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Mechanisms for Forming IT-clusters as "Growth Poles" in Regions of Kazakhstan on the Way to "Industry 4.0"

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Abstract. The main prerequisite for successful innovative development is the natural course of modernization of world industries, currently characterized by the transition to "Industry 4.0", where the main driver is information technology (including digital). With regard to the Kazakhstan economy, the emphasis is increased according to the Message of the President of Khazakhstan Nazarbayev N.A. to the people of Kazakhstan "The Third Modernization of Kazakhstan: Global Competitiveness", dated 31.01.2017. He delivered "the first priority – accelerated technological modernization of the economy". At the same time, an important aspect of accelerated technological modernization is the provision that it is important "to cultivate new industries that are created with the use of digital technology". The purpose for the article is to develop scientific and practical recommendations and effective organizational and economic mechanisms to form IT-clusters in the regions of Kazakhstan on the way to "Industry 4.0".

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Within the framework of the set goal the following main objectives are addressed: research the concept of "growth poles" and the possibility of its use in the formation of an IT-cluster; study the effect of local factors on the IT-cluster formation; present organizational and economic mechanisms to form IT-clusters amid the transition to "Industry 4.0". The fundamental difference between the ideas of this research from the existing similar ones lies in the fact that we formulate and propose scientific provisions concerning the formation of IT-clusters in Kazakhstan, expand the existing knowledge about the development of digital technology, green information and communication technology and the introduction of breakthrough smart projects in IT. The proposed scientific research applies general research methods which help explore and organize the available data through theoretical and practical analysis. In particular, the article implies the application of the following general research methods: generalization (establishing common properties and characteristics of clusters; any features can be identified (abstract-general) or essential); system analysis (study based on review of clusters as an integral set of elements in the set of relations and connections between them); simulation. The article proposes the mechanisms to form IT-clusters as growth poles in the medium and long term, taking into account the requirements of the four-stage model of IT-cluster formation and development (a strictly defined sequence).

Key words: *regions, regional economy, innovative development, cluster, IT-cluster, digital technology, green IT.*

Introduction

Nowadays, Kazakhstan is facing global economic challenges: the geopolitical role it will play in the 21st century depends on it. At the Republican meeting on issues of digitalization in September 13th, 2017, President of Kazakhstan Nazarbayev N.A. noted that **"it is necessary to build cooperation between the government and private enterprises"** and **"to create conditions for wide introduction of digital technology"** [1]. This process can be accelerated only by a better understanding of the global trends in digital technology facing Kazakhstan within the framework of Industry 4.0:

– the first trend is reaching new horizons for increasing operational efficiency;

– the second – the development of breakthrough technology through the introduction of new business models;

– the third – a complete digital transformation of manufacturing companies.

The proposed digital trends of Industry 4.0 suggest the use of new methods of innovative processes organization. It is no accident that such world powers as the US and the EU allocate considerable funds for the implementation of Industry 4.0, especially for IT development and IT personnel training. They view Industry 4.0 as the industrial revolution mainly in terms of productivity and application of energy-saving technologies (green IT). This will lead to the formation of a new competitive environment and fundamental changes in traditional economic sectors.

At the same time, achieving a positive effect from the implementation of the Industry 4.0 model is possible only through digitalization of industrial production – production individualization and adaptation to the needs of enterprises by combining different sources of information. It should be recalled that Industry 3.0 included the automation of individual processes and machines, while Industry 4.0 is a smart factory aimed at complete digitalization of all production processes and their integration into the digital ecosystem taking into account the use of energy – saving technology.

A key success factor in digital transformation is the development of digital culture in industrial enterprises and replacement of the need for human capital (qualified IT specialists) development. Industrial enterprises need to have open access to elements of Industry 4.0 – mobile devices, cloud storage, augmented reality (smart gadgets), geolocation (positioning), advanced interface for interaction between a computer and an individual, 3D printing, Big-Data analysis and advanced algorithms, client profile personification. It is necessary to emphasize that the main problem in digitalization of industrial enterprises will be a great need for IT-environment (carriers of digital culture, which can appear only in the digital society) and the need to develop a knowledge management system in this environment, rather than the choice of new promising technology.

In this regard, it becomes clear that in order to achieve results with the implementation Industry 4.0, the formation of an IT-platform is required: that is, a kind of cluster environment domain – a modern innovation platform of the new generation. The role of such digital IT platforms can be assumed by IT clusters capable of transmitting advanced IT products and IT contents (3D printing, models of digital formations, robotics, fusion of artificial and biological intelligence through mind machine interface, genetic engineering, etc.) to the vast country's periphery. Today, successfully functioning IT clusters create unique opportunities for market ownership in the era of data revolution and global space digitalization.

Therefore, the proposed scientific research is especially relevant now, since its ***purpose*** is *to develop scientific and practical recommendations and effective organizational and economic mechanisms for the formation of IT clusters in the regions of Kazakhstan on the way to Industry 4.0.*

The purpose of the research is fully consistent with the objectives set in the Address of President of Kazakhstan Nazarbayev N.A. – Kazakhstan 2050 Strategy [2], the state program Digital Kazakhstan – 2020 [3], the Concept for the transition of the Republic of Kazakhstan to "green" economy [4] and other government policy documents, which stress the need for the development of new industries using digital technology.

The *research novelty* is provided by the fact that the scientific provisions related to the development of mechanisms for the formation of IT clusters as growth poles in the medium term (increasing business and economic susceptibility to innovation, support for innovative companies, development of science, building human resources and search for leading regions) and in the long term (development of IT business incubators, increased funding, development of horizontal links, creation of an innovation center and attraction of experienced cluster managers) prospects have been developed and substantiated. The research is expected to consider a wide range of issues in the context of knowledge-intensive technology development, introduction of breakthrough smart IT projects and the impact of local factors.

The "growth poles" concept and its possible application in IT cluster formation

In foreign and domestic scientific literature it is widely recognized that for the development of "high" technology in both developed and developing countries it is necessary to identify the drivers, i.e. "growth poles" of innovative growth and have a well-thought-out regional policy to guide them [5, 6]. At the same time, the tools and mechanisms for implementing the effective regional policy are different.

The concept of searching for possible "growth poles" was initially developed for the sectoral structure of the economy, i.e. it was based on the idea that leading industries are able to extend their potential to backward regions. In the future, this concept was developed and extended to other elements of the economic space, in the framework of studying the effects of urban agglomerations, as well as the theory of "innovation diffusion" which notes that any development is born in the center and then extends to the periphery.

Leading Western area studies specialists note that a "growth pole" is agglomeration geographically concentrated and distinguished by intense innovation processes [7]. At the same time, the centers and areas of the economic space with enterprises of leading industries or cluster structures become attraction poles for production factors as they ensure their most efficient application [5]. This leads to the concentration of active enterprises and the formation of "growth poles". Thus, "growth poles" are created in order to intensify economic activities in backward peripheral problem areas; new investment is concentrated in the "growth poles" instead of diluting them throughout the region [8].

With the development of information economy and high-tech industries more and more research focuses on their impact on the spatial structure [9, 10]. At the same time, research in design and explanation of the correlation between the factors of high-tech production location and agglomerations is considerably important. Thus, most of the leading experts in cluster development agree that the concept of "growth poles" should include a set of four elements [11–14]:

– territory's environment and geographical conditions;

– rapidly developing industries (most promising and least expensive for a particular territory);

– sustainably functioning enterprises (basic for region's sectors) and availability of the developed infrastructure;

– region's development programs (implemented in the region, suitable for further development).

Also, some scholars argued that active intervention of the state and local self-government based on a wide range of mechanisms in relation to the cluster policy had a positive impact on the spatial processes of high-tech clusters [15, 16]. Moreover, scholars noted in some publications that the role of the state in supporting the development of high-tech clusters based on "growth poles" should be long-term. The promotion of "growth poles" is impossible without state assistance, including in order to pull depressed regions requiring special attention to the mid level.

Foreign scientific literature widely recognizes that for the development of high-tech breakthrough smart projects in both developed and developing countries it is necessary to identify the drivers ("growth poles") of innovative development and have a well-designed regional policy to guide them [17-19]. At the same time, the tools for implementing the effective regional policy are different. They must accelerate technological upgrading or should be based on new trends, modern incentives and new models of smart projects aimed at intensive interaction through quick communication to address variable and "smart" objectives.

The US experience is of particular relevance with about 16 leading IT clusters. At the same time, most experts recognize that the leading IT cluster is Silicon Valley, which accounts for about a third of all venture capital investment in

the United States [20]. The territory of Silicon Valley is characterized by dense local networks between high-tech companies engaged in design and production of microprocessors, software, mobile devices and other IT products. Today, the US regional authorities consider the development of IT clusters as one of the most important mechanisms for the development of high-tech industries.

Turning to the experience of CIS countries, it should be noted that in Russia, as well as throughout the world, there are no unified tools for identifying and developing high-tech clusters, including IT clusters. Some Russian experts note that most of cluster performance evaluation programs are fragmented and sometimes contradictory [21]. However, there are a lot of Russian scientific studies containing a complex mechanism for revealing sectoral areas which are the most promising from the point of view of high-tech cluster development potential at the regional level [22, 23, 24]. At the same time, special attention is paid to identifying high-tech and knowledge-intensive clusters with distinguishing the possible "growth poles". In addition, the methodology and implementation of the cluster policy in Russia corresponds to the conceptual foundations of foreign IT cluster formation and development. In Russia, particular attention is drawn to the SKOLKOVO IT cluster aimed at supporting and developing a comprehensive ecosystem for the development and commercialization of IT projects.

Thus, it is advisable to start the development by searching for possible "growth poles" which can play the role of high-tech translators on the wide country's periphery. These functions can be assumed by ***IT clusters*** *as growth poles aimed at transfer of high technology and knowledge to the wide country's periphery.* In other words, IT clusters as "growth poles" will not just develop independently, but will spur the development of the entire territory in which they are located. This is achieved through the ability to obtain maximum return on investment in such "growth poles".

We propose to implement practical measures to form a successful IT cluster as a "growth pole" in several successive stages (*Figure*).

Thus, IT cluster formation is a certain system that develops in a strictly defined sequence: that is, completing its development through a number of stages:

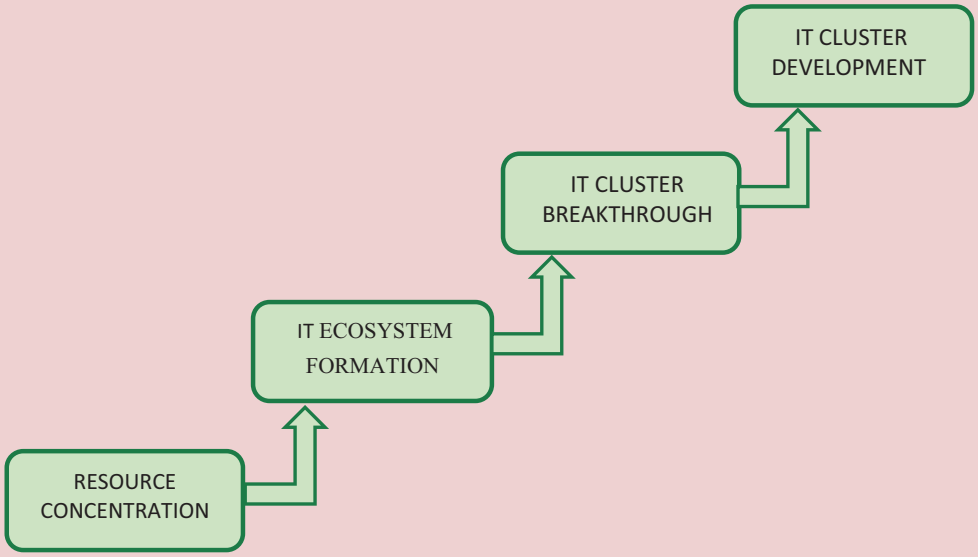
The first stage is the concentration of resources. At this stage, research and innovation capacities are built, entrepreneurial activity is formed, and technological platforms are developed.

The second stage is the formation of the IT ecosystem. At this stage, a symbiosis of technological start-ups, small and medium enterprises, fast-growing innovative business takes place; stable relations are built between high-tech companies; local authorities take up active policy to support innovative entrepreneurship and create the necessary innovation infrastructure (special economic zones, science cities, technoparks, business incubators, technology transfer centers, research organizations).

The third stage is a breakthrough. At this stage, there is a rapid development of fast-growing IT companies with great potential and prospects, attractive to suppliers and service organizations; significant growth of start-up IT companies; formation of market for digital and interactive technology; development of mobile networks and embedded computing.

The fourth stage is mature development. At the last stage, an effective infrastructure to support innovative enterprises and start-up IT

Development model of a successful IT cluster as a growth pole



Source: compiled by the authors.

companies is established, becoming more scalable and technological; the anchor core of the IT cluster is developed; integration into existing and creation of new technological chains based on international cooperation.

The effect of local factors on the IT cluster formation

It should be noted that it is not correct to investigate the problem and propose economic mechanisms for IT cluster formation without dealing with the concept of an IT company. Thus, we can identify several variants of its definition:

1. This company – manufacturer of IT products – produces products such as hardware, computers, device tools, smartphones, digital devices and gadgets, i.e., something that is capital-intensive. Such IT companies are sensitive to changes in national regulation due to built-in financial, physical and capital resources [25].

2. This company – producer of IT content – produces a variety of digital, interactive and multimedia contents, i.e. something that is integrated with a high degree of process automation. Such companies are sensitive to changes in the regulation of their activities, which directly or through customers can reduce their flexibility and mobility [26].

In general, both types of IT companies may be subject to clustering processes. In order to explain the clustering of IT companies, both national and regional conditions are important, including access to highly skilled workforce, capital, developed infrastructure, related industries, and new knowledge.

The peculiar feature of our study is that we distinguish *hard local factors* and *soft local factors*. Hard local factors should be understood as support from the state and local authorities, as well as various institutions for regional development. Soft local factors imply local skilled workforce, developed infrastructure, proximity to universities, etc. The reason is that we expect that hard and soft local factors may not be of much relevance to innovation

and activity of IT companies. In addition, hard and soft factors have a different impact on the clustering processes of IT companies. It can be expected that hard factors are more important than soft factors, especially for IT companies producing IT products. At the same time, soft local factors can be assessed as important for IT companies producing IT content.

Earlier in our research we noted that an IT cluster is a kind of a "startup accelerator", i.e. a modern innovation platform for IT companies, where ideological inspirers, motivated professionals and IT specialists work together on creating and developing new products and services [27].

Modern experts argue that the choice of an IT cluster location is influenced by *the proximity to local educational institutions (universities) and research institutions*, which intensifies cooperation and development of high-tech research [28, 29]. In particular, this concerns the commercialization of new technology and ideas. IT companies often cooperate with leading universities, non-profit organizations and research centers. At the same time, manufacturers of IT products often use public fundamental and applied research in their activities, which intensifies valuable scalable IT products. In turn, IT content companies and service companies may be less dependent on breakthrough innovation and advanced technology since their competitiveness can be ensured through digital technology. For example, the creation of high-tech clusters such as Silicon valley drew attention to the geographical framework of digital technology development, which led to the adoption of various regional strategies for IT development in many cities and countries all over the world [6].

An important aspect in IT cluster construction is a local network between IT products and their demand. On the one hand, low local network density can limit research activity in the IT cluster. On the other hand, low local network density can promote the development of in-house scientific developments which reduce costs and simplify the automation processes. However, high density of local networks does not guarantee that IT companies will take advantage of the commercial potential of existing knowledge and ideas.

Therefore, not all IT companies using available local networks can take advantage of the networks they create. Thus, less potential startups associated with the commercialization of new ideas and knowledge will be established. Moreover, high-density local networks can also be unstable because they increase uncertainty and reduce the ability to accept new ideas and bring them to market.

Therefore, we can formulate *the hypothesis that high-density local networks cause a kind of de-clustering effect*, as they complicate and increase the cost of transfer of new knowledge and ideas.

The hypothesis can be particularly important when forming IT-clusters. Since most IT companies affected by high-density local networks will experience problems in generation of innovation and spread of new ideas, thereby increasing transaction costs. For example, disputes over intellectual property rights and rights to receive royalties may be more likely in high-density local networks, where standards and cultural expectations vary greatly.

At the same time, universities and research institutes in the immediate vicinity of an IT

cluster help IT companies effectively use the available scientific, human and infrastructure resources. This could result in flow of knowledge becoming faster and more transparent, and accelerate the process of knowledge and information sharing.

Mechanisms of IT clusters formation on the way to Industry 4.0

Industry 4.0 high technology such as IT production, increased operating performance, digital transformation and introduction of energy-saving technology, hold out the prospect of becoming the main drivers of innovative development within the decade. Of course, for almost any country, including Kazakhstan, IT cluster formation will be a huge challenge requiring drastic measures from the state and business amid innovation industrialization.

For most manufacturing IT companies a quick approach to the implementation of new technology seems quite risky. Nevertheless, the Industry 4.0 concept is the framework of most modern production processes, affecting the chain of popular IT products and IT content. Therefore, manufacturing IT companies carefully weigh the benefits and risks of introducing new technology.

In our opinion, neglecting the above sequence of IT cluster development will entail huge unjustified costs aimed at solving the objective of the next, not yet prepared stage. At the same time, non-compliance with strict sequence leads, at best, to lack of desired results, and, at worst, to stagnation. Almost all the successfully functioning IT clusters have encountered a certain number of common problems during the development process.

Accordingly, there are tools and mechanisms for their solution, which we have developed and presented.

We propose to consider in detail the main vectors of IT cluster formation as growth poles in the medium term (*Tab. 1*).

The spatial features of technological development of Kazakhstan regions have the following specific characteristics:

– technological multi-structure and multi-branch specialization of economic sectors;

– predominant technology from the 3rd and 4th wave of innovation in the regional economy;

– multifunctional nature of regional management processes;

– significant predominance of monopolized structures and large industrial enterprises;

– limited participation of local governments in management of territory's resource potential development.

As a result, it is possible to identify the main problems of technological development and accelerated technological modernization in Kazakhstan regions.

First, it is the slowdown in transition to new technology of the 5th and 6th wave of innovation.

Second, it is impossible to implement new forms of interaction between regional authorities and economic actors within the system "science–education–production" as a key to creating a national innovation system.

Third, it is difficult to implement the regional policy of structural reforms with the predominance of the process of "fragmented" development of the institutional environment.

Thus, a unified approach to Kazakhstan regions is impossible due to uneven economic space and inter-territorial differences (natural, geographical, socio-demographic, economic, etc.). In turn, there is a need for fundamental changes in approaches to spatial development

Table 1. Mechanisms of IT cluster formation as growth poles in the medium term

No.	Type of tool	Implementation mechanism
1.	Increasing the susceptibility of business and economy to innovation	Increasing investment attractiveness for promising high-tech economic sectors, especially new industries with the use of digital technology. Introduction of a set of measures to implement regional development programs, improvement of legislation (including tax and tariff), as well as assistance in attracting qualified personnel and additional financial resources.
2.	Development of hard local factors	Expanded support for newly established IT companies by state development institutions, including support for small businesses and specific projects within the framework of relevant state regional programs and projects designed for the development of new industries with the use of high technology.
3.	Improving the efficiency of science and education	Effective integration of Kazakhstan science into global scientific community, including the development of competence centers through supporting research institutions, bringing the leading universities and research centers to the global level. Implementation of pilot projects to develop mechanisms to support large-scale innovation programs of business structures, in particular support for cluster initiatives and formation of technology platforms; restructuring of higher education focused on R&D in IT.
4.	Human capacity-building	Activation of human capital by increasing the volume and quality of territorial human capital, improvement of its structure, its intensive development. To activate human capital it is necessary to create new jobs in high-tech and knowledge-intensive economic sectors, stimulate research and support private laboratories in the leading regions.
5.	Searching for leading IT regions	Selection of potential IT clusters as growth poles taking into account the level of innovative development, regional concentration and specialization in IT. The following groups of indicators can be used to draw up a regional map for the formation of cluster zones in IT: – *Krugman Specialization Index (KSI)* is an absolute index of assessment of industry specialization in regions; – *Herfindal-Hirschman Index (HHI)* is a relative measure of specialization in regions, which shows the influence of the agglomeration effect in the region.
Source: compiled by the authors.		

associated with the action of new factors of Industry 4.0 – the formation of "knowledge economy" and strengthening the role of high technology.

While developing the basic mechanisms for IT cluster formation as growth poles in the long-term we considered the requirements to the four-stage model of IT cluster formation and development (strict sequence), uneven territorial development, as well as basic innovation management technology (*Tab. 2*).

In general, the above-mentioned promising areas of IT cluster formation in the form in which they are presented are sufficient for full support and further use in practice. The proposed mechanisms for IT cluster formation include a variety of blocks of related IT sectors.

For most CIS countries, including Kazakhstan, IT development is a new trend to improve competitiveness both at the national and regional level. Therefore, many developed countries have begun to design and implement comprehensive regional programs to develop strategic competencies, centralize numerous virtual data centers and use the opportunities of the IT sector. By 2050, Kazakhstan should strive to enter the top thirty developed countries by GDP. However, this goal is more important for the country's prestige, rather than for improving the competitiveness of the national economy. Undoubtedly, this goal should be reached, but to do it, it is necessary to prioritize the development of high technology on the way to Industry 4.0. It is necessary to realize that at least 80% can be achieved by adapting

Table 2. Mechanisms of formation of IT clusters as growth poles in the long term

No.	Type of tool	Implementation mechanism
1.	Support for scientific research in digital economy development based on using green IT.	In order for Industry 4.to achieve certain results it is necessary to form a new policy of IT development, taking into account the priorities of the Concept for the transition of the Republic of Kazakhstan to "green" economy. Such policy should be based primarily on new trends, modern incentives and models of smart projects (Green Ethernet) aimed at optimizing the production process and efficient use of energy. For example, embedded energy-efficient industrial digital platforms and high-performance industrial servers can be used to reduce energy consumption and increase uptime.
2.	Development of soft local factors	Development of the innovation infrastructure, assistance in employment through training or retraining, support for local universities and research institutions. Coordination of a number of operational procedures at the regional and national level (e.g. promotion of innovation and transfer of new technology; support for R&D projects, training and retraining of IT professionals, etc.).
3.	Networking within an IT cluster	Formation of local relations (including horizontal) between the participants of an IT cluster – independent subjects (groups of subjects) of the innovation process (business – state – science – representatives of the civil society) within the framework of open innovation systems. The main goal for the new IT clusters is catching-up development, such connections compensate for the shortcomings of the institutional environment and are necessary, first of all, to increase the level of mutual trust between the participants of the IT cluster. In mature IT clusters, network and horizontal connections help save time and reduce financial costs for establishing business cooperation and are a catalyst for the development of IT business. It is necessary to strengthen the role of development institutions in order to finance R&D, to systematically increase budget expenditures on R&D.
4.	Creating an efficient infrastructure of an innovation center	An effective infrastructure of an innovation center is not just a building, but an innovative business environment that stimulates the growth of IT companies and is shaped by specific local conditions and needs on the IT market. In mature IT clusters, as cluster cores, it becomes important to create competitive advantages of an IT cluster as a whole and its participants. In particular, through integration in a single space (science, business, government and civil society) in the framework of open innovation systems.
5.	Management and branding (PR) within an IT cluster	Creating a favorable business environment and providing services demanded by IT companies for business maintenance and development. An IT cluster should be considered as a development project, quite specific and focused on production of IT and digital technology. It is very important to follow the four-stage sequence of an IT cluster development, which is a prerequisite for its success. It is also necessary to establish cooperation with the society (in the broadest sense) and its individual elements (business and science), and this is one of the key factors in effective IT cluster development. In particular, successful experience of IT cluster development proves that the choice of an effective strategy for the development of individual brands and PR support is particularly relevant as the number of IT companies increases.
Source: compiled by the authors.		

existing approaches used by successful IT clusters. At the same time, the emphasis on adaptation of existing strategic competencies and technological solutions does not contradict the development of knowledge-intensive industries. Improvement and modification of IT distribution and scaling processes, in turn, will ensure more effective use of ideas of domestic scientists.

Conclusions

Summing up, we should highlight the theoretical and practical significance of the research. The theoretical significance lies in the fact that the ideas put forward in the research and the developed theoretical and methodological provisions can significantly enrich the theory of formation of IT clusters as growth poles focused on transfer of high

technology and knowledge to the wide country's periphery. The practical significance is provided by the fact that the formation of IT clusters can significantly contribute to improving the competitiveness of Kazakhstan economy through using of the above mechanisms both in the medium and long term.

First, the formation of a successful IT cluster is proposed to perform based on previously identified practical activities with several successive stages: resource concen-tration, IT ecosystem formation, breakthrough and mature development. At the same time, the establishment of an IT cluster is possible on the basis of the existing scientific and infrastructure frame-works, which, in turn, is an important factor in GDP growth, as well as in creation of new highly skilled jobs. It is obvious that in Kazakhstan, the development of key scientific and technological competencies in IT meets the interests of the global high-tech market and increases the country's prestige.

Second, it can be achieved through increa-sing demand and productivity in knowledge-intensive economic sectors in terms of IT consumption. In turn, this will have a serious impact on competitiveness through using hard and soft local factors, forming an innovation center and creating the most transparent investment climate

Third, the formation of an IT cluster will contribute to the development of all economic sectors as a result of introduction of digital technology and green IT and using highly qualified personnel. This will have a positive effect on the development of competence centers to support research institutions, bringing leading universities and research center to the global level, as well as transferring entrepreneurial skills and culture to the participants of IT startups.

And finally, due to creating a favorable business environment not aggravated by monopolized structures and a low level of horizontal ties, the IT cluster will be considered as a development project focused on high-tech production. At the same time, it is very important to observe the four-stage sequence of an IT cluster development, which is a necessary condition for its success. It is also necessary to establish cooperation with the society (in the broadest sense) and its individual elements (business and science), and this is one of the key factors in effective development of an IT cluster.

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