda 51/55 Str., Warsaw, 00-818, Poland
eko@twarda.pan.pl; ewonia.korcelli@gmail.com
ORCID ID: https://orcid.org/0000-0002-9247-6182

Nelia Chorna
D.Sc. (Economics), Professor,
Ternopil National Economic University
11 Lvivska Str., Ternopil, 46009, Ukraine
neolla@ukr.net
ORCID ID: http://orcid.org/0000-0001-9719-6043

Nazariy Popadynets
PhD (Economics),
State Institution «Institute of Regional Research named after M. I. Dolishniy of the NAS of Ukraine»
4 Kozelnytska Str., Lviv, 79026, Ukraine
popadynets.n@gmail.com
ORCID ID: http://orcid.org/0000-0002-7556-6135

Development of regional IT clusters in Ukraine: institutional and investment dimensions

Abstract
Introduction. Accelerated introduction of modern IC technologies in all areas of the country's social life, development of the digital economy and the national information infrastructure, integration to the global information space and improvement of information security conditions are the strategic objectives of the development of information society in Ukraine. Furthermore, recent years are characterised by active creation of new network organisation forms and cluster cooperation in the IT sphere based on joint endeavours of IT companies, scientific and educational establishments, NGOs and other actors. Organisation of clusters in the IT sphere contributes to not only the optimisation of economic processes management in the course of creation, introduction and use of information technologies and products and services of IT companies, but also to forming of powerful integrated groupings with high economic capacity, which is essential for the development of the national economy.
Purpose. The paper aims to analyse both the institutional and investment environment, in which regional IT-clusters develop, in particular the features, tendencies and priorities of their functioning to assess the role of venture capital in the development of the IT sector in Ukraine and to define the strategic directions to improve the instruments of public policy relevant to the development IT clusters in forming of an innovation ecosystem.
Methods. Fundamental provisions and principles of innovative development theories and concepts of clustering, economic convergence and integration, diffusion of innovations and place-based innovation systems constitute the methodological basis of the research. Structural-functional and factor analyses are applied in order to reveal major tendencies and preconditions of the development IT sector in Ukraine and to evaluate the impact of venture capital on its establishment and activation. A Multi-factor regression analysis is conducted to perform econometric modeling of the impact of institutional features peculiar to the impact of the entrepreneurship activity environment on the development of the IT sector and forming of its investment capacity in Ukraine. The measures to improve the mechanism to assist the development of IT clusters in forming of an innovation ecosystem are suggested as a result of using the system approach.
Results. The authors of the article have elaborated suggestions relating to the improvement of the public IT sector development policy in Ukraine. The intensity of the impact of venture capital on the establishment and development of the IT sector in Ukraine is assessed. The dynamics of exports of Ukrainian IT outsourcing products is researched. It shows that IT outsourcing is one of the most dynamic and leading directions of the IT sector in Ukraine. The evaluation of the impact of entrepreneurship activity and institutional environment on the development of the sphere of information technologies and forming of its investment capacity (the system of venture investment) is conducted on the basis of a correlation and regression analysis.
Conclusions. The conducted research has revealed the major preconditions of the development of regional IT clusters in Ukraine. Overall conditions of the development of information and telecommunication technologies, as well as the ecosystem and infrastructure, are the most influential development factors of the Ukrainian IT sector. A high number of qualified IT specialists and a competitive level of their remuneration are the major preconditions for the dynamic growth of the IT sector in Ukrainian regions. The imperfect business environment of Ukraine is the key obstacle for conducting legitimate business, which deteriorates economic security in general and negatively impacts the quality of functioning of the innovation ecosystem, in particular in the IT sector. It includes a complicated tax system and a high level of shadow economy and corruption. Perspective opportunities to boost the development of the high value product segment of the IT sector and the internal IT market directly depend on the business climate and conditions of the country's business environment, as well as on the level of the development of the national innovation ecosystem and its functioning efficiency.

Keywords: Information Technology; IT Cluster; IT Sector; Venture Investment; Country's Innovation Ecosystem; Development of IT Clusters; Public Policy of IT Clusters Development
JEL Classification: O18; R22; R58
DOI: https://doi.org/10.21003/ea.V173-03

Мельник М. І.
доктор економічних наук, професор, завідувач сектору просторового розвитку,
ДУ «Інститут регіональних досліджень імені М. І. Долішнього НАН України», Львів, Україна
Корцеллі-Олєйнічак Є.
доктор економічних наук (соціально-економічна географія), доцент, відділ демографічних досліджень та містобудування, Інститут географії та просторової організації, Польська академія наук, Варшава, Польща
Чорна Н. П.
доктор економічних наук, професор, кафедра обліку та економіко-правового забезпечення агропромислового бізнесу, Тернопільський національний економічний університет, Тернопіль, Україна
Попадинець Н. М.
кандидат економічних наук, старший науковий співробітник, відділ регіональної економічної політики,
ДУ «Інститут регіональних досліджень імені М. І. Долішнього НАН України», Львів, Україна

Розвиток регіональних ІТ-кластерів в Україні: інституційний та інвестиційний вимір

Анотація
У статті розроблено пропозицію щодо удосконалення системи інституційного забезпечення державної політики розвитку ІТ-сектору в Україні. Оцінено інтенсивність впливу венчурного капіталу на становлення і розвиток ІТ-сектору в Україні. Досліджено динаміку експорту продукції українського ІТ-аутсорсингу, яка показала, що одним з найбільш динамічних та провідних напрямів ІТ-сектору в Україні є ІТ-аутсорсинг. На основі кореляційно-регресійного моделювання проведено оцінювання впливу інституційного середовища підприємницької діяльності на розвиток сфери інформаційних технологій та формування її інвестиційного потенціалу (системи венчурного інвестування). Проведене дослідження показало основні передумови щодо розвитку регіональних ІТ-кластерів в Україні. Найбільш впливовим чинником розвитку українського сектору інформаційно-комунікаційних технологій є загальний стан розвитку інформаційно-комунікаційних технологій, екосистеми та інфраструктури. Встановлено, що потенційні можливості для активізації розвитку високоприбуткового продуктового сегменту ІТ-сектору та внутрішнього ринку ІТ безпосередньо залежать від ділового клімату та стану бізнес-середовища країни, а також від рівня розвитку національної інноваційної екосистеми та ефективності її функціонування.
Ключові слова: інформаційні технології; ІТ-кластер; ІТ-сектор; венчурне інвестування; інноваційна екосистема країни; забезпечення розвитку ІТ-кластерів; державна політика розвитку ІТ-кластерів.

Мельник М. И.
доктор экономических наук, профессор, заведующий сектором пространственного развития,
ГУ «Институт региональных исследований имени М. И. Долишнего НАН Украины», Львов, Украина
Корцелли-Олейничак Е.
доктор экономических наук (социально-экономическая география), доцент, отдел демографических исследований и градостроительства, Институт географии и пространственной организации, Польская академия наук, Варшава, Польша
Черная Н. П.
доктор экономических наук, профессор, кафедра учета и экономико-правового обеспечения агропромышленного бизнеса, Тернопольский национальный экономический университет, Тернополь, Украина
Попадинец Н. Н.
кандидат экономических наук, старший научный сотрудник, отдел региональной экономической политики,
ГУ «Институт региональных исследований имени М. И. Долишнего НАН Украины», Львов, Украина

Развитие региональных ИТ-кластеров в Украине: институциональное и инвестиционное измерение

Аннотация
В статье разработано предложение по совершенствованию системы институционального обеспечения государственной политики развития ИТ-сектора в Украине. Оценены интенсивность воздействия венчурного капитала на становление и развитие ИТ-сектора в Украине. Исследована динамика экспорта продукции украинского ИТ-аутсорсинга, которая показала, что одним из наиболее динамичных и ведущих направлений ИТ-сектора в Украине является ИТ-аутсорсинг. На основе корреляционно-регрессионного моделирования проведена оценка влияния институциональной среды предпринимательской деятельности на развитие сферы информационных технологий и формирования его инвестиционного потенциала (системы венчурного инвестирования). Проведенное исследование показало основные предпосылки для развития региональных ИТ-кластеров в Украине. Наиболее влиятельным фактором в развитии украинского сектора информационно-коммуникационных технологий является общее состояние развития информационно-коммуникационных технологий, экосистемы и инфраструктуры. Установлено, что потенциальные возможности для активизации развития высокодоходного продуктового сегмента ИТ-сектора и внутреннего рынка ИТ напрямую зависят от делового климата и состояния бизнес-среды страны, а также от уровня развития национальной инновационной экосистемы и эффективности ее функционирования.
Ключевые слова: информационные технологии; ИТ-кластер; ИТ-сектор; венчурное инвестирование; инновационная экосистема страны; обеспечение развития ИТ-кластеров; государственная политика развития ИТ-кластеров.

1. Introduction

Under current conditions of a priority in transition to forming of a new economy based on knowledge and values of information society, the development of information space and information technologies serves as a powerful factor of economic growth, establishment of public society, improvement of the competitiveness of the national economy, and strengthening of social, political and economic integration in the country. New information technologies impact the transition from extensive to intensive growth of production and contribute to core changes in the division of labour and management technologies. Well-developed information technologies open the way to a higher development level of national economies, and the cluster cooperation of enterprises in the sector is an efficient tool of integration into the global economic space, attraction of venture investment and development of countries' scientific capacity, which ultimately improves the level of information and ecological security. Cluster structures in the IT sphere are the growth points and efficient platforms for cooperation of IT companies and related educational and scientific institutions, infrastructural institutes and state authorities. Clusters stimulate innovativeness, high productivity, accessibility to production factors and financial resources, and harmonization of interests of all economic entities.

2. Brief Literature Review

Development of information technologies encompasses wide activity areas, impacts functioning of many institutions, forms an environment for efficient production development and granting of services, and defines capacity of large cities

which are considered to be the core innovative, scientific, infrastructural, cultural and information development [1].

Various aspects of scientific and practical issues of the development of innovation clusters, as well as the boost of cluster cooperation processes in certain types of economic activity and, in particular, in the sphere of information technologies are outlined in a range of works of foreign and domestic researchers. S.-C. Park (2017) [2] researches the way the Fourth Industrial Revolution can change the global productive chain and the way new technologies function in branches. He focuses on the way innovation clusters should develop to correspond to the requirements of the Fourth Industrial Revolution and analyses whether innovation clusters can serve as centres of innovative technologies in the real world and as cyberphysical systems in the age of the Fourth Industrial Revolution.

Researching the necessity of strategic state level actions directed at strengthening of regional economic development, G. Pronesti and C. Bevilacqua (2018) [3] consider the use and realization of the Smart Specialisation Strategy, emphasising the innovative policy at the local level of regional economic development. They pay special attention to the Entrepreneurial Discovery Process, which is the decisive stage in the development of the Smart Specialisation Strategy, because it is directed at defining of priorities, focusing on examining and approbation of new opportunities to be used at the clustering stage. They outline and analyse the conceptual model designated to reveal the specific cluster factors (from the viewpoint of dynamism, cooperation among companies, diversity of knowledge and spatial importance) that potentially contribute to functioning of the Entrepreneurial Discovery Process and strengthening of the Smart Specialisation Strategy.

S. H. Lawton (2018) examined theoretical and empirical problems of development of regional innovation ecosystems [4]. In particular, he considers entrepreneurship to be the basis of economic changes and a driving force of regional innovation systems and related policies. C. Marcotte (2014) [5] analyses the works of Schumpeter and Kirzner on the goals of entrepreneurship from the viewpoint of economic and institutional context of transition economies. He reveals four profiles: innovative entrepreneurship of the Schumpeter Mark I type, innovative entrepreneurship of the Schumpeter Mark II type, opportunity-based Kirznerian entrepreneurship and the fourth cluster described as a potentially emerging Schumpeter Mark II profile. Economic and governance indicators are favourable in two innovative entrepreneurship clusters, while the context innovations indicators are especially favourable in the Schumpeter Mark II group. The study proves the importance of harmonization of theory, methods and context in entrepreneurship comparative research. Instead, M. P. Feldman and J. Francis (2001) [6] outline the development of the technology-intensive industrial cluster based on the endeavors of entrepreneurs who have adapted both to the constructive crisis and new opportunities, creating factors and conditions contributing to their business interests. They examine the primary factors that impact certain decisions to become entrepreneurs and the way external factors influence both the formation and the location of technology-intensive clusters. The perspective is that entrepreneurs are an important element of cluster forming and their actions are important for analysis of clusters as complex adaptive systems.

B. Asheim, P. Cooke and R. Martin (2006) [7] show the first critical analysis of clusters theory, assessing the cluster concept and revealing not only its strong points but also its weak points and restrictions. They research the way the cluster model is used as an instrument to improve competitive abilities, innovations and growth at local, regional and national levels. Despite its popularity, there are many problems emerging in the hasty use of the «cluster idea».

D. Ia. Hoshchynska (2016) in the course of her research of institutional and investment conditions of the development of IT clusters concludes that nowadays they face the choice of their business development models based on two major tendencies in the ICT sphere: the first one is strengthening of competition between the IT companies for investment, resources, qualified personnel, information and new knowledge in order to maintain their competitive abilities; the second one is strengthening of internal and external cooperation between the key participants of clusters that are developing on the basis of knowledge and technologies transfer and diffusion of open innovations [8].

R. Ie. Iaremchuk and O. H. Kolomiiets (2016) considers IT-clusters as the ecosystems of corporate, regional and international levels and studies the peculiarities of their development in the context of forming of the institutional environment of the Ukrainian innovation ecosystem [9]. Ukraine needs systemic and well-founded mechanisms of maintenance of the country's favourable institutional and investment environment to form investment capacity and to stimulate the development of regional IT clusters.

3. The purpose of the paper is to analyse the institutional and investment environment of the development of regional IT clusters, in particular the features, tendencies and priorities of their functioning; to assess the role of venture capital in the development of the IT sector in Ukraine and to define strategic directions to improve the instruments of public policy of the development of IT clusters in the process of forming of innovation ecosystem.

4. Methodology

Structural-functional and factor analyses are applied in order to reveal major tendencies and preconditions of the development of the IT sector in Ukraine and to evaluate the impact of venture capital on its establishment and activation. A multi-factor regression analysis is conducted to perform econometric modelling of the impact of institutional features peculiar to entrepreneurship activity environment on the development of the IT sector and forming of its investment capacity in Ukraine. The measures to improve the mechanism to assist the development of IT clusters in forming of an innovation ecosystem are suggested as a result of using the system approach.

5. Results

Diagnostics of the institutional environment[1] the IT sphere in Ukraine in the context of maintenance of state policies relating to the development of the domestic IT sector, a regulatory framework of the development information society strategic, electronic document management and e-governance, legalisation of software and cybersecurity has shown that major Ukrainian legal acts in the IT sphere correspond to the main principles and strategic priorities of the global information development and comply with the legislation of the European Union. However, the level of the development of information society does not correspond to the capacities and possibilities of Ukraine due to numerous problems with real application of the country's current legislation (inefficient implementation procedures, permanent poor funding of the sphere, dispersion of management functions and budget resources), as well as crisis tendencies of social and economic development in general.

With regard to investment, despite the positive dynamics of venture investment in the IT sector, both the Ukrainian innovation system and the system of venture investment are still in the process of their establishment. Asset management companies (AMC) and closed-type joint investment institutions (JII) managed by them remain to be the major entities of the venture investment industry in Ukraine. Despite the negative dynamics of the last four years, their number increased almost twofold in 2007-2017. Within the abovementioned period, venture funds defined the dynamics of the industry in general; their share in the overall number of JII increased by 9.4% up to 88.6%. However, the share of securities in the structure of assets amounting to 70.2% had lost over 77% of its volume by the end of 2017 (or 54.5%) [10]. It is related to the stagnation of the Ukrainian stock market (reduction of both overall volume of securities admitted to trading at Ukrainian stock markets and activity of trade in securities).

[1] Due to the fact that all IT companies located in large cities form the relevant IT clusters there, the conducted analysis based on official statistical data on IT sphere in fact corresponds to the aggregated statistics on clusters.

In the past 9 analysed years domestic investors, legal persons, have invested over UAH 970 billion in Ukrainian venture funds or 77.7% of overall investment [10]. Furthermore, we can observe a tendency towards expanding of investment presence of foreign legal persons and Ukrainian individual investors. However, the research shows that low presence of Ukrainian venture funds with transparent investment strategies and long-term life cycles is one of the problems at the market. Moreover, the poor funding share of enterprises in high technology sphere in the structure of venture investment is explained by higher risks of projects compared to the sphere of financial services and retail trade.

Moreover, data of the Venture Capital Country Attractiveness Index calculated by IESE business school in the University of Navarra (Spain) [11] testifies to the absence of substantial positive changes regarding investors' protection, efficiency of corporate management system, entrepreneurship culture and business opportunities, social development and inconsistent regulation system. It significantly deteriorates opportunities for the development of the IT sector in Ukraine and reduces its competitive ability.

The conducted comparative analysis also reveals the dependence of national competitive ability rankings by the Venture Capital Country Attractiveness Index and the IT Industry Competitiveness Index (Figure 1) [12]. Lacking the developed innovative infrastructure for creation and support of innovations, Ukraine remains to be an economy with a low added value and competitive ability of domestic products due to poor pace of development of high-technology sectors.

The IT sector in Ukraine is one of the innovative economy segments, which is dynamically developing, including in terms of exports, and is one of the most important sources of growth of Ukraine's international competitive ability in the nearest perspective.

The IT projects are most in demand among Ukrainian and foreign investors. Starting from 2010, the venture investment in the IT sector has significantly intensified due to its financial (a higher level of profitability) and tax advantages and less start-up money for IT project development - from USD 10 thousand, with USD 0.5-1 million in the real economy sector.

In 2010-2017, the average annual growth of investment in the IT sector of Ukraine amounted to 55.2%, despite a significant fall in the investment activity in 2016 (-33% or USD 44 million) compared to 2015. A high growth in the IT sector of Ukraine occurred in 2012 (+150%), in 2015 (venture investment growth amounted to 238% or USD 93 million) and 2017 (+201% or USD 177 million) due to several large investment agreements with the involvement of foreign and Ukrainian investors, which accounted for over 50% of the overall venture investment volumes.

In 2017, Ukrainian investors and funds invested only USD 10.6 million in the development of Ukrainian IT sphere, which is three times less than in 2016 and six times less than in 2015. Digital Future, Venture Capital, Detonate Ventures and CIG were the most active Ukrainian funds in 2014-2017 by the number of contracts. Foreign funds and investors invested over USD 254.4 million (96.1% of the overall venture investment volumes), which is 5.4 times more than the rate of 2016, and 3.4 times more than in 2015. The share of foreign funds and investors in 2017 reached the record 96.1%.

E-commerce and software were the leading and most profitable Internet segments in the structure of venture investment in 2010-2015 (in 2015 their aggregate share accounted for 77% or USD 109.3 million). However, in 2016-2017 the share of e-commerce in the structure of venture investment sweepingly declined to 31% in 2016 with a further downfall of 8% in 2017. Instead, the share of software significantly grew in 2017

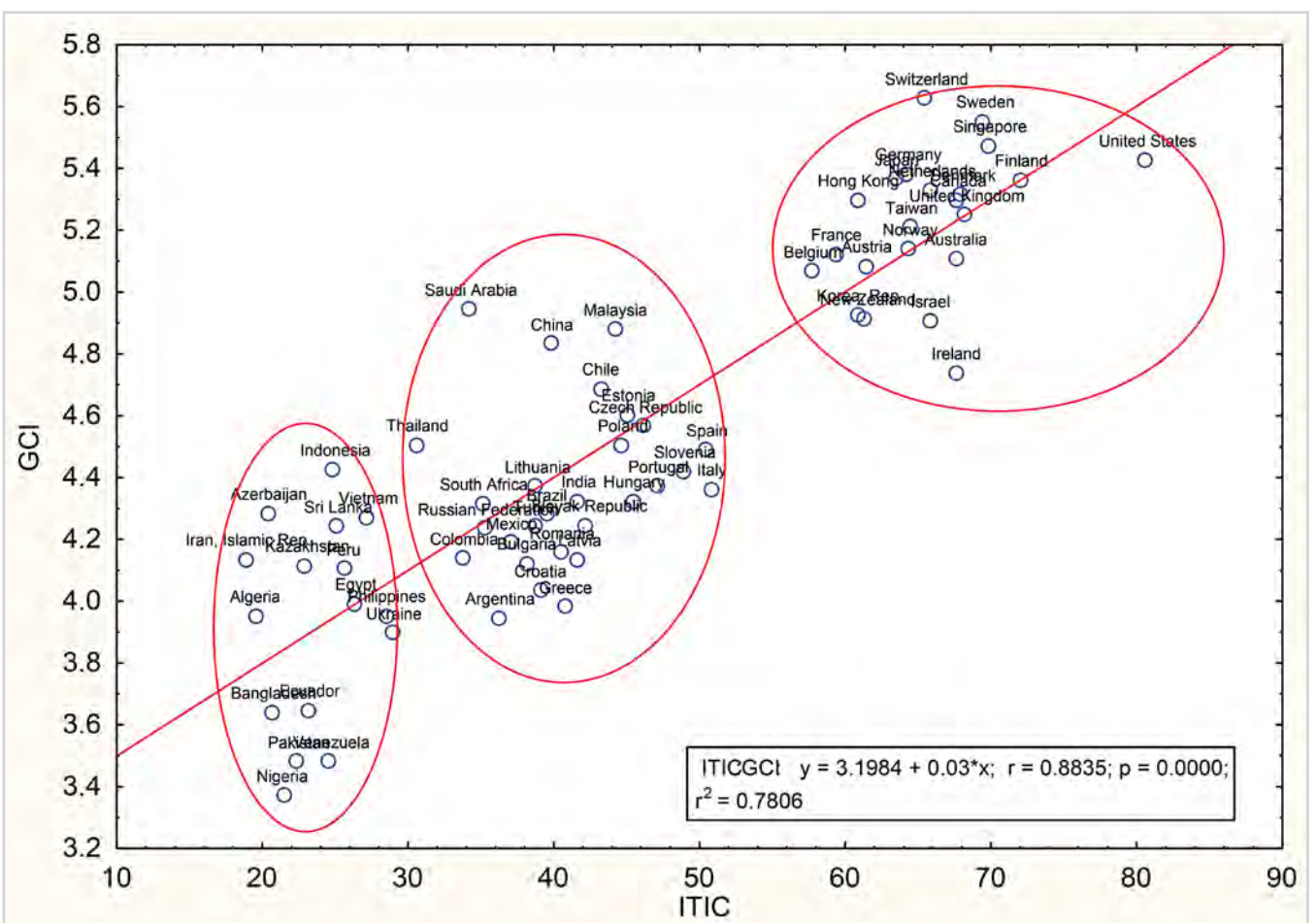

Fig. 1: **Dispersion of the values of the Global Competitive Index (GCI) and the IT Industry Competitiveness Index (ITIC)**
Source: Developed by the authors based on [13-14]

(+52 p.p. or USD 137.8 million) after the rapid decline in 2016 (-10 p.p.).

Venture capital plays the leading role in the structure of funding sources of new and support of already existing IT projects in Ukraine. Its average annual share in 2010-2017 accounts for almost 70% of the overall funding volumes. For instance, in 2017 its volumes increased more than 4 times, from USD 17.3 million in 2010 to USD 70.2 million, showing the average annual growth of 25.3% in 2012-2017 [15].

The growth of the number of IT-projects and companies in Ukraine urges their founders not only to actively search for funding of their development, but also to differentiate the sources, in particular through crowdfunding (collection of funds, usually through the Internet, in order to provide start-up capital and attract the first clients).

In general, Ukrainian IT companies managed to attract almost USD 2.3 million in 2017, surpassing the rate of 2016 more than twofold (USD 0.9 million) and the rate of 2015 threefold. The majority of successful crowdfunding campaigns initiated by Ukrainian IT companies represented the consumer Internet segment and the Internet of things.

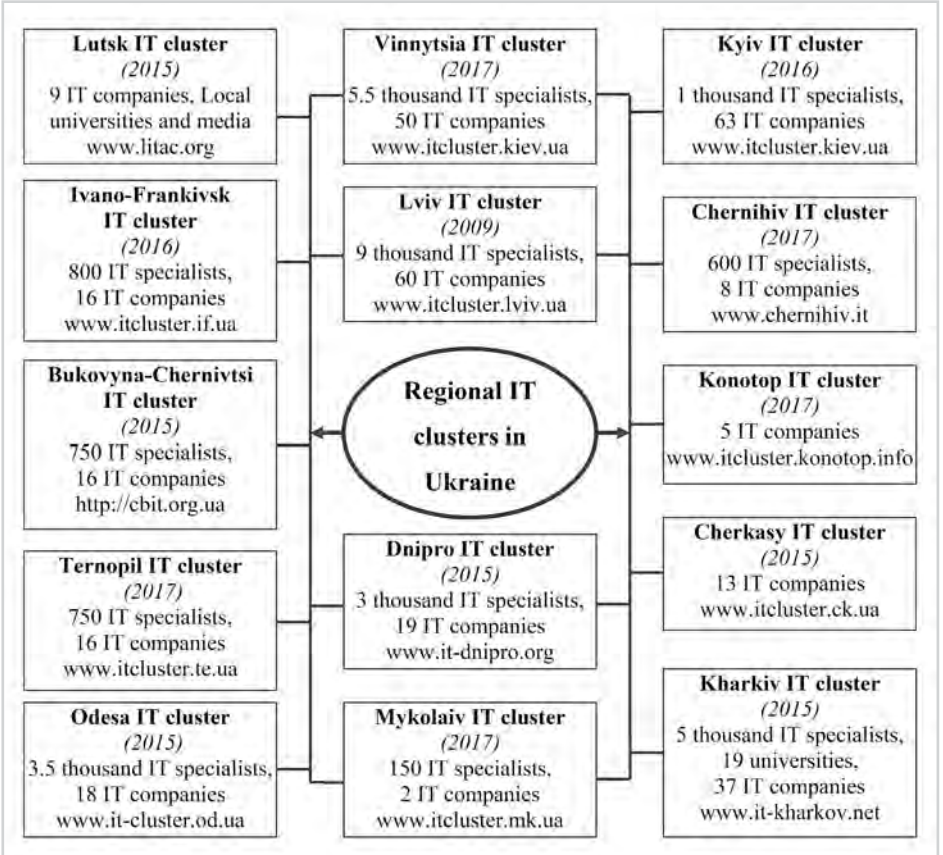

Fig. 2: **Localisation of regional IT clusters in Ukraine**
Source: Developed by the authors based on [16]

Despite the positive dynamics of venture investment in the IT sector and successful examples of IT business development in Ukraine, both the Ukrainian innovation ecosystem and the system of venture investment in its classical sense still remain in the process of establishment. Currently, Ukraine lacks venture funds with transparent investment strategies and long-term life cycles. Only several venture funds can support innovation or technological entrepreneurship across the complete cycle of venture investment. Among the positive changes in this direction, we can name the creation of independent electronic system of public procurement, introduction of 4G connection standards and expansion of 3G services, the system of electronic document circulation and certain open electronic public registers as well as the platform of distance fiscal monitoring, known as the «National Monitoring System», which provides automated data collection on real volume of operations in various spheres of social activity.

The IT sector is one of the most dynamic export directions of the Ukrainian economy, because in the last 11 years the overall volume of IT services has been growing almost uninterruptedly - the annual growth amounts to 28.6% on average. The average growth rate of the Ukrainian IT sector in this period exceeds the average rate in the world twofold.

The development of IT clusters not only has positive economic effects for the country (ICT contribution exceeded 3% of the Ukrainian GDP in 2017 compared to 0.8% in 2012), but it also performs a significant social role in the context of inclusive development goals, in particular productive employment, and provision of a decent level of remuneration and various social projects essential for the county's development.

Highly skilled specialists are the most valuable asset of IT clusters forming and the level of their concentration is the leading factor for the localisation and further development of IT business in the regions. At the beginning of 2018, 127 thousand of specialists worked for over 9000 companies in the Ukrainian IT market, located mostly in Kyiv, Lviv, Kharkiv, Dnipro and Odesa, i.e. the largest regional IT clusters of Ukraine (Figure 2). Currently, almost 44% of IT specialists is accumulated in Kyiv, a key centre of the Ukrainian IT industry. Regarding other important IT centres of Ukraine, 15.5% are employed in Kharkiv, 11.5% in Lviv, 7.6% in Dnipro, 5.4% in Odesa and almost 16% if IT specialists in other regions.

The average salary of a domestic IT specialist in 2017 amounted to USD 1,485 per month (or USD 10 per hour), which is almost 4.2 times as high as the level of the average monthly salary of one employee in the industrial sector of Ukraine. However, the volume of the average annual salary of an IT specialist in Ukraine is more than 4 times less than the same rate for the USA, the acknowledged world IT leader, and 2.6 times less than in Germany and Israel.

IT companies in the main regional centres of Ukraine consolidate specialised educational establishments and services structures in the ICT sphere. In such a way they create IT clusters for common implementation of projects to develop the IT sector and high-technology areas at both the national and international levels to conduct systemic transitions in the business environment and to implement social and infrastructural projects.

The analysis has shown that IT outsourcing is one of the most dynamic and leading directions of the IT sector. The export volumes of its production in 2017 covered 57.3% of all sector markets. In the period between 2003 and 2017, it grew 32 times (from USD 110 million to USD 3.6 billion) [15]. Its average annual growth during the period amounted to 29% (Figure 3). Furthermore, Ukraine's competitive advantages lie in a large number of highly qualified specialists and a low level of labour remuneration. Therefore, four Ukrainian IT companies (EPAM System, Intetics, Luxoft and Miratech) are in international rankings of top 100 world outsourcers. Services of Ukrainian outsourcing IT companies constitute one of the key directions of national exports (3rd place in 2017) with the perspective of entering the leading position in Ukraine by 2025, since the activity of 90% of IT companies is aimed at granting qualitative and reliable services in the global market.

According to the data by the 2017 Global Service Location Index (GSLI) [17], one of the leading rankings in the global

outsourcing industry, provided by the international consulting company A. T. Kearney, Ukraine was positioned among ten most attractive European countries for outsourcing and 24th in the global rankings.

At the beginning of 2017, Ukraine accounted for almost 1,000 outsourcing IT companies, with almost 70 thousand employees. Headquarters of most IT outsourcing companies are usually located in the main IT centres of the country, i.e. they have become the core of 14 IT clusters formed in Ukraine (including 9 actively functioning) located in Kyiv, Lviv, Kharkiv, Odesa, Dnipro, Lutsk, Ivano-Frankivsk, Vinnytsia, Mykolaiv, Ternopil, Cherkasy, Chernivtsi and Chernihiv (Figure 2). In general, Ukrainian IT companies own offices in 52 countries across six continents. In particular, headquarters of 61% of the companies are located in Ukraine, 25% in North America, 12% in Europe and 2% in Israel.

The conducted regression modelling resulted in revealing the interdependencies between institutional parameters of the country's business environment and the major parameters of the IT sector functioning and the venture investment system in Ukraine.

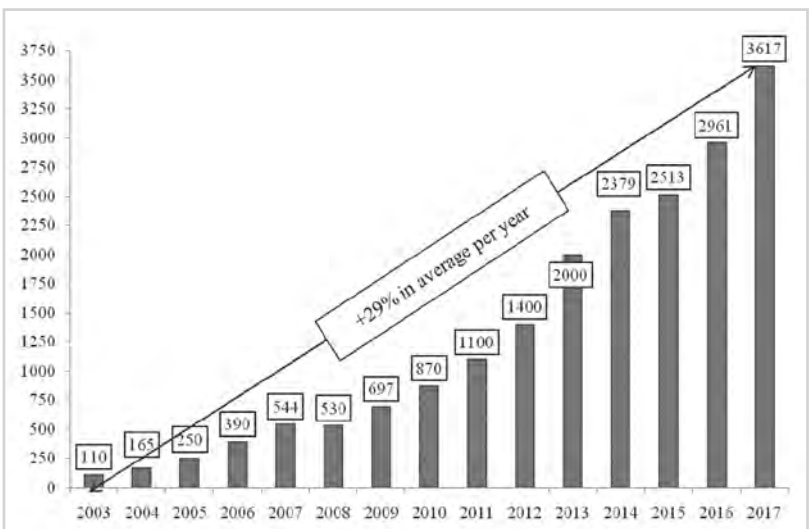

Fig. 3: **Export dynamics of Ukrainian IT outsourcing products in 2003-2017 (USD million)**
Source: Developed by the authors based on [17]

The dependence of the export of information and communication technologies (ICT) services on the factors of entrepreneurship activity and IT infrastructure in 2005-2017 is represented by formula (1):

$$Y_1 = 0.0805 + 0.0215x_1 + 0.1871x_2 - 0.004x_3 - 0.003x_4; \quad R^2 = 0.997641, \quad (1)$$

where:
Y_1 - the volume of ICT services export, USD million;
x_1 - the number of IT specialists, thousand persons;
x_2 - the ICT development index, value;
x_3 - the number of tax payments per year;
x_4 - the level (integral) of shadow economy,% of GDP.
The coefficients before the variables x are β.

Therefore, the overall condition of the ICT ecosystem and infrastructure development is the most influential factor impacting improvement of the ICT sector export capacity. The influence of the ICT development index testifies to the latter. Dynamics of IT outsourcing development in Ukraine and of the volume of export of IT services that can be granted by Ukrainian IT specialists directly depends on the growth of the number of Ukrainian IT specialists (if the number of IT specialists (x_1) grows per 1 thousand persons, the overall volume of export of ICT services (Y_1) grows by USD 21.5 million). The imperfect business environment of Ukraine (the complicated tax system (x_3) and the high level of shadow economy (x_4)) not only creates numerous obstacles for legal businesses and reduces export opportunities of the sector, but also negatively affects the quality of the innovation ecosystem, in particular in the IT-sector. Diminishing the overall level of shadow economy in Ukraine is one of the key factors for the development of the domestic IT market and activisation of Ukrainian product and start-up IT companies. However, the low tax burden on individual entrepreneurs granting IT services is a significant competitive advantage of Ukraine over other countries.

The dependence of the volume of venture investment in the IT sector on the factors forming the entrepreneurship environment and IT infrastructure in 2005-2017 are shown in formula (2):

$$Y_2 = -121.57 - 1.61x_4 + 99.31x_5 + 51.58x_6 + 2.029x_7; \quad R^2 = 0.843502, \quad (2)$$

where:
Y_2 - the volume of venture investment in the IT sector, USD million;
x_4 - the level (integral) of shadow economy,% of GDP;
x_5 - the value of the E-Governance Development Index;
x_6 - the volume of ICT services export, USD billion;
x_7 - the rate of the Venture and Private Investment Country Attractiveness Index.

Therefore, a transparent and balanced operation of the country's economic system is especially important for venture capital, which is very sensitive to the quality of its development environment (β_4 = -1.61). Efficient application of opportunities provided by e-governance significantly simplifies doing business and narrows the field for corruption. The implementation of E-governance in Ukraine creates good opportunities for the development of the domestic IT market, which is a positive sign for venture capital (β_5 = 99.31). The overall volume of export of ICT services is one of the most important indicators for venture investors, which characterises the efficiency of the country's IT ecosystem (β_6 = 51.58). The export volumes of Ukrainian IT sector services is swiftly growing, mostly due to the activity of outsourcing IT companies which execute more than 90% of their orders for foreign clients (especially the USA and the EU member states) [18]. The country's attractiveness for venture investment (x_7) as one of the major components of the country's innovation ecosystem defines perspective opportunities for boosting a high-yield productive segment of the IT sector and the domestic IT market, directly impacting the volumes of venture investment in the IT.

Institutional and investment development of regional IT clusters in Ukraine should be based not only on solving numerous problems with real application of the current legislation, but also on defining organisational and economic priorities of state policies of the development of the IT sector in the context of improvement of its competitive ability and commercialisation of IT innovations.

6. Conclusions

Forming of institutional and investment environment favourable for the improvement of competitive abilities of the IT sector entities in the domestic and international markets depends on the efficiency of professional education system, reduction of administrative barriers for IT business entities, use of the measures of state innovation policies synchronized in time and scale, creation of a positive image for The country's IT clusters and promotion of domestic innovations in the IT sphere in foreign markets, improvement of a regulative basis for venture investment attraction and stimulation of innovations in the IT sphere, creation of information maintenance of innovation activity as a platform for cooperation between the developers of innovative production in the IT sphere and domestic and foreign investors interested in their introduction. In this regard, the following measures should be considered:

- audit of the existing measures (legislation) of IT companies' support (adoption of the Law of Ukraine «On State Program of Information and Communication Technologies Development in Ukraine»);
- creation of favourable conditions for the taxation relevant to the IT sector, securing an opportunity to work with private entrepreneurs;
- providing the transparency of state procurement and state orders for the development of software and IT services, as well as open tenders;
- improvement of legislation on intellectual property management;
- promotion of joint endeavours of science, education and industry in the IT sphere;
- forming of a transparent system of IT projects and their results expertise attracting the professional specialists' environment, etc.

Systemic and consistent state policy of IT clusters support significantly boosts the development and efficient functioning of the national innovation ecosystem due to the creation of favourable business conditions and maintenance proper resources relating to their target initiatives and projects. Conceptually, support of IT clusters should be carried out taking into account the priorities of their development across the major stages of state innovation ecosystem's life cycle: development of separate elements, integral forming, and establishment of efficient functioning of the system. The creation of a state venture company will attract investment to the highly technological and innovation spheres, which will be the link between large international investors, national venture funds and start-ups for maintenance of sustainable funding of the best Ukrainian technological start-ups and their development in the Ukrainian economy in view of the best practices of the USA, the EU, China and Canada. The abovementioned contributes to the evolution of the Ukrainian IT sector from the dominating outsourcing model to a productive one (creation of new intellectual property and replication of finished products in international markets) as well as transition of perspective IT clusters to innovation and technology hubs at the national and supranational levels, including further improvement of the competitive ability of the domestic economy.

References

1. Melnyk, M. I. (2014). Conceptual approaches and applied aspects of spatial and functional analysis of metropolisation processes in the region. *Economic Annals-XXI, 11-12,* 80-84. Retrieved from http://soskin.info/ea/2014/11-12/201426.html
2. Park, S.-Ch. (2017). The Fourth Industrial Revolution and implications for innovative cluster policies. *AI & SOCIETY, 33*(3), 433-445. doi: https://doi.org/10.1007/s00146-017-0777-5
3. Pronestì, G., & Bevilacqua, C. (2019). The Life Cycle of Clusters: A New Perspective on the Implementation of S3. In F. Calabrò, L. Della Spina, & C. Bevilacqua (Eds), *New Metropolitan Perspectives. ISHT 2018. Smart Innovation, Systems and Technologies, vol. 100* (pp. 215-225). Springer, Cham. doi: https://doi.org/10.1007/978-3-319-92099-3_26
4. Lawton Smith, H. (2018). Entrepreneurship Policies and the Development of Regional Innovation Systems: Theory, Policy and Practice. In A. Isaksen, R. Martin, & M. Trippl (Eds), *New Avenues for Regional Innovation Systems - Theoretical Advances, Empirical Cases and Policy Lessons* (pp. 239-256). Springer, Cham. doi: https://doi.org/10.1007/978-3-319-71661-9_12
5. Marcotte, C. (2014). Entrepreneurship and innovation in emerging economies: Conceptual, methodological and contextual issues. *International Journal of Entrepreneurial Behaviour & Research, 20*(1). doi: https://doi.org/10.1108/IJEBR-09-2012-0089
6. Feldman, M. P., & Francis, J. L. (2001). *Entrepreneurs and the Formation of Industrial Clusters.* Retrieved from https://www.researchgate.net/publication/228790774_Entrepreneurs_and_formation_of_industrial_clusters
7. Asheim, B., Cooke, P., & Martin, R. (Eds.) (2006). *Clusters and Regional Development Critical Reflections and Explorations* (1st edition). London: Routledge. doi: https://doi.org/10.4324/9780203640890
8. Hoshchynska, D. Ia. (2016). *Information and communication maintenance of enterprises' cluster cooperation.* (Doctoral dissertation). Kyiv: TNTU. Retrieved from http://www.dut.edu.ua/uploads/p_1537_16868746.pdf (in Ukr.)
9. Iaremchuk, R. Ie., & Kolomiiets, O. H. (2016). Forming of institutional environment of innovation ecosystem development in Ukraine. *Social and economic problems of the modern period of Ukraine (Sotsialno-ekonomichni problemy suchasnoho periodu Ukrayiny), 119*(3), 9-14 (in Ukr.).
10. The Ukrainian Association of Investment Business (2017, September 23). *Quarterly and annual reviews of JII market in Ukraine.* Retrieved from http://www.uaib.com.ua/analituaib/publ_ici_quart.html (in Ukr.)
11. IESE Business School University of Navarra (2015). *The Venture Capital and Private Equity Country Attractiveness Index.* Retrieved from http://blog.iese.edu/vcpeindex
12. Kolomiiets, O. H. (2017). *Maintenance of IT clusters development in Ukraine on the basis of venture investment.* (Doctoral dissertation). Rivne: NUWEE. Retrieved from http://ep3.nuwm.edu.ua/6326/1/Дисертація%20Коломієць%20зах.pdf (in Ukr.)
13. Economist Intelligence Unit (2011). *Investment for the Future. Benchmarking IT Industry Competitiveness 2011.* Retrieved from http://globalindex11.bsa.org/upload/key-finding/keyfindings.pdf
14. World Economic Forum (2017). *The Global Competitiveness Report 2016-2017.* Retrieved from https://www.weforum.org/reports/the-global-competitiveness-report-2016-2017-1
15. Ukraine Digital News (2016, April). *IT Ukraine - IT services and software R&D in Europe's rising tech nation.* Version 1.11. Retrieved from http://www.uadn.net/files/ua_hightech.pdf
16. Melnyk, M. I. (Ed.). (2018). *Spatial forms of business organization in Ukraine: tendencies, perspectives and development mechanisms. A Scientific Report.* SI Institute of Regional Research named after M. I. Dolishniy of the NAS of Ukraine. Lviv. Retrieved from http://ird.gov.ua/irdp/p20180301.pdf (in Ukr.)
17. Community of Ukrainian Developers (2018). *Official web-site.* Retrieved from http://dou.ua (in Ukr.)
18. Ministry of Economic Development and Trade of Ukraine (2018). *Invest Ukraine. Open for you.* Retrieved from https://mfa.gov.ua/mediafiles/sites/rei/files/MEDT_Brochure_A4_View.pdf

Received 28.10.2018