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The Impact of ICT Costs on Innovation Activity of Digital Hubs in Regions of Kazakhstan: Universities, SMEs and R&D

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Abstract

Purpose: the study aims to examine the impact of ICT on the formation of digital hubs in regions of Kazakhstan, specifically the influence of ICT costs on the level of innovation activity of enterprises, the number of its actors as legal entities by size and region, small and medium enterprises, universities and research and development organisations. **Research design, data and methodology:** the research methodology is based on the collection of secondary data from the official statistical yearbooks of the Bureau of National Statistics of the Republic of Kazakhstan and the use of quantitative methods, in particular, correlation analysis and multiple regression. Five indicators related to the formation of digital hubs in the regions of the country were selected. **Results:** the study revealed that ICT spending has an impact on the formation of digital hubs in regions, in particular on the development of the number of legitimate enterprises, SMEs and R&D organisations as actors in digital hubs. A positive dynamic in the growth of the number of actors is visible. However, the hypotheses on the impact of ICT costs on the number of universities and the level of innovation activity were not supported. **Conclusions:** based on the results of the study, recommendations such as government proposals on strategy development, funding projects of innovation and digital hubs, and business proposals on engaging local entities in digital transformation for the formation of digital hubs in the country's regions have been developed.

Keywords: Innovation Management, Innovation, Innovation Activity, Digital Hub, Digital Transformation, Distribution of Resources, Businesses, Enterprises

JEL Classification Code: M12, O31, O32, R12

1. Introduction

The global network of social and economic activities enabled by ICT refers to the digital economy. The new economy, characterized by a networked way of coordinating economic relations and based on knowledge, is the digital economy. Digital economy and Industry 4.0 lead to the digital transformation of organisations and the development of the ICT sector. DIHs act as an instrument policy for improving digital transformation of enterprises. Such giant

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companies like Huawei, McKinsey & Company, Oracle, and ZTE prefer the development of ICT and investing in data, technologies, people and processes to increase the innovation activity and innovation of organisations. The development of ICT and innovation of Huawei has made it possible to develop new models of smartphones, televisions and other consumer products. McKinsey focuses on consulting and solving strategic problems by focusing on developing various programs used with the help of ICT for financial and management planning. The company Oracle is known for the development of products for data centers. Zte is engaged in the production of smartphones and telecommunications equipment. A digital hub is a comparatively new concept in the era of digital technologies and Industry 4.0. Digital innovation hub (further - DIH) acts as multi-partner cooperation with the stakeholders and actors such as other organisations, including universities, research institutes, technology organisations, regional and national authorities, investors, chambers of commerce, industry associations, accelerators, incubators, training institutes and regional development agencies (Kalpaka et al., 2020). For instance, Basque digital hub in Spain is ruled by universities, R&D organisations and vocational training centres, offering companies services like testing, assessment of technologies, and scaling up projects. The Egile Group company received support from this hub in developing a high-precision computer-aided surgery system. The Lithuanian Robotics Association runs Lithuanian Robotics DIH and has supported Lithuanian SME Robobend in connection with Danish Robotics. As a result, it got the angel investment and public funding from the connected hub.

Government policies and initiatives of the European Union have been applied to programs “Horizon 2020”, “Digital Europe” and “EU4Digital” in order to become more competitive and achieve the goals of digital transformation and Industry 4.0. Digital innovation hubs are applied in programs as policy instruments for the digital transformation of its actors or local SMEs, enterprises and organisations like technoparks, incubators, scientific institutions, research organisations, laboratories and others. Digital hubs also significantly influence the distribution of resources, knowledge and innovation in business, especially in the field of startups. The critical role of DIH is to provide service portfolios to organisations at local, national and government levels. DIH focuses on a few economic sectors, depending on the region in which it is situated and local infrastructure. It has functions as: 1) test before investing; 2) training; 3) technological operations; 4) finding investors. One of the tasks of functioning DIHs is to support SMEs and local organisations in developing or improving innovations through their products and services. According to the digital hubs, the one feature is that the local organisations may be actors and stakeholders of DIH, so the clients of them. As a result of the supported help, innovations were implemented by the SMEs or other customers with the request to find a solution to a digital hub.

Innovation management focuses on a new way of offering services, new products, or some changes in the product in a new, innovative way. Since 2008, the impressive distribution of R&D and economic expenditures has heightened worldwide (Howells, 2008). Research and development processes are considered the primary source of innovations (Freeman, 1994; Mairesse & Mohnen, 2005; Kireyeva et al., 2022). However, in Kazakhstan, R&D expenditures are comparatively lower than in other developed and developing countries. Innovations in digital hubs are tested through the test-spaces provided by its actors in order to qualify the implementation of a new way of giving service or a new way in the design of the product or other decisions towards the appearing problem, to decide the investor whether to invest money in the project or not. Research and development organisations, science institutions, universities, business start-ups contribute to creating innovations. Digital hub solutions institute innovations through using digital technologies.

ICT plays the distribution role of basement in the concept of Industry 4.0 and specifically, in the formation of digital hubs. Government policies, existing local infrastructure and the development of the ICT sector of the region are the main factors for the formation of DIHs. The processes of digitalisation firstly, are contributed to the ICT factors, including Internet access, computer use, technologies and others. Digitalisation is only possible with ICT, while the digital hubs are only the policy instruments of digitalisation and digital transformation of the organisations. Examining the ICT factors of diverse regions of a country makes it possible to identify the most developed regions to form digital hubs there. That is why the ICT expenditure was chosen as an independent variable in the paper to assess its impact distribution on the number of actors of DIHs: enterprises, active SMEs, universities, R&D organisations and the level of innovation activity of organisations. This study proposes to examine the influence of ICT on the actors of digital hubs, identify various definitions of a digital hub and provide recommendations for policy to enhance the formation of digital hubs in regions.

1.1. Hypothesis

The study aims to test five hypotheses on ICT costs impact on various variables listed below. The hypothesis tested:

H1: ICT costs influence the number of enterprises.
H2: ICT costs influence the number of active SMEs.

H3: ICT costs influence the number of universities.
H4: ICT costs influence the number of R&D organisations.
H5: ICT costs influence the level of innovation activity of organisations.

1.2. Research Question

The current study aims to answer the following research questions:

RQ 1: Have ICT costs impact the number of actors of digital hubs?

RQ 2: What organisation's ICT expenditure influence most?

2. Theoretical Framework and Literature Review

The questions of improvement of ICT, skills in innovation and innovation activities were studied by researchers (Boons et al., 2013; Carayannis & Walter, 2014). ICT was confirmed as a basis for improving and developing the digital economy. Business models and opportunities are still made with ICT (Langley et al., 2021; Cristofaro, 2020). Integration into the global market, facilitating access to innovative assets can be achieved by ICTs (Kostis & Ritala, 2020; Ranta et al., 2021). The following studies (Chege et al., 2020; Yunis et al., 2020) show the positive impact of ICT on organizational productivity. ICT also has an impact on external and internal communication in the innovation activities of companies (Neirotti et al., 2018). Studies on the impact of ICT on small enterprises also describe positive effects on performance, productivity and efficiency (Gërguri-Rashiti et al., 2017; Cuevas-Vargas et al., 2016). Start-up SMEs may need more time to develop ICT and innovation skills like creating a business model, business process, new product, and technology skills (Haneberg, 2021). Innovation today is seen as a continuous development within business operations (Ghezzi & Cavallo, 2020). It was revealed that the higher the diversity of ICT in a local region, the higher the number of innovative enterprises (Colombelli et al., 2016). The higher the ICT expenditure, the more complex the ICT capacity of the industry and the more complex the ICT utilization patterns (Neirotti & Paolucci, 2014). The ICT expenditure variable can be compressed because it explains cross-industry variation in ICT capacity and utilization. The study revealed three types of ICT spending at the industry level: 1) standard, 2) limited capability of deploying ICT, and 3) high-ICT spending (Neirotti & Pesce 2018).

The level of innovative activity is described as the ratio of the number of organizations that carried out technological, organizational, or marketing innovations to the total number of organizations surveyed for a certain period in a country, industry, region, etc. (Baimukhamedova & Baimukhamedov, 2023). ICT and innovation are closely related to the new concept called "digital innovation hub", where with the use of ICT and digital technologies, innovations are made. Organizations that use ICT in products, business processes and services are considered more innovative (Arvanitis, 2013), the theoretical ratio of ICT spending per number of actors in digital hubs. Digital hubs are regarded as another space for the economy and community development. The technological or digital hubs are operated as digital centres, providing the local communities with digital services, including stakeholders such as universities, technological parks, scientific institutions, incubators, accelerators, state government, organizations, medium and small enterprises, and others (Youtie & Shapira, 2008; Hervas-Oliver et al., 2021). Hubs function as spaces where researchers, IT specialists, and other technology-based specialists, managers, and leaders gather to create concrete solutions for problems in the organizations. These hubs are the distribution of resources according to the economic spheres where management uses particular digital technologies. The function of rural areas as a space for digital hub development was investigated by Rundel et al. (2020). Moreover, they suggest three main types of digital hubs. Hubs related to businesses are a combination of private businesses and the development of technological innovations. Hubs developing communities focus on training and improving skills related to digital literacy among the population. The third type combines the first two hubs for business and community purposes. One can concentrate on robotics, while others focus on agriculture using digital technologies such as the Internet of Things. The impact of hubs and services offered by the management may extend to local, regional, and national levels (Atiase et al., 2020).

The services offered by digital hubs include access to the latest technology, expertise, knowledge, testing, experimentation of specific business processes, business models or products and services. One of the main functions of a digital hub is to link with business angels and investors, seek funding for the digitalisation of businesses, and provide a permanent link between users and innovation providers along the value chain. Using digital technologies to improve a particular company's business process contributes to synergies between other key technologies like nano-technology, advanced materials and biotechnology.

The provision of these services is highly relevant for enterprises with relatively low levels of digitalisation, and also for enterprises with insufficient resources and staff to address the challenges of digitisation of enterprise business. When managing the formation of digital hubs, one of the

main factors in the development of hubs is to distribution both on advanced digital technologies and on a specific sector of the economy, for example, construction, agriculture, textiles, education and others. The location of a digital hub and companies in the same region is an important factor for the rapid and effective implementation of tasks that need to be carried out through the use of digital technologies. The definitions of the term "digital hub" is provided in Table 1.

Table 1: The definitions of the term "Digital Innovation Hub"

Source	Definition
Ashmore, F., Price, L., & Deville, J. (2020)	*«…Physical spaces with access to superfast broadband and community and business-oriented services. A physical space, which may be fixed or mobile, focused on digital communication, digital skills and/or new technologies...»*
Casorati, A., & Verbeek, A. (2020)	*«…Important regional coordinators with the participation of many partners: research and technological organizations (NITO), universities, industry associations, chambers of commerce, incubators and accelerators, regional development agencies and governments...»*
European Digital Innovation Hubs in Digital Europe Programme (2020)	*«… A legal entity selected in accordance with Article 16 to perform tasks under the Program, in particular, to directly provide or provide access to technological knowledge and means of experimentation, such as equipment and software that allow the use of digital technologies. transformation of the industry, as well as facilitating access to finance...»*
Kalpaka et al., (2020)	*«…Digital Innovation Hubs are one-stop-shops that help companies become more competitive with regard to their business/production processes, products or services using digital technologies, by providing access to technical expertise and experimentation, so that companies can "test before invest"...»*
Rissola, G. & Sörvik, J. (2018)	*«…a DIH is defined as helping "… companies in the region become more competitive by improving their business/production processes as well as products (and services) by means of digital technology...»*
Roundtable on Digitising European Industry: Working Group 1 - Digital Innovation Hubs, (2017)	*«…A support mechanism that helps companies become more competitive by improving their business/production processes, as well as products and services using digital technologies. DIH acts as a "one-stop shop" helping companies digitize their business in their region and abroad...»*
Sassanelli et al., (2021)	*«…Digital Innovation Hubs (DIHs) have been identified as a strategic means to support companies' digital transformation, especially SMEs, and foster digital technologies' adoption in their business...»*
Virkkunen, R., Still, K., & Rosso, L. (2019)	*«…DIH is designed to become a universal support center for companies, especially SMEs, in their digital transformation. DIHs are multilateral networks or ecosystems that often focus on regional innovation and business development...»*

Source: Organized by authors based on the collected data

Digital innovation hubs serve as critical, regional multi-partner coordinators. They are at the heart of the innovation and digitalisation ecosystem and comprise various organisations, including research and technology organisations (RTOs), universities, industry associations, chambers of commerce, incubators and accelerators, regional development agencies and governments. As a first-line, local access point, they play a critical role in facilitating the digitalisation of European companies across industries and regions. Digital Innovation Hubs (DIHs) are not-for-profit one-stop shops that support companies, notably SMEs, and the public sector in their digital transformation. At the core of the DIH, there is usually a research and technology organisation (RTO) or university lab offering, in collaboration with partners, services such as: 1) Test before invest: Experimentation with new digital technologies – software and hardware (e.g. artificial intelligence, High-Performance Computing, Cybersecurity, Blockchain…) – to understand new opportunities and return on investments; 2) Skills and training to make the most of digital innovations: boot-camps, traineeships, exchange of curricula and training material; 3) Support to find investments; 4) An innovation ecosystem and networking opportunities (Virkkunen et al., 2019).

Several investigations have been into the digital or technological hubs considering ecosystems built to enhance the business. The management of digital hubs spans a broad range of industries and sectors, including those in education (Patterson et al., 2018), agriculture, health, fashion, retail, energy, aviation, and others. The functioning of digital hubs also involves working with global aggregator organizations, and content enterprises like Netflix, Amazon, and Facebook (Van der Aalst et al., 2019) and various cloud services and system integrators such as Google, Yandex, Microsoft, and Oracle (Radovanović et al., 2020).

The peculiarity of managing the formation of digital hubs is to provide a space for competent specialists and professionals in their field to discuss ideas and brainstorm, to provide development of specialist competencies through various creative training programs, events, and hackathons, to test startups, business incubation, to build competitive businesses, thereby developing the socio-economic position of the country's population.

The value and importance of managing the formation and development of digital hubs have been recognized by venture capitalists, stakeholders, and international businesses. They have given considerable funding and attention to these hubs, as they see innovation and business as an integral part of moving forward. This purpose is to encourage future entrepreneurs to create creative ideas and start-ups. For the benefit of international businesses, the

results and outcome of the services provided by digital hubs will serve to create many jobs and generate various sources of income/profits in the mobile industry and ensure business prosperity. Thus, one of the main functions of digital hubs is to create innovation ecosystems (Littlewood & Kiyumbu, 2018; Nzomo et al., 2020; Kolade et al., 2021; ElHoussamy et al., 2020).

In the academic community, most scientists have noted in their research papers that the promotion of business development and innovation contributes to poverty alleviation and is accompanied by economic growth in the long run (Fagerberg, 2009; Hall et al., 2012; Abisuga-Oyekunle et al., 2020). Most prominently, the productivity of digital development is critical in rural areas. However, one major drawback of remote areas is that the population usually underestimates the significance of digital skills, the digitalization of the economy and the development of digital hubs. This is usually because rural areas mostly focus on the possibility of having access to finances. However, the development of the financial sector is doomed without the digitalization of the area (Dyba et al., 2020). As a result of the formation of hubs, citizens are seen through the lens of market players as entrepreneurs and citizens improving their development.

In many developed countries such as Spain, France, and the United Kingdom, universities and research and development organisations are in the role of a head-organisation among other actors of DIHs. Mainly, these stakeholders provide such services as traineeships, laboratories, working spaces, round tables, technological experts, test-spaces and others. Universities graduate specialists in the sphere of innovation management, IT, economics and others, which is one of the main factors in forming DIHs- needed human capital.

SMEs drive economic growth (Wellalage & Locke, 2020). Human resources, capital investments and marketing are some of the main factors influencing the performance of SMEs. The most fostering factor of SMEs' high performance was innovation (Grupp, 1998; Cheng et al., 2013; Kim & Huarng, 2011). Innovations also contribute to the organization staying competitive in the market (Vrontis et al., 2021). Improvement of existing products of SMEs matters in the marketplace. Customers prefer a more prime way of buying products or getting the service. The design, colour, and size of the product matter on the shelves, even the side from where it is easy to buy matters. Innovation is divided into two: 1) incremental innovation (improving some features of the product, some benefits of current technologies) (Tont & Tont, 2016); 2) a new product or technology (Ayyagari et al., 2011).

Digital hubs operate as instruments for implementing digital technologies in business, government, industrial organisations and communities. These hubs are divided by the leading sectors in a region. SMEs, universities and R&D organisations act as main actors of hubs, where the main services are provided (skills and trainings, testbeds, experiments). The main output of services of DIH is innovation. Innovation distribution considers working with the digital economy, technology transfer, commercialisation of intellectual property and strategic innovation management.

Studies on the impact of ICT costs on innovation activities were conducted by a researcher and confirmed that ICT spending has an influence on innovation activities as a supporting factor (Zoroja, 2016). The decline of ICT expenditure during COVID-19 and its better resilience to the crisis was reviewed in a study (Rojko et al., 2022). The authors studied the items of significant expenditure initiatives on GDP (Amiri & Woodside, 2015). The results of this study revealed that ICT works as an efficiency-enhancing technology and web development as a market application had a competitive advantage if there was innovation in the product (Higón, 2011). The uniqueness of this study is that the impact of ICT costs on the innovation activity of digital hubs has not been studied yet.

3. Research Methods and Materials

The research design of the study is based on the provided literature review. It uses quantitative research methods to establish the impact of ICT costs on actors of digital hubs. The methodology of multiple case studies was used in the authors' research (Atiase et al., 2020). The authors used desk-based research and gathered data from reports, hub websites, documents, agencies, and journal papers. The other work authors used literature review methodology for the decade, using matrixes of digital rural hubs and innovative models of rural financing (Dyba et al., 2020). According to the author's study (Hervas-Oliver et al., 2021), interviews of operating ten Spanish digital innovation hubs and using secondary data were selected as the work methodology. The authors provide concrete steps and experience of forming digital hubs, the differences between DIH and EDIH, and the methodology proposed is anchored in good examples (Kalpaka et al., 2020). The role of SMEs in poverty alleviation was highlighted in research by Abisuga-Oyekunle et al. (2020).

The methods of using secondary data to make a situational analysis of SSA were used from official websites and documents of the World Economic Outlooks, World Bank, Africa Economic Outlooks and others. Also, policy initiatives were analysed by creating an environment for the development of innovations. The studies are similar in using secondary data from official documents and websites. In the research, data was gathered from the Bureau of National

Statistics. As dependent variables were chosen, the actors of digital hubs as the number of universities, R&D organisations, SMEs and enterprises, and the level of innovation activity was selected to identify the correlation between the independent variable: ICT costs. Mostly, the studies of digital hubs use qualitative methods as interviews of operating and forming digital hubs, analysing the service portfolio of digital innovation hubs, analysing two-mode network approach to examine the functioning of the enterprises which play the role of digital hubs in regions (Ujwary-Gil & Florek-Paszkowska, 2022), construction of database, Smart Specialisation Platform (S3P) with a rich dataset (Georgescu et al., 2023). However, the role of digital hub actors was not been appropriately investigated yet. This study fills this gap.

The methods of gathering statistical data and correlation analysis were used in the paper.

Correlation analysis is applied in the research, the formula of which is presented below (1):

$$r_{xy} = \frac{\Sigma(x_i - x_{medium})(y_i - y_{medium})}{\sqrt{\Sigma(x_i - x_{medium})^2 * \Sigma(y_i - y_{medium})^2}} \quad (1)$$

where r_{xy} −is Pearson correlation coefficient,
x_i −is the i-th element of the selection x,
y_i −is the i-th element of the selection y,
$x_{medium,}\ y_{medium}$ −are the i-ths elements of the selection x and y.

For the current research following variables were chosen:
y – ICT costs,
x_1 − number of registered legal entities of RK by region and size;
x_2- number of active small and medium-sized enterprises;
x_3- number of higher education organisations;
x_4- number of organisations (enterprises) that carried out R&D, units;
x_5- level of innovation activity, in %.

The data was collected from the official statistical yearbooks of the Bureau of National Statistics of the Republic of Kazakhstan from 2007 to 2021 and were seen in Table 2 below.

Table 2: Description of the study sample

Indicator	Variable	Unit of measurement	Period of time
Y	ICT costs	Million KZT	2007-2021
X1	Number of registered legal entities of RK by region and size	Units	2007-2021
X2	Number of active small and medium-sized enterprises (SMEs)	Units	2007-2021
X3	Number of higher education organisations	Units	2007-2021
X4	Number of organisations (enterprises) that carried out R&D	Units	2007-2021
X5	Level of innovation activity	%	2007-2021

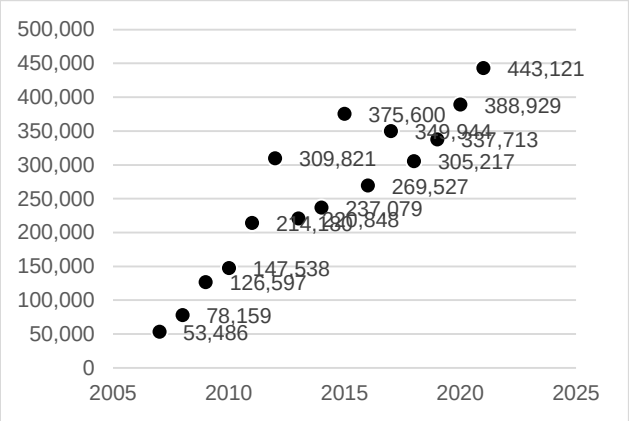
Source: Organized by authors based on the collected data

For the formation of digital hubs, the most significant factor on which lies all the other factors, which is the foundation is ICT sector of regions. Digital hubs implement digital technologies like artificial intelligence, virtual reality, 3D-printing, blockchain, Big Data, robotics, Internet of Things and others, in supporting local SMEs and other customers in digitilising its management, activities and operations. For that reason, ICT factor, exactly ICT costs, which is the basis of digital economy is the most reliable variable. For the X-indicators were selected: X1- number of registered legal entities of RK by region and size, as local business infrastructure in the form of organisations, entities are the stakeholders and customers of DIHs, what can offer such services of DIHs like conducting training courses with business angels, business practitioners, leaders, the variable was selected; X2 - number of active small and medium-sized enterprises, mostly SMEs are the customers of DIHs and DIH act for them as one-stop-shops, offering solution to their concrete request, the variable as number of SMEs is desperately needed; X3 - number of higher education organisations, in European countries universities mostly become the main centre, organisation which is responsible for the work of DIHs, also offer services of trainings with professors, technologists, laboratory space like testers for the upcoming innovations; X4- number of organisations (enterprises) that carried out R&D, in the process of R&D, innovations are the outcome. R&D activities are based on detailed and practised actions, which leads to getting new ways of offering services or products; X5- level of innovation activity, in %. This factor is the final result of organisations and entities, SMEs, concentrated on business and innovation management. To examine how ICT costs affect the level of innovation activity as a result of DIH support, the following was selected.

4. Analysis

The digitalization is one the main priorities of the country to improve on. In order to advance the National plan till 2025 the following principles are highlighted: 1) human-centricity (requests from the problems and needs to improve

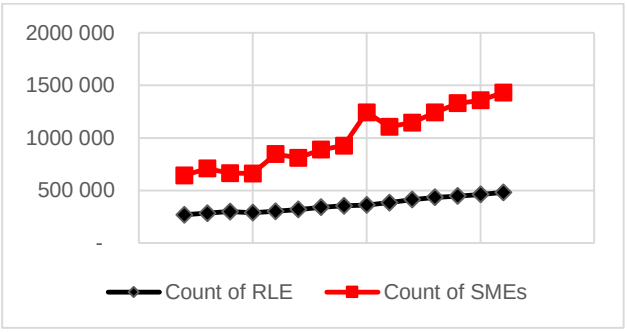
the quality of life); 2) main focus on the results (systematic changes implementing digital technologies); 3) openness and transparency (using digital instruments for direct communication between the people and the state); 4) service approach (evaluation of the work of public authorities by citizens and business via digital tools); 6) flexibility (analysing priorities and trends in achieving goals); 7) Pragmatism (elimination of multiplication of information systems); 8) Trust (digital security and protection of privacy and personal data); 9) Transfer of open data for market use; 10) Transition to horizontal hierarchical systems. In the long-term perspective one of the major purposes is creating conditions for the formation of a culture of technological entrepreneurship, the emergence of smaller companies with high capitalisation in Kazakhstan. The most significant directions for ICT development in Kazakhstan are support SMEs in ICT, increasing the share of local content in the ICT industry, enhancing the level of information security and stimulating domestic developments through import substitution, establishing a priority procedure for purchasing competitive Kazakhstani IT developments in the state and quasi-state sectors. The dynamics of expenditures on digitalisation in Kazakhstan, using ICT as an example, for 2006-2022 is presented in Figure 1 below.



Source: Organized by authors based on the collected data

Figure 1: ICT expenditure for 2006-2022, in mllion KZT

The illustration shows ICT costs in millions KZT from 2006 to 2022. A gradual increase is seen in the figure since 2007, showing 53 486 million KZT. The ICT costs rose to one and a half in 2012, demonstrating 309 821 million KZT, while in 2011, it showed 214 180 million KZT. However, in 2013, the costs were decreased to 220 848 million KZT, adding just 16 231 million KZT for the following year. Then, the cost of ICT doubled in 2015, amounting to 375 600 million KZT. Between 2017 and 2019, the ICT expenditure fluctuated a bit, with a slight increase from 2020 to 2022. The number of SMEs and legal entities is shown in Figure 2 below.



Source: Organized by authors based on the collected data

Figure 2: Number of registered legal entities (RLE) of the Republic of Kazakhstan by region and size and SMEs

Figure 2 illustrates the number of SMEs for the period of 2006-2022. According to Figure 2, it is seen that the number of registered legal entities a bit fluctuated between 2006 and 2010, then increased to the number of 846 111 in 2011. The peak of the number of SMEs was clearly seen in 2015, showing the numbers of 1 242579. In 2016 the amount of small and medium-sized enterprises decreased to 1 106353. Then gradual rise is seen till 2022, illustrating 1 431647, also the number of legal entities by size and region showed gradual increase since 2007 from 268564 to 298028 in 2009, then it is seen a bit decrease in 2010. From 2011 the number of legal entities gradually increased till 2021, showing 481732.

Table 3 shows the number of R&D organisations, number of higher education organisations and level of innovation activity in percentage.

Table 3: The number of higher organisations, R&D organisations and level of innovation activity.

Year	Number of higher education organisations	Number of organisations (enterprises) that carried out R&D	Level of innovation activity, %
2007	167	438	4,8
2008	143	421	4
2009	148	414	4
2010	149	424	4,3
2011	146	412	5,7
2012	139	345	5,7
2013	128	341	8
2014	126	392	8,1
2015	127	390	8,1
2016	125	383	9,3
2017	122	386	9,6
2018	124	384	10,6
2019	125	386	11,3

2020	125	396	11,5
2021	122	438	10,5

Source: Organized by authors based on the collected data

Table 3 illustrates the number of R&D organisations, number of higher education organisations and level of innovation activity in percentage. Table 3 shows that the number of higher education organisations in 2007 was 167, gradually decreasing to 122 in 2021. From 2017, it fluctuated between 122 and 125, while the number of R&D organisations illustrated 438 in 2007, then fell to 421 in 2008. From 2010, the number of R&D organisations gradually fell till 2017, fluctuated a bit and reached the number it was in 2007, 438 in 2021 too.

In the third column, the level of innovation activity in percentage is illustrated. According to the data from the Bureau of National Statistics, it is seen that for the decade and half the level of innovation activity rose by half more, in 2007 showing 4,8 % and in 2021 it showed 10,5 %. In 2013, the percentage of innovation activity of enterprises rose to two and a half, showing 8 %. 11,5 % was seen in 2020, however the percentage decreased to 10, 5 % in 2021.

5. Results

Information coefficients that summarise the data set represented by a sample of the general population or in the entire population represent descriptive statistics on the indicators. By analysing the indicators, statistical inferences about the distribution can be made. The following statistical indicators are used: mean, median, observed min, observed max, standard deviation, excess, kurtosis, skewness, cramer-

von mises the p-value. The table is given below, in which descriptive statistics of the indicators were carried out for the study indicators.

According to Table 4, the average sum of observations is named mean. The highest value shows indicator Y, leaving indicator X5 the least one. The median is calculated by taking two or one number in the middle and calculating its mean. As evident in the table, indicator Y has the highest value, following the second indicator, X2 and leaving the last one, X5. The higher the standard deviation value, the more scattered the values in the sample, thus indicating that the study sample is sufficiently scattered. Cramer's V is a strength measurement of the relationship between two nominal variables. It ranges from 0 to 1, where 0 indicates no relationship between two variables. One indicates the excellent relationship between two variables. Referring to the above table, the Cramer V coefficient of X1-0.294, X5-0, 209, and X4-0, 310, and degrees of freedom = 2 indicate a medium (or "moderate") relationship between the indicators.

Excess kurtosis and skewness are the indicators of normal distribution. Skewness evaluates the extent to which a variable's normal distribution is symmetrical, while excess kurtosis assesses whether the distribution is peaked. According to the normal distribution, skewness parameters between -1 to +1 are assumed as excellent and between -2 to+2 as acceptable, so skewness of the indicator of X3 is assumed as excellent, and indicator Y is evaluated as acceptable. The indicators X1, X2, X4 and X5 have a zero skew, which means they are reasonable if skews are between 0.4 and −0.4, cutoffs for large samples. A negative kurtosis value indicates a flatter distribution, where a positive value indicates a more peak-shaped distribution. The Y indicator shows the highest value of 6.543, which shows a large peak in the distribution. Whereas indicators X1, X2, and X5 have a value of -1, which suggests a flat distribution. When both skewness and excess are close to zero, the pattern of responses is considered a normal distribution (George & Mallery, 2019; Hair et al., 2022).

A measure indicating the presence of a relationship between variables is called Cramer-von Mises p value. A value of 1 indicates perfect relationship while 0 indicates no relationship between nominal variables. The p value of Cramer von Mises is that the null hypothesis (greater than zero) $p > 0.05$ means the distribution is normal and is accepted, the null hypothesis is rejected if the value is less than $p < 0.05$ and indicates non-normality of the distribution (Martínez-Camblor et al., 2014). In current study Cramer von Mises p value are null hypothesis except the indicator X3, which is 0.004. Descriptive statistics of study indicators are presented in Table 4.

Table 4: Descriptive Statistics of Study Indicators

Name	Mean	Median	Observed min	Observed max	Standard deviation	Excess kurtosis	Skewness	Cramer-von Mises p value
Y	4 879545.3	3 098 212	534 858	23 707 936	5 962 418.203	6.543	2.584	0
X1	362 033.8	353 833	268 564	481 732	68 547.113	-1 3	0.353	0.294
X2	1 000 170.9	926 844	643 376	1 431 647	269 674.211	-1 565	0.131	0.167
X3	134.4	127	122	167	13.007	0.663	1.144	0.004
X4	396. 7	392	341	438	27.930	-0 04	-0 453	0.310
X5	67.4	81	4	115	38.164	-1 056	-0 514	0.209
Note: Type of data – MET								

Source: Organized by authors based on the collected data

The results show that ICT costs mostly affect the number of active SMEs and enterprises, leaving behind the number of universities and R&D. The least influenced variable showed innovation activity, which is interesting indeed cause logically, while ICT costs are higher, innovation activity is rising. The coefficient of skewness can help assess the normality of data. In an ideal normal distribution, the skewness coefficient is 0, indicating that the data is symmetric about the mean. However, ideal conditions are rarely encountered in practice, and some deviation from zero is considered acceptable. In this case, most of the coefficients deviate slightly from 0 (the value of 2.584 is very much shifted to the right), so most of the data is usually distributed and therefore, the Pearson correlation coefficient is applied. Table 5 demonstrates correlation matrix.

Table 5: Correlation matrix

Item	Y	X1	X2	X3	X4	X5
Y	1					
X1	0,8704	1				
X2	0,9106	0,9592	1			
X3	-0,8306	-0,8346	-0,8347	1		
X4	-0,3185	-0,1398	-0,1461	0,4703	1	
X5	0,8352	0,9568	0,9445	-0,8500	-0,2875	1

Source: Organized by authors based on the collected data

According to the results of the correlation matrix, it can be seen that the number of active SMEs has a strong direct relationship with ICT expenditure, showing a value of 0.959192. The first variable is slightly behind the second variable, thus also showing a strong direct relationship with the number of registered legal entities, 0.870365. Number of organisations (enterprises) that carried out R&D show a medium direct relationship with ICT expenditures and show a value of 0.47034805. A strong inverse relationship is shown by variable X3 - number of higher education institutions -0.834735272. Weak inverse relationship is shown by the variable of innovation activity level - 0.287539999. This means that mostly ICT costs impact on the number of active SMEs and number of registered legal entities, which are in business sector, leaving behind R&D centres to the medium correlation relationship. However, level of innovation activity and number of universities showed weak and strong inverse correlation relationship, meaning those indicators work for the worse. Table 6 demonstrates regression statistics.

Table 6: Regression statistics.

Item	Meaning
Plural R	0,956518414
R-square	0,914927476
Adjusted R-squared	0,867664963
Standard error	42652,74171
Observations	15

The multiple correlation between two predictor variables and a response variable is Plural R. In this study it indicates 0,956518414. The coefficient of determination is R-Square. The adjusted number of predictor variables in the model is Adjusted R-squared. The mean distance of values moving away from the regression line is called standard error. In this study, the mean distance shows 42652.74171. The sample size of a set of certain data which is used for regression model is called observation. The ANOVA is presented below in Table 7.

T

Item	df	SS	MS	F	Sifnificance F
b Regression	5	176000000000	35217924863	19,35841772	0,000141881
l Residual	9	16373307380	1819256376		
e Totals	14	192000000000			

7 The degree of freedom of regression is equal to the number of regression coefficients - 1. Calculated as the regression MS/residual MS for the regression model is the F **NOVA** tic. The F value represents the p-value from the overall F statistic. The F statistic indicates the significance of the regression model. In this study it indicates 0,000141881, which is less than the usual significance level 0.05 and indicates that the regression model is statistically significant. Table 8 demonstrates overall regression significance.

Table 8: Overall regression significance.

Item	Coefficients	Standard error	t-statistics	P-Value	Bottom 95%	Top 95%
Y-intersection	215829,3386	302910,2745	0,712519042	0,494200147	-469401,3085	901059,9858
X1	1,005747703	0,758889966	1,325287919	0,217732121	-0,710980668	2,722476074
X2	0,522499798	0,161562228	3,234046739	0,010255958	0,157020646	0,88797895
X3	389,9517178	2107,791565	0,185004876	0,857327141	-4378,204069	5158,107504
X4	-1445,624976	614,860955	-2,351141285	0,043224193	-2836,537089	-54,71286215
X5	-42120,43271	18271,84737	-2,305209313	0,046600444	-83454,22311	-786,6423089

With predictor variables held constant, the average increase in the response of a variable per unit increase in the predictor variable interprets each coefficient. The measure of uncertainty in a variable's coefficient estimate is considered the standard error. The coefficient divided by the standard error is considered the t-stat value. The P-value is related to t-stat and shows the significance of the response variable in the model. This suggests that these predictor variables affect the number of actors in digital hubs. The largest and smallest values in the table represent the lower and upper bounds of the 95% confidence interval for the coefficient estimates (Hilbe, 2009).

H
:
H2: ICT costs influence the number of active SMEs – supported.

H
: ICT costs influence the number of universities – not
H4: supported.
- supported.

H5: ICT costs influence the level of innovation activity of organisations – not support.

6. Discussion

According to the first hypothesis, which was proved and accepted, ICT costs influence the number of enterprises, shows for ICT that its expenditure has an impact on the number of active enterprises, showing 0,870365 on the correlation matrix, which is near the 1, and means that these two variables correlate with each other. As ICT is the leading sector of economics, enterprises adhere to a competitive strategy of using technologies in their operation management. For ICT, it shows the growth of the number of enterprises and competitive advantage in making innovations and new products and services in great competition. For the number of enterprises and digital hubs, it investigates that more enterprises raise awareness of new products and innovations, making the competition more robust. Thus, domestic enterprises will contribute to the country's GDP, assessing the digital maturity of enterprises in the digital transformation. In the role of an actor of DIH, enterprises competing with each other will lead to the contribution of DIH support in making new decisions to make innovations. The second hypothesis was proven and accepted, showing for ICT that its expenditure has an influence on the number of active SMEs, presenting 0,959192 as the highest indicator of the correlation matrix among other variables. For ICT expenditure, spending more on the number of SMEs means creating new jobs, falling unemployment, fighting poverty, and the possibility of entrepreneurship.

As an actor of DIH, SMEs and mid-caps are the drivers of the economy, mostly coming to DIH centres to make new decisions using digital technologies. ICT costs influence the number of universities, hypothesis number 3 was unproven and rejected. On the correlation matrix, the indicator showed -0,83474, an inverse direct relationship, which means that ICT costs do not have an impact on the number of universities in the country. As universities, firstly, the higher educational organisations, education is put to 1st priority of the nation. However, there was no correlation seen between variables. In most countries, universities act as a head of digital hubs, and as an actor of DIHs, universities have no diverse relation with the ICT sector. However, it uses their elements in educational processes. The other hypothesis: that ICT costs influence the number of R&D organisations was proven and accepted. On the correlation matrix, it showed 0,470348, about the average. For the ICT sector, development of R&D means more innovations, they, in turn, raise the economy at the regional, national and world levels. For the number of R&D organisations, ICT expenditure also affects the human resources of R&D organisations, commercialization of intellectual property, as a DIH actor, more test sites and a laboratory for research and testing of innovations. The last hypothesis about ICT costs and their impact on the level of innovation activity of organisations was unconfirmed and rejected, showing on the correlation matrix -0,28754, the most minimal correlation indicator. Surprisingly, the costs of ICT do not nearly affect the level of innovation activity of organizations. However, there could be assumptions that ICTs are directly related to innovations and innovative activity.

7. Conclusion

The research purpose is to test five hypotheses on the influence of ICT costs on the innovation activity and actors of digital hubs such as universities, enterprises, SMEs, and R&D. The findings of this study are nearly similar with the studies of researchers Zoroja (2016) and Higón (2011) in the context that ICT costs impact on innovation activities of enterprises, however this research examined the influence of ICT expenditure on the number of actors of digital hubs. Also results show similarity in SMEs contributing to the sustainable development of the economy and serve as drivers for digital transformation (Abisuga-Oyekunle et al., 2020; Georgescu et al., 2023, Kalpaka et al., 2020). Entrepreneurship policy has a positive and negative impact on the development of the region’s economy and on the distribution of resources, knowledge and innovation in business. Depending on assessing only economic and social

indicators, the latter show a more positive effect since weak institutions and entrepreneurs can also have detrimental effects on the economy (Hall et al., 2012). The following authors investigated the role of R&D in innovation and the problems faced (Howells, 2008; Mairesse & Mohnen, 2005). Also, there are studies on the role of universities as education hubs, but not digital one (Youtie & Shapira, 2008). However, universities may become the head organization of the digital hub.

Proposals for the government: to make new strategies on digitalisation and digital innovation hubs as an instrument for digital transformation and distribution of resources. When this proposal is implemented, national and regional projects for the formation of hubs will start to operate, with funds allocated for the projects to be carried out. Second proposal: as ICT costs mostly influence innovation activity of enterprises, SMEs and R&D organisations, searching as public so private investments to these organisations. Third proposal: formation of digital hubs in every region of the country, implementation of the proposal will contribute to the development of digital transformation in the regions, improving the quality of digital services of enterprises, SMEs and others. The fourth proposal is for the state to make funds and supportive finance for forming digital hubs in each region, to purchase equipment, technology, and technical services, and to provide the highest quality services. The fifth proposal: digital awareness and advertisement of digital hubs to local SMEs, enterprises, and R&D organisations through advertising, development of infrastructure in the region, advertising on social networks such as Instagram, Facebook, TikTok and others, subsequently attracting specialists and clients.

Business proposals: the first proposal is to utilize ICT expenditures to acquire the right technologies, and on strategic planning, as planning determines the future visibility of business outcomes. The second proposal: making roundtables of local organisations as an operating infrastructure to form digital hub centres, with the aim of interaction between local infrastructure and heads of organisations to select one organisation as the main one. The third proposal: divide diverse functions of a digital hub into concrete organisations according to the capital they have (human resources, investors, testing places, organising training and others), with the aim of effective interaction between stakeholders to provide services to the organisations. The fourth proposal: assessing the digital maturity of every organisation in the region (actors of digital hubs), aiming to identify gaps in digitalisation to address them. The fifth proposal: making the website of the digital hub with all the services provided on the portfolio to make the digital hub's website available to organisations. The sixth proposal: finding business angels for the start-ups and testing innovations to realise funding for innovations. The seventh proposal: making the network of DIHs in regions and countries, with the aim of cooperation between hubs to improve the digital maturity of organisations. The eighth proposal: making an online platform for currently operating DIHs in Kazakhstan, with the aim of awareness and openness of project implementation.

The lack of data or valid data on existing digital hubs in Kazakhstan indeed results in the need to limit the scope of this study. It may be a significant barrier to identifying a pattern and a relevant relationship.

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