Analysis of the Impact of ICT on Economic Growth: Empirical Data from 16 Regions of Kazakhstan

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Abstract: In the last decade, ICT has significantly impacted economic growth in many developing countries, such as Kazakhstan. In addition, there is practically no analysis of the level of interconnections between the communication infrastructure and economic growth in the regional context. This article will consider the impact on GRP per capita of the following ICT factors: volume of communication services, number of fixed telephone lines, enterprises using computers, enterprises using the Internet, internal costs for R&D by regions, the number of organizations that have created and use new technologies and equipment. The data for the article were collected over ten years, from 2010 to 2020 as part of the dynamic panel data approach, which includes 14 regions and two cities. The initial data were taken from the statistical data of the Bureau of National Statistics of the Republic of Kazakhstan. The methodology used in the article includes the study of the proposed indicators and conducting correlation and regression analysis in the STATA program. The conclusions presented in our work showed that the ICT infrastructure has a significant positive impact on regional development, and the coefficient of elasticity of the ICT infrastructure to regional development is greater than the coefficient of elasticity of the degree of integration. The government can use the results of this study to develop programs to improve regional development.

Keywords: economics; economic growth; ICT; network access; digital technology; region; Kazakhstan

1 Introduction

The COVID-19 pandemic has shown how important the level of development of information and communication technologies (ICT), digital technologies, and access to the network is, all over the world. In recent years, ICTs in everyday life have been present in various fields, such as education, business, culture, finance, etc. The significant role of ICT is due to globalization, structural changes, the continuous growth of technology, and the expansion of opportunities for society to transform information. The development of the level of ICT and its impact on economic growth has increased very rapidly, both in developed and developing countries. However, many scientific studies on this issue have yielded contradictory results related to different research methodologies, geographical diversity, and different specifics of the study. At the same time, new challenges have emerged that require severe measures from the state, businesses, households and change the economic policy of the whole country.

Recently, some scientists have deduced the relationship between telecommunications, the Internet, and economic growth with monetary and human capital [6] [9]. Other scientists argue that the state's economic growth is primarily due to various factors, including the impact of ICT on economic development through access to the network [1] [20] [32]. Most of these studies associate the growth of ICT with the improvement of human capital in the country, improving the quality of educational programs [12] [14]. The next group of scientists believes that economic growth is possible if financial instruments for capital investment appear in the country, leading to industry development [11] [35] [36]. In addition, statistical data on the relationship between GDP growth and various indicators over the past decades suggests that the impact of information technology on economic growth is faster than low.

Despite a lot of work, there is still insufficient evidence of the contribution of ICT to economic growth in developing countries like Kazakhstan. In addition, there is practically no analysis of the level of interconnections between the communication infrastructure and economic growth in the regional context. Based on the statistical data of Kazakhstan, we can talk about the presence of various types of territories according to the degree of accessibility of digital technologies: from the availability of full Internet access in 117 cities and 3324 rural settlements to their complete absence in more than 600 settlements with an average population of 500 people or more.

Therefore, for statistical analysis in this article, panel data were used, including 14 regions and two cities of republican significance from 2010 to 2020. During the construction of the model, which is based on econometric analysis, the difference in the development of ICT technologies between the regional indicators presented in this article is shown.

This article has the following structure: a literary review, the current situation, a methodology that includes a description of the data and the model used, the results

and discussions will be shown in the last chapters of the article, conclusions will be drawn separately.

1.1 The Current State of Development of the ICT Sector in Kazakhstan

The ICT sphere's development level in Kazakhstan is ensured by the state policy to form and develop a single digital space. Nevertheless, an essential condition for the further development of the digitalization of the economy of Kazakhstan is the volume of communication services, the level of development of communications (access to communications), and the availability of the level of productivity of new technologies on which the products of organizations in the information and communication technology sector are formed. Over the period 2010-2020, the share of organizations using computers also increased by two times compared to 2010. Moreover, Kazakhstan's volume of communication services has grown markedly, from 479905.30 KZT to 926626.10 KZT (Figure 1).

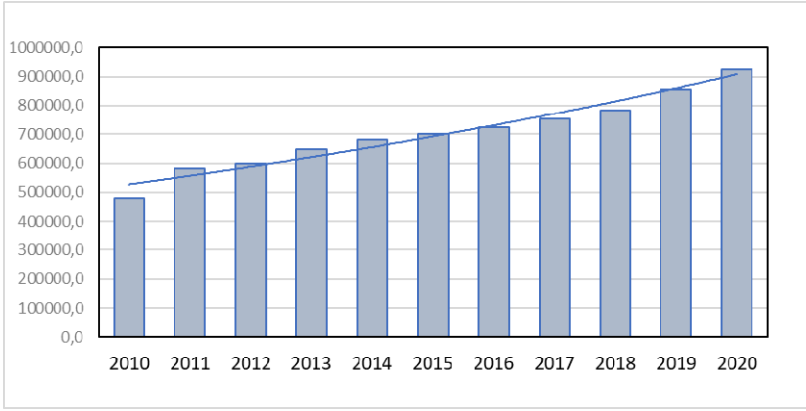

Figure 1
Dynamics of the volume of communication services in Kazakhstan for 2010-2020, in KZT

According to the presented data, it can be seen that the volume of communication services in Kazakhstan has a positive growth trend. At the same time, the growth was achieved due to a significant increase in the population's spending on the Internet and mobile communications. In 2002, about 40% of the total market volume of communication services accounted for Internet services, 25% - for mobile services, and the remainder for other telecommunications services. In addition, the most significant indicators of the volume of communication were shown by the megacities - Almaty and Nur-Sultan. The growth in the volume of digital technologies was facilitated by the stimulation of domestic demand for ICT; the development of e-government and the provision of public services in electronic form; the dissemination of basic skills in the use of information technology, and others.

Thus, information and communication technologies are increasingly penetrating all spheres of society in Kazakhstan. Accordingly, the ICT supply is expanding, and the volume of ICT goods and services is growing. On average, the share of Internet users in 2010-2020 increased annually by 10-15% (Figure 2).

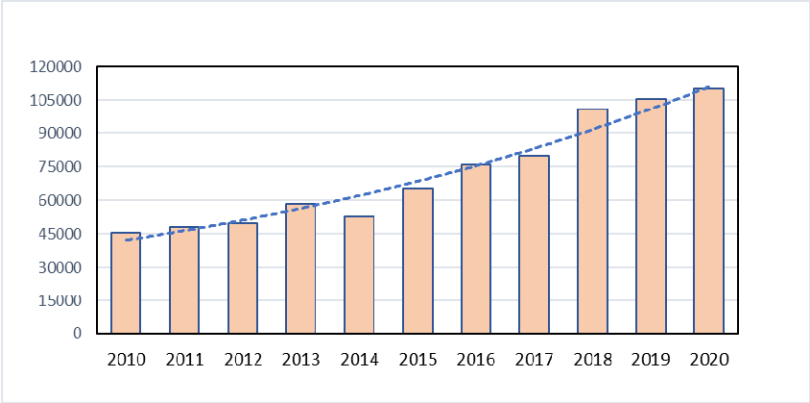

Figure 1

Dynamics of Internet users in organizations in Kazakhstan for 2010-2020

According to the data presented for 2010-2020, it is clear that the share of enterprises using the Internet is overgrowing. This is due to the growing popularity of mobile communications, communication, and telecommunication networks in Kazakhstan. Thus, in 2020 the number of enterprises using the Internet amounted to 110,246, which is two times less than in 2010. Interestingly, the number of users decreased in 2014, but only slightly. The most significant number of enterprises using the Internet is also located in the megacities of Almaty and Nur-Sultan (Table 1).

Table 1

The number of organizations using the Internet in the regions of Kazakhstan for 2010-2020

Region	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Akmola	1677	1840	2203	2659	2818	2782	2906	3008	3183	3347	3636
Aktobe	2912	3410	3300	3581	3165	3721	3484	3714	3981	4101	4049
Almaty	1314	1792	1830	2637	2551	2911	3121	3434	3982	4394	4242
Atyrau	2497	1789	1647	2042	1741	2455	2303	2346	2656	3127	2727
West Kazakhstan	1669	1453	1440	1957	1743	1769	2418	2352	2120	2410	2326
Zhambyl	971	1163	1320	1653	1543	1947	1838	1930	1925	2012	2198
Karaganda	3818	3709	3900	4493	4639	5732	6321	6896	7673	8175	8089
Kostanay	2006	2468	2737	3057	3339	3238	3601	3939	4162	4309	4845
Kyzylorda	1009	1172	1227	1235	1385	1719	1695	1635	1894	1909	1999

Mangystau	2002	2035	2182	3124	1979	2079	1744	2667	2956	2780	2840
South Kazakhstan	2276	2597	3698	3904	2949	3869	4321	4512	8 066	7906	9084
Pavlodar	1874	2129	2284	2761	2805	2979	3691	3770	4104	4370	4653
North Kazakhstan	1632	1745	1762	2226	2266	2294	2500	2852	2999	2939	3494
East Kazakhstan	3287	3772	3988	4249	4135	4148	4452	4940	5375	5351	5769
Nur-Sultan city	3159	3772	3907	4202	4862	5855	9000	10225	21427	22146	20513
Almaty city	13251	13218	12428	14676	10710	17688	22384	21438	24199	26255	29782

Note: compiled by the authors.

Based on the data, it can be concluded that there is an increase in the number of organizations using the Internet in most regions. The highest growth rates over ten years were typical for four areas of Kazakhstan – Almaty city, Nur-Sultan city, South Kazakhstan, and Karaganda. Low indicators of the distribution of the number of organizations using the Internet were recorded in the following regions: Zhambyl, Atyrau, and Western Kazakhstan. An interesting fact is that economically developed regions show low Internet usage rates.

1.2 Related Studies Review

According to the existing references, many scientists focus their research on the importance of economic growth for developing ICT, including digital technologies and network technologies. Moreover, according to the distributed encryption system, economic growth is positively influenced by the country's technological development and innovations actively supported by the state [8] [9]. This statement is supported by other scientists who have noted the importance of digital technologies in modern society [36]. They also found a long-term stable relationship between technological innovations and their determinants on the level of digitalization.

Recently, there have been significant changes in the economic activity of the regions and have an advantage in the development of ICT. Some scientists in their works considered a vital indicator such as telecommunications and the level of Internet penetration within rural areas. Previously, the same strong effect of business development was given by the spread of telecommunication technologies, fixed telephones, fax machines, and many other things. Scientists have also deduced the relationship between telecommunications, the Internet, and economic growth with monetary and human capital [6] [14] [21].

Furthermore, some works note the usefulness of the Internet. It is also evident that it is more expensive for rural areas to conduct and maintain communication systems

than large cities. At the same time, the main problem is that backward regions have weak rural development agencies due to the migration of human capital (9; 18; 30]. Regarding communication services, there are already many indicators describing the main parameters that show the degree of penetration of the digitalization of the economy. For instance, Kurilova and Antipov proposed the following indicators: the level of availability of high-quality Internet connection and other telecommunications; demand among the population for digital products; investments in the knowledge-intensive sphere (R&D, development of robotics and, in general, "Industrial Revolution 4.0") [10] [16] [18] [19] [30].

The high level of technology, the financing of science, and the development of engineering communications form the basis of innovation. Internal R&D expenditures by regions in Kazakhstan are weak due to a reduction in the level of grant funding [25]. In contrast, Kazakhstan has had a historically established and dominant administrative command system for many decades, negatively affecting the economy [18]. In many cases, the financing of innovations gives a positive result. Thus, Xin et al. (2019) and other scientists studied Chinese organizations that create and use new technologies and objects of technology: computers telecommunications equipment [35]. In comparison, R&D financing is positively and statistically associated with corporate bonds, company shares, and increased technology, which positively impacts the social and financial sphere of the state [17] [27] [33].

Other scientists have used the generalized method of the moment growth model to identify the extent of the impact of ICT on financial and economic growth through broadband [4]. Mobile or landline phones are catalysts for economic growth, increase household well-being, reduce inequality, and develop cooperation. At the same time, mobile technologies lead to problems – gambling addiction, reduced confidentiality, more accidents on the roads (in some countries, laws have been passed prohibiting the use of mobile phones while driving), anxiety, and many others [22] [30].

When using a gender approach to mobile phone users, scientists are divided into two camps. Some say that the spread of ICT through mobile phones reduces poverty, especially in rural areas [2] [31]. Others do not find this confirmation in their work. Instead, there is a dependence on the person's digital skills, not gender and location [1].

Scientists have highlighted that ICT positively affects the population's health: easy access to services in a shorter time ensures prompt medical care in time. Digitalization of the education sector also regulates the work of the entire healthcare system, which is a lagging sector of the economy, which is gradually introducing ICT into its activities [3] [5] [13] [16] [26]. At the same time, scientists have found a negative impact of digitalization on people's health: cyber-attacks, privacy violations, false information, and some others [23].

Based on the review of existing video sources, how ICTs affect economic growth.

As can be seen from the related works, there are various factors such as R&D, human capital, access to the network, the production of new technologies that contribute to economic development. In general, there are many works on the chosen research topic. However, there are no thorough studies that consider the influence of factors on regional economic growth, which would provide reliable data for analysis in developing countries. In the next section, we can consider the study's methodology, which will allow us to assess the impact of ICT on regional economic growth.

2 Methodology of Research

The use of ICT requires States to train and retrain highly intellectual human capital with modern digital skills. Moreover, using the example of 45 countries, it has been proved that the indicator of innovation increases in the presence of a skilled workforce [7]. Scientists also believe that skills that contribute to professional development and high staff income lead to an overall increase in the economic indicators of rural regions and the macroeconomic level of the whole country [6] [20]. Many Central Asian countries, including Kazakhstan, have already started training IT specialists and retraining specialists from different fields. In addition, the introduction of digital topics into curricula at all levels of education solves the strategic task of teaching digital skills to the population [15].

To study the impact of ICT on the business sector, some scientists use the DESI Index and the State ICT Development Index (IDI). Both indices include indicators of manufacturability. So the State ICT Development Index (IDI) is calculated based on the number of equipment, the number of equipment and technologies, and the second indicator of the DESI Index is based on qualitative indicators: the type of connection, staff skills, Internet connection speed, the possibility of integration between programs, companies, business and the state, the degree of data protection. The scientist's conclusion showed that some European countries are in stagnation, but Eastern countries have a noticeable technological growth [24].

To eliminate heterogeneity, and specifically consider the elastic value of the impact of infrastructure on the regional development, a double logarithmic OLS regression model at the regional level is constructed accordingly [28] [29]:

$$lnGDP_{\gamma,\tau} = a_0 + a_1 \ln com\ X \ln tel_{\gamma,\tau} + a_2 \ln com\ X \ln Int_{\gamma,\tau} + a_3 \ln RD + a_4 \ln tech + \varepsilon_{\gamma,\tau} = a_0 + a_1 \ln Ifra\ com_{\gamma,\tau} + a_2 \ln Ifra\_ict_{\gamma,\tau} + a_j \sum \ln Controls_{\gamma,\tau} + \varepsilon_{\gamma,\tau} \quad (1)$$

In the formula (1), *lnGRP* - Gross regional product (GRP) per capita in thousand KZT, *lncom* - Volume of communication services in a million KZT, *lntel* - *n*umber of fixed telephone lines, *lncomp* - enterprises using computers in numbers, *lnInt* - enterprises using the Internet in numbers, *lnRD* - internal costs for R&D by regions

in mln. KZT, *lntech* - the number of organizations that have created and used new technologies and equipment, $\ln controls_{r,t}$ contains the control variables that affect the regional development, r and t represent the fixed regional and time effects, respectively, and $\varepsilon_{r,t}$ is random error terms (see Table 2).

Table 2

Variables and their measurements used in the study

No.	Code	Interpretation of indicators
1	lnGRP	Gross regional product (GRP) per capita - thousand KZT
2	lncom	The volume of communication services, million KZT
3	lntel	Number of fixed telephone lines, number
	lncomp	Enterprises using computers, number
4	lnInt	Enterprises using the Internet, number
5	lnRD	Internal costs for R&D by regions - million KZT
6	lntech	The number of organizations that have created and used new technologies and equipment

Note: compiled by the authors

Based on the idea of the SFA stochastic cutting-edge production function model, a calculation model for the integration of communication and information technology is proposed, and a collaborative evolution model of the regional development is constructed. The relative distance between the actual value of information technology and the leading edge constitutes the strength of the promotion of communication technology.

In selecting regional ICT infrastructure, there have been more studies on the number of fixed telephone lines and the scope of communication services to form proxy variables for regional communication infrastructure. The strength of the communication infrastructure constructed in this paper is measured by the regional mobile phone exchange capacity ratio to the region's permanent population at the end of the year. In addition, the rapid development of the Internet has accelerated the integration of the original information, communications, and other industries and brought about drastic substitution effects. To better reflect the level of ICT infrastructure in various regions, the influence of the Internet penetration rate, an ICT infrastructure proxy variable, was investigated in the robustness test.

3 Empirical Results and Analysis

The COVID-19 pandemic has become the biggest challenge for Kazakhstan in the last two decades. The government has introduced quarantine to combat the pandemic, starting with Almaty and Nursultan, and extended it to all regions.

As a result, many areas, cities, urban-type settlements, and rural settlements of Kazakhstan were isolated. At the same time, we had to switch to a forced remote format of work using digital tools and services. However, due to the forced nature, it turned out that not all regions of Kazakhstan have a sufficient level of digitalization development. Based on the current research results, regional economic growth has become the social foundation for integration, and the provincial per capita GRP is used to measure it. It is the comprehensive application ability of composite skills and complex knowledge. In the final analysis, internal R&D costs and New technologies and equipment objects have become an essential factor in promoting the development of the integration.

To obtain a more robust conclusion, all indicators choose 2010-2020-year panel data from 16 regions in Kazakhstan; the primary data are derived from the Bureau of National statistics of the Agency for Strategic planning and reforms of the Republic of Kazakhstan over the years. The calculation indicators of communication infrastructure and ICT infrastructure are derived from the National Statistics Bureau website. Table 3 shows the statistical description of regression variants.

Table 3
The statistical description of regression variants

Variable symbol	Indicator	Mean	Standard deviation	Min. value	Max. value
Regional development					
GRP per capita	Gross regional product per capita	7.743587	0.6965029	6.061457	9.587708
Infrastructure					
Communication	Scope of communication services	9.54666	1.133288	8.099494	13.19283
Telephone	Number of fixed telephone lines	5.357449	0.506978	4.281	6.599
Computers	Number of businesses using computers	8.210211	.6494777	7.167038	10.32466
Internet	Number of organizations using the Internet	5.357449	0.506978	4.281	6.599
R&D	Internal R&D costs	7.267846	1.414747	4.375757	10.43501
Tech	New technologies and equipment objects	3.397634	0.9183592	0	5.713733

Note: compiled by the authors

The coefficient of influence of the strength of the communication in the model is significantly negative at 1%, and the communication infrastructure greatly hinders the degree of integration. According to the theoretical explanation, this is because the promotion of regional development by communication infrastructure is more than informatization.

However, informatization is still at the initial and middle stages of rapid development. It can be seen from this that the communication infrastructure represented by the number of fixed telephone lines and scope of communication services plays a more significant role in promoting regional development, thereby contributing to the faster growth of regions, which led to a more unstable situation between communication and informatization. Consequently, the communication infrastructure hurts the degree of integration. Using models (3) (4) and (5), it is known that the average throughput of mobile telephone exchanges is significantly higher at the level of 1%, and the ICT infrastructure has contributed substantially to increasing the degree of regional development (Table 4). The principle underlying it is similar to the direction of communication infrastructure. The ICT infrastructure has significantly contributed to the development of informatization. Therefore, the speed of informatization development is higher than that of regional development, which effectively eliminates the gap between informatization and communication and allows them to enter a relatively interconnected state of development.

The interaction conditions between communication infrastructure and ICT infrastructure are significantly favorable at the level of 1%. The interaction between two infrastructures with different attributes has an impact and has led to an increased degree of integration. The control variable, internal R&D costs, have a positive effect, while the area receiving the water level is not disturbed, consumption patterns, water level demand, and industry structure are at a high level of adjustment direction when the income level is low, large-scale industrial production of "good price" industrial products for mainstream consumption, people at the lowest prices to get maximum efficiency with a whole foot; as the level of income increases, industrial products should meet the actual requirements of consumers more, and not meet the different nature of consumer demand to promote industrial production in the direction of Mai information into a significant force, starting from consumer demand for pre-testing, to the product of the intellectual output, highly efficient inexpensive information services are provided in shopping areas, information promotion and communication to a more interconnected state. The positive impact of human capital on the degree of integration was also confirmed. Information-based construction requires intensive investment in human capital. The adequate human capital is, the more it contributes to the development of informatization, which can effectively compensate for the lag in the development of informatization and a low degree of integration. Situation. Government intervention hurts the degree of integration. The government's macro-regulation function is shifted towards communication.

It ignores the development of informatization, which has led to a growing gap between communication and informatization, and the degree of integration between them is constantly decreasing. Table 4 shows the main results of the regression.

Table 4
The main results of the regression

Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Infra_com	-0.8887		-1.4790***	24.6513***	20.1333***
Infra_ict		3.5118***	3.5974***	28.4484***	23.8284***
Infra_com X Infra_ict				-6.0408***	-5.0166***
R&D	0.4947***	0.1951***	0.1815***		0.1500***
Tech	0.0107	-0.0025	0.0277		0.0252
Cons	7.5993***	-8.389***	-2.9478	- 108.7316***	-89.6842***
Adj R^2	0.3649	0.2810	0.3614	0.1416	0.2576
F	29.61	117.92	97.18	129.83	88.11

Note: «***», «**», «*» means that the variable is significant at the level of 1%, 5%, and 10%, and the value in parentheses is a standard error; the explanatory variable and the dependent variable are represented as a number.

Testing the model shows that the coefficient of elasticity of the communication infrastructure to the integration efficiency is small, and none of them passed the significance test. This indicates that the contribution of communication infrastructure to the efficiency of integration is insignificant. The main reason is that, although communication infrastructure directly contributes to regional development, on the other hand, it also leads to the fact that the degree of integration has decreased. Consequently, the two effects of communication infrastructure compensate for each other, and the degree and direction of the impact cannot be effectively observed. The value of the infrastructure coefficient ICT is stable and positive, and the values of the coefficients in models (3) and (5) are significant at the level of 1% (Table 4). From the point of view of the elasticity value, the elasticity coefficient of the ICT infrastructure for integration efficiency is greater than the elasticity coefficient of the degree of integration. The main reason is that there are two main ways to increase the efficiency of integration provided by the ICT infrastructure. One is to promote better integration, and the other is to encourage the development of information technology.

The direct results of Table 4 showed that the infrastructure constitutes an important influencing factor for regional development. However, there is also the possibility that the regional development will affect the infrastructure, which will cause a two-way causal relationship and influence the return result. To further observe whether there is a reverse causal relationship, this article uses the timing of Variables

to examine whether the reverse causal relationship causes the impact of infrastructure on regional development. The original time point is reversed; the dependent and control variables are delayed by a period, while the core explanatory variable adopts the current value. In this way, it is tested whether the future explanatory variable can predict the existing dependent variable.

The results show a robust, causal relationship, between the infrastructure and the degree of integration, and there is no inverse causal relationship between the integration performance and the infrastructure. The above research results show a specific reason to worry about the endogenous nature of the problem, and the regional development will objectively promote the development of infrastructure.

To eliminate the endogenous disturbances of the experimental results, this paper uses the second-stage tool variable regression model for re-examination. The results of the time-point test of the variable show that the primary source of endogeneity is the trend factor of the variable; the late stage of explaining the variable is used as a tool variable, which can eliminate and alleviate the endogeneity problem to a large extent - the results of the second-stage tool variable regression model. Excluding the endogenous regression results, it shows that the infrastructure still offers the same trend of change as the actual results for the effects of the regional development variables. The direction of the main variables remains the same, and indicators such as coefficient size and significance are consistent with the regression results in Table 3, indicating that the impact of infrastructure on regional development is relatively stable.

Conclusions

Building on the existing research results, this paper was devoted to studying the impact of ICT on economic growth in the regional context. The results show that the communication infrastructure represented by the volume of communication services and several fixed telephone lines hinders the improvement of the regional development. In contrast, the ICT infrastructure significantly promotes the progress of regional development. The contribution of ICT infrastructure to regional development is not significant. Still, the ICT infrastructure has a significant positive impact on regional development. The elasticity coefficient of the ICT infrastructure to the regional development is greater than the elasticity coefficient of the degree of integration. On the contrary, the promotion effect of ICT infrastructure is greater than that of communication infrastructure. This leads to a result: the more the ICT infrastructure develops, the more it leads to regional development. ICT infrastructure development has effectively eliminated the gap between informatization and industrialization and promoted coordinated action between the two. The “visible hand” how the government can correctly use the baton to promote the development of two-integration has important practical significance and value for Kazakhstan's economic innovation and development, structural adjustment, and industrial transformation and upgrading. Industrial transformation and upgrading are of great importance and value.

In implementing the regional development, the government needs to fully recognize the complexity of integrating the two systems and correctly distinguish the relationship and sub-work of "government and market". Promoting the integration of the two infrastructures of enterprises is not only an old way to promote the regional development of critical enterprises and typical enterprises and allocate development funds. Conversely, the policy effectiveness it brings has yet to be tested. On the other hand, it is not conducive to the development of the majority of small, medium, and micro-enterprises. The policy implication of this article is: correctly divide the direction of the government's efforts, and establish a perfect market competitive environment. When faced with how to promote the regional development and build their optimal competitive arrangements, the government needs less intervention in the strategic integration of the two infrastructures. Still, it invests the primary energy and resources in infrastructure construction and improvement that benefits all enterprises. The government needs to provide a perfect development environment for the grand vision of integrating the two so that enterprises can have a healthy market environment foundation.

The thinking framework of this article will help to improve the understanding of the integration of the infrastructures and promote regional development. The goal is to encourage informatization and achieve a state of mutual promotion, mutual integration, and joint action. At the same time, it is also necessary to achieve higher integration benefits. It is essential to comprehensively consider the aspects of industrial construction, information development, and the improvement of integration. Therefore, the government's integrated infrastructure resources should comprehensively consider the infrastructure needs of many aspects to bring about maximum policy effectiveness. In a nutshell, promoting the improvement of integration is not all part of the infrastructure. Policies should pay attention to the benefits brought about by the integration of the infrastructure.

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