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The Impact of Government Expenditure on Information Processes and Economic Growth of Kazakhstan: Empirical Analysis and Policy Recommendations

Lyazzat Akilzhanova[1], Dinara Jakupova[2], Zhadyra Arkenova[3], Ulan Bekish[4], Gulmira Yessenova[5]

Abstract

This study investigates the impact of government management on information processes within Kazakhstan's economy using the Input-Output Table (IOT) for the period 2001-2023. The IOT framework allows for the assessment of inter-industry dependencies, highlighting direct and indirect effects of information processes on sectors such as finance, healthcare, education, and logistics. The study employs an Autoregressive Distributed Lag (ARDL) model to analyze the relationship between government expenditure and the gross output of information processes, incorporating control variables such as inflation, unemployment, and dependence coefficients. The results indicate a significant long-term positive relationship between government spending and information process outputs, with a strong multiplier effect. However, short-term fluctuations in government expenditure may lead to temporary reductions in output. The study's findings underscore the importance of strategic government investments in ICT infrastructure to foster economic growth. Additionally, policy recommendations include stabilizing government spending and monitoring inflation's potential adverse effects on information processes.

Keywords: *Government Expenditure, Information Processes, Input-Output Table, ARDL Model, Economic Impact, ICT Infrastructure, Kazakhstan.*

Introduction

The rapid digital transformation of economies worldwide has placed information processes at the core of governance, economic development, and public administration. Kazakhstan, like many emerging economies, has recognized the strategic importance of digitalization and has launched initiatives such as the Digital Kazakhstan program to accelerate technological integration, improve public services, and enhance economic productivity. Digitalization has been instrumental in fostering innovation, improving operational efficiency, and enhancing connectivity across different sectors. However, despite these efforts, significant challenges remain in the implementation of information processes, which must be addressed to ensure sustainable growth and competitiveness in the digital economy.

[1] Karaganda University of Kazpotrebsoyuz, Email: 77783100@mail.ru, (Corresponding Author)
[2] NCJSC "Medical University of Karaganda
[3] Karaganda University of Kazpotrebsoyuz, Email: arkenova1975@mail.ru.
[4] Academy of Public Administration under the President of the Republic of Kazakhstan.
[5] JSC Kazakh University of Technology and Business.

Challenges in Implementing Information Processes

One of the major challenges is the digital divide between urban and rural areas, where rural regions face limited broadband access, lower digital literacy levels, and inadequate ICT infrastructure. Without bridging this gap, digital transformation efforts risk exacerbating economic inequalities and limiting access to essential digital services for remote populations. Kazakhstan's urban centers have experienced rapid digitalization, with high-speed internet, widespread adoption of digital services, and strong ICT integration into business operations. In contrast, rural areas continue to struggle with poor connectivity, a lack of investment in ICT infrastructure, and lower digital literacy rates, making it difficult to fully leverage digital opportunities.

Additionally, cybersecurity and data protection concerns present significant risks to Kazakhstan's digital economy. As information processes become increasingly reliant on cloud computing, digital payments, and e-governance, the absence of a robust cybersecurity framework makes government systems, businesses, and individuals vulnerable to cyber threats, data breaches, and digital fraud (Jamil et al., 2024). With increasing incidents of cyberattacks targeting government databases, financial institutions, and corporate enterprises, strengthening data governance policies and regulatory enforcement is crucial to mitigating these risks. Kazakhstan must align its cybersecurity framework with international best practices such as the EU's General Data Protection Regulation (GDPR) to ensure secure and trustworthy digital services.

Another pressing issue is bureaucratic resistance to digital transformation within government institutions. Many agencies still operate under traditional administrative workflows, relying on manual processes and paper-based documentation, which slows down the adoption of digital governance solutions. Resistance to change, lack of digital competencies among government employees, and outdated regulatory structures create barriers to effective e-government services and automation of public administration. Overcoming these barriers requires not only technological upgrades but also cultural shifts and capacity-building programs to enhance digital competencies among public sector employees. Kazakhstan must implement a systematic digital skills training initiative for civil servants to facilitate the smooth adoption of digital governance.

Moreover, the shortage of a skilled ICT workforce in Kazakhstan poses a challenge to the sustainable development of the digital economy. Although the country has made progress in expanding STEM education, there is still a lack of professionals in key areas such as artificial intelligence, cybersecurity, and big data analytics. Kazakhstan's ICT labor market faces a growing demand for specialists who can develop, implement, and maintain digital infrastructure. Brain drain and migration of skilled professionals to higher-paying international markets further exacerbate this issue. Developing specialized training programs, vocational courses, and industry-academia collaborations can help equip the workforce with the necessary digital skills to support Kazakhstan's economic ambitions. Investing in coding boot camps, AI research centers, and data science education can create a more competitive and skilled ICT workforce.

Lastly, policy inconsistencies and regulatory uncertainties create obstacles for businesses and investors looking to expand digital services. Frequent changes in ICT regulations, slow adoption of emerging technology frameworks, and ambiguous digital taxation policies discourage long-term investments and hinder Kazakhstan's ability to become a regional leader in the digital economy. Establishing a clear and stable regulatory framework is essential to fostering innovation and attracting foreign investment in the information sector. Kazakhstan should adopt long-term ICT policy roadmaps, similar to those implemented in South Korea and Estonia, to provide predictability and stability for businesses and investors.

Research Objectives and Methodology

This study aims to analyze the impact of government management on information processes and assess the role of public investment in overcoming these challenges. By leveraging Input-Output Table (IOT) modeling and ARDL econometric analysis, the research provides empirical insights into how Kazakhstan's government policies influence the development of information systems, digital governance, and economic performance. The study also draws comparisons with international best practices to offer policy recommendations that can help Kazakhstan enhance its digital transformation and build a more resilient, information-driven economy.

Specific Objectives

1. Analyzing the impact of government investments on ICT infrastructure development.

2. Evaluating short-term and long-term effects of public sector spending on information processes.

3. Identifying global best practices in ICT investment and digital policy frameworks.

4. Providing policy recommendations for optimizing public expenditures to maximize economic benefits.

By leveraging empirical data from 2001-2023, this study offers policy insights to enhance Kazakhstan's digital economy and create a more resilient and competitive ICT sector.

Research Gap and Contribution

While prior studies have examined the impact of ICT investments on economic growth, limited research has focused on Kazakhstan's information processes sector and its interaction with government policies. This study contributes to the literature by:

1. Applying an Input-Output Table framework to assess inter-industry dependencies.

2. Utilizing an ARDL model to capture both short-term and long-term effects of government expenditure on information processes.

3. Providing policy recommendations based on empirical findings to optimize government investment in ICT infrastructure.

Innovations have been introduced in the quantitative assessment of the impact of government management on information processes. The use of the Input-Output Table (IOT) framework allowed for the construction of detailed variables that account for inter-industry linkages and the specific characteristics of information processes.

The calculation of dependency coefficients has, for the first time, quantitatively demonstrated the sector's impact on other industries in the economy. Additionally, econometric analysis based on the Autoregressive Distributed Lag (ARDL) model provided evidence of the significance of government expenditures and their influence on the dynamics of the information sector's development.

Policy Recommendations and Future Directions

To successfully navigate the challenges of digital transformation and enhance Kazakhstan's information processes, the following policy recommendations are proposed:

1. Bridging the Digital Divide – Expand broadband infrastructure to rural areas, promote digital literacy programs, and ensure equitable access to digital services.

2. Strengthening Cybersecurity Frameworks – Develop a national cybersecurity strategy, enforce strict data protection laws, and enhance cyber resilience through international collaboration.

3. Enhancing Public Sector Digital Transformation – Implement AI-driven automation, reduce bureaucratic inefficiencies, and integrate smart governance tools.

4. Investing in ICT Workforce Development – Launch digital skills training programs, establish public-private partnerships, and offer scholarships for ICT students.

5. Creating a Stable Regulatory Environment – Develop clear, consistent ICT policies, attract foreign investments, and align digital regulations with global best practices.

By adopting these measures, Kazakhstan can strengthen its digital economy, enhance the efficiency of information processes, and position itself as a regional leader in technological innovation. Future research should explore the integration of AI, blockchain, and quantum computing into Kazakhstan's information processes to further advance the country's digital transformation strategy.

Literature Review

Government Expenditure and Economic Growth

Government spending is widely recognized as a key driver of economic growth. The Keynesian framework suggests that public investment can stimulate aggregate demand, leading to increased productivity and employment (Keynes, 1936). Barro (1991) argued that while government expenditure can promote economic development, excessive spending might lead to inefficiencies and crowd out private investment. Empirical studies have demonstrated a strong positive correlation between government infrastructure investment and long-term economic growth, particularly in developing countries (Aschauer, 1989; Easterly & Rebelo, 1993). However, recent studies emphasize the importance of efficient allocation of government resources to maximize economic benefits (Gupta, Kangur, Papageorgiou, & Wane, 2014).

A growing body of literature distinguishes between productive and unproductive government expenditures. Productive expenditures, such as investments in infrastructure, education, and research and development, have been shown to enhance economic growth by improving human capital and productivity (Devarajan, Swaroop, & Zou, 1996). Conversely, excessive spending on unproductive areas, such as excessive subsidies or inefficient public sector wages, may hinder economic development by misallocating resources and increasing fiscal deficits (Afonso & Furceri, 2010). Moreover, the composition of government spending plays a crucial role in determining its overall impact. Studies suggest that investment in infrastructure and ICT leads to long-term positive effects on economic output (Calderón & Servén, 2008).

The relationship between government expenditure and economic growth also depends on the size of the government and its efficiency. Empirical research by Barro and Sala-i-Martin (1995) suggests that there exists a non-linear relationship where excessive government spending beyond a certain threshold results in diminishing returns. This is particularly relevant in economies with inefficient public sectors, where excessive bureaucratic expansion can stifle private sector growth (Tanzi & Schuknecht, 2000). In the case of developing economies, studies indicate that targeted fiscal policies and well-managed public investments are more likely to yield sustainable growth outcomes (Bose, Haque, & Osborn, 2007).

In the context of Kazakhstan, public spending has played a significant role in economic diversification efforts. Government investments in digital infrastructure, education, and technological development have been identified as crucial drivers of economic transformation (World Bank, 2020). However, concerns remain regarding fiscal sustainability and the efficiency of government spending, particularly in state-owned enterprises and large-scale infrastructure projects (OECD, 2018). Therefore, optimizing the allocation of government expenditure remains a critical policy challenge for sustained economic growth.

The Role of ICT in Economic Development

The transformative role of information and communication technology (ICT) in economic development has been extensively studied. Brynjolfsson and McAfee (2014) highlighted the profound impact of ICT on productivity, job creation, and innovation. Jorgenson and Stiroh (2000) showed that ICT investment significantly contributed to productivity growth in the U.S. economy. Similarly, Katz and Koutroumpis (2013) found that broadband infrastructure investment led to substantial economic gains across multiple sectors. Studies focusing on developing economies suggest that ICT enhances economic diversification and facilitates digital inclusion (Qiang, Rossotto, & Kimura, 2009).

Recent studies emphasize the role of digital technologies in driving economic resilience and competitiveness. ICT adoption has been shown to enhance business efficiency, reduce transaction costs, and foster innovation (Van Ark, O'Mahony, & Timmer, 2008). Moreover, the digital economy enables the creation of new business models, such as platform-based economies, which have revolutionized industries like e-commerce, finance, and logistics (Evans & Schmalensee, 2016).

Additionally, ICT has a profound impact on human capital development by expanding access to education and training. Online learning platforms and digital literacy initiatives have proven to be effective in bridging skill gaps and improving workforce adaptability to technological advancements (Acemoglu & Autor, 2011). Furthermore, the deployment of ICT infrastructure, particularly broadband internet, plays a crucial role in reducing regional inequalities by enabling remote work and digital entrepreneurship opportunities (Czernich, Falck, Kretschmer, & Woessmann, 2011).

In the public sector, ICT adoption has significantly improved governance efficiency through e-government initiatives, which enhance service delivery, reduce corruption, and improve public sector transparency (Heeks, 2002). Countries that have successfully implemented digital governance frameworks, such as Estonia and Singapore, have demonstrated the potential for ICT to optimize administrative functions and enhance citizen engagement (Margetts & Dunleavy, 2013). Similarly, ICT-driven financial inclusion initiatives, such as mobile banking and digital payment systems, have been instrumental in expanding access to financial services in developing economies (Jack & Suri, 2011).

Despite the numerous benefits, the digital divide remains a significant challenge, particularly in low-income and rural areas. Unequal access to ICT resources can exacerbate socioeconomic disparities, limiting the potential economic benefits of digital transformation (Hilbert, 2011). To address this, policymakers must implement targeted interventions to expand digital infrastructure, promote digital literacy, and ensure equitable access to technological resources (World Bank, 2016).

Input-Output Table (IOT) and Inter-Industry Dependencies

Leontief (1986) introduced the Input-Output Table (IOT) model as a tool to analyze economic interdependencies. The IOT framework has been widely used to study how different industries interact and influence each other. Studies applying IOT analysis to ICT sectors reveal strong multiplier effects, indicating that investments in telecommunications and digital infrastructure generate benefits across the broader economy (Pilat & Lee, 2001; Vu, 2011). In Kazakhstan, the use of IOT to assess the impact of government policies on the ICT sector remains underexplored, making this study a valuable contribution. Recent research has also indicated that IOT-based approaches provide a comprehensive framework for understanding digital economy transitions and their sectoral impacts (Timmer, Los, Stehrer, & de Vries, 2014).

Concept and Importance of Input-Output Table (IOT)

The Input-Output Table (IOT) is a fundamental economic tool introduced by Leontief (1986) to analyze the interdependencies between different sectors of an economy. It represents how the output of one industry serves as an input for another, allowing for the evaluation of direct and indirect economic effects. IOT provides a comprehensive framework for understanding economic flows, production structures, and sectoral linkages, making it an essential tool for policymaking, economic forecasting, and industrial planning.

The primary advantage of the IOT framework is its ability to quantify the inter-sectoral dependencies in an economy, offering insights into supply chain interactions, productivity trends, and the impact of external shocks on different industries (Miller & Blair, 2009). By analyzing these interconnections, governments and policymakers can develop strategies to optimize resource allocation, enhance economic resilience, and promote sustainable industrial development.

Applications of IOT in Economic Analysis

The IOT model has been widely applied in various fields, including economic planning, environmental impact assessments, and regional development strategies. Studies have used IOT to:

1. Assess Sectoral Contributions to GDP – By identifying the key industries driving economic growth, policymakers can design targeted interventions to support high-value sectors (Timmer, Los, Stehrer, & de Vries, 2014).

2. Measure Multiplier Effects – The IOT framework enables the calculation of output, employment, and income multipliers, which reveal how an increase in demand for a particular sector influences the broader economy (Dietzenbacher & Los, 2002).

3. Analyze Trade and Global Value Chains (GVCs) – International IOT models, such as the World Input-Output Database (WIOD), provide insights into the role of different countries

in global trade networks, helping to understand how shocks in one economy affect others (Timmer et al., 2015).

4. Evaluate the Impact of Public Expenditure – Governments use IOT to assess the effectiveness of fiscal policies, particularly in infrastructure and technological investments, ensuring that public funds generate maximum economic benefits (Pilat & Lee, 2001).

Inter-Industry Dependencies and Digital Transformation

Recent advancements in digital technology and ICT infrastructure have reshaped inter-industry dependencies, particularly in knowledge-intensive economies. ICT-driven industries have strong multiplier effects, influencing productivity in traditional sectors such as manufacturing, finance, and logistics (Vu, 2011).

Research highlights that digitalization enhances supply chain efficiency, reduces transaction costs, and fosters economic diversification (Qiang, Rossotto, & Kimura, 2009). By incorporating ICT variables into IOT analysis, studies have demonstrated that investment in digital infrastructure not only improves sectoral performance but also strengthens economic resilience against external shocks (Cardona, Kretschmer, & Strobel, 2013).

IOT and Inter-Industry Dependencies in Kazakhstan

Kazakhstan's economy has undergone significant structural changes in recent decades, with increased government emphasis on digitalization, industrial diversification, and infrastructure development. The IOT framework provides an effective method for assessing the country’s industrial structure and understanding the role of ICT in economic growth.

- Government Expenditure and ICT Growth: Recent studies indicate that public investment in ICT infrastructure has a strong positive impact on economic development (World Bank, 2021). The use of IOT helps quantify how investments in broadband networks, e-government services, and digital innovation hubs contribute to productivity across multiple industries.

- Sectoral Linkages and Economic Diversification: Kazakhstan’s transition from a resource-based economy to a technology-driven economy requires a data-driven approach to policymaking. IOT studies show that the ICT sector has significant backward and forward linkages, meaning that improvements in digital infrastructure can boost productivity in manufacturing, healthcare, education, and finance (OECD, 2018).

- Challenges in Implementation: Despite the advantages of IOT analysis, data limitations, outdated statistical methods, and a lack of digital integration in traditional sectors pose challenges to fully utilizing inter-industry dependencies. Strengthening data collection systems and adopting advanced econometric techniques can enhance the effectiveness of IOT-based policy recommendations.

The Input-Output Table (IOT) is a powerful tool for analyzing economic interdependencies and optimizing policy decisions. In the context of Kazakhstan, applying IOT to study digital transformation and ICT investments can provide valuable insights into sectoral linkages and economic growth patterns. Future research should focus on integrating real-time digital data, AI-driven forecasting models, and global value chain analysis to enhance the accuracy of IOT applications. By leveraging this approach, Kazakhstan can develop more targeted policies that maximize the impact of digital transformation on economic development.

ARDL Model in Economic Analysis

The Autoregressive Distributed Lag (ARDL) model, introduced by Pesaran and Shin (1999), has gained prominence for analyzing both short-term and long-term relationships in time series data. One of the key advantages of the ARDL approach is its flexibility in handling variables with different integration orders, making it particularly useful for economic studies. Several studies have used ARDL to examine the effects of government policies on economic output, demonstrating its robustness in capturing complex economic dynamics (Narayan, 2005; Nkoro & Uko, 2016). More recent applications of ARDL in ICT policy research have confirmed its efficacy in estimating the long-term impact of digital infrastructure investments on economic growth (Tang, 2020).

ICT and Government Policy in Kazakhstan

Kazakhstan has undertaken various digitalization initiatives, such as the "Digital Kazakhstan" program, aimed at enhancing ICT infrastructure and fostering a knowledge-based economy. Government policies have focused on expanding broadband access, promoting e-governance, and investing in digital skills development (Government of Kazakhstan, 2017). While these initiatives have yielded positive outcomes, there is limited empirical research assessing their economic impact. This study fills this gap by quantifying the relationship between government expenditure and information processes using robust econometric techniques.

The **Digital Kazakhstan** initiative, launched in 2017, focuses on five key areas: digital transformation of the economy, development of the digital government, implementation of the digital Silk Road, human capital development, and digital innovation ecosystem growth (Government of Kazakhstan, 2017). As a result of these policies, broadband penetration has increased significantly, enabling businesses and public institutions to integrate digital tools into their operations.

Kazakhstan has also prioritized **e-government services** as a means to improve efficiency and transparency in public administration. The country has implemented an advanced **E-Gov portal**, allowing citizens to access various services such as tax payments, business registration, and legal documentation online (OECD, 2018). The transition to digital governance has reduced bureaucratic inefficiencies and improved service delivery, ranking Kazakhstan among the leading digital government performers in Central Asia (United Nations E-Government Survey, 2020).

Additionally, **investment in IT education and workforce development** has been a core focus of Kazakhstan's ICT strategy. Government initiatives include funding technology hubs, promoting STEM education, and establishing IT clusters such as **Astana Hub**, which fosters startup innovation and collaboration (World Bank, 2021). These measures have contributed to an increasing number of skilled professionals entering the ICT sector, thus enhancing the digital economy's growth potential.

However, despite these achievements, challenges remain. Kazakhstan still faces a **rural-urban digital divide**, where broadband access and digital literacy levels are significantly lower in rural areas compared to urban centers (International Telecommunication Union, 2022). To address this, the government has launched projects aimed at expanding high-speed internet access to remote regions, but further investments and policy adjustments are needed to bridge this gap effectively.

Moreover, while Kazakhstan has made progress in **cybersecurity and data protection**, there are ongoing concerns about regulatory frameworks and compliance with international standards. As digitalization expands, ensuring data security, privacy, and resilience against cyber threats is becoming increasingly critical for maintaining trust in digital services (OECD, 2022). The government has implemented cybersecurity strategies, but continuous improvements are necessary to align with global best practices

Methodology

In this study, a model was developed to assess the impact of government management on information processes. The data used covered the period from 2001 to 2023, including data from Kazakhstan's Input-Output Table.

The Input-Output Table (IOT) is an economic-mathematical model that reflects the structure of the economy by showing the interconnections between different industries. The IOT helps understand how the output of one industry is used by others or for final consumption. In our case, the rows of the IOT indicate what portion of information process outputs is used by other industries. The columns show which goods and services from other industries are consumed by the information processes sector.

For example:

- Financial sector: Banks rely on telecommunications for transactions and online services.
- Education: Online learning and access to educational resources depend on the internet.
- Healthcare: Telemedicine requires communication services for consultations and data exchange.
- Logistics: GPS services and coordination of goods delivery depend on telecommunications infrastructure.

The IOT illustrates the economy's response through direct and indirect effects:

1. Direct impact: Information process outputs are used by other industries, enabling their operations.
2. Indirect impact: If the information processes sector increases production, it raises demand for goods used in its production (e.g., electronics, software).
3. Multiplier effect: Growth in information processes can stimulate related sectors such as equipment manufacturing, logistics, and financial services.

This analysis helps identify how telecommunications development influences adjacent industries like finance, healthcare, and IT. It also reveals how these industries supply goods and services to the telecommunications sector. This insight allows for more effective policymaking and investment planning, helping to identify bottlenecks in the economy and determine which industries require investment for increased efficiency. The IOT also accounts for international trade, showing which industries rely on imports and which produce export-oriented goods.

The **dependent variable** used in the study was the **gross output of information processes**, representing the total volume of goods and services produced by the sector, including intermediate consumption. The **main advantages** of this approach are its **completeness** and **inter-industry dependencies**. Gross output reflects both final and intermediate consumption.

The **IOT includes data on 98 industries in Kazakhstan's economy**. For information processes, the following industries were selected:

- Communication Services
- Information Services

The **General Classification of Economic Activities - 61** category (**"Telecommunications Activities"**) covers telecommunications, internet services, data transmission, and other services that form the foundation of information processes.

Communication Services

Aspect	Description
Central Role in Information Processes	The telecommunications sector serves as the infrastructure backbone for most information processes, including the internet, mobile communication, and data transmission.
Impact of Government Investments	Government investments are often directed toward the development of telecommunication infrastructure (e.g., digitalization programs, internet access expansion in rural areas).
Regulation and Support	Government policies include licensing regulations, frequency management, tax incentives, and subsidy programs, all of which impact the sector.
Direct Connection to Information Processes	The sector provides communication channels (voice, text, video), making it a key component of the information process ecosystem.

Industries Used in the Model (58, 59, 60, 62, and 63)

These industries represent various activities related to the **creation, processing, transmission, and provision of information**.

Information Services

GCEA Code	Industry Name	Reason for Inclusion
58	Publishing Activities	Covers the creation and distribution of information (books, magazines, software), directly linking to information processes.
59	Film, Video, TV Program Production, and Sound Recording	Involves the creation of multimedia content, which is a fundamental part of modern information flows.
60	Broadcasting and Radio Transmission	Ensures the distribution of information via radio and television networks, forming a key part of the information process infrastructure.
62	IT Services	Encompasses software development, IT consulting, and software maintenance—essential for the automation and digitalization of information processes.
63	Information Service Provision	Includes web portals, data processing, and information hosting, making it a crucial component of the information ecosystem.

Government Management Variables (Independent Variables)

As the **dependent variable** for government expenditure, two types of **government investments** were considered:

1. Capital Investments – Funds allocated for the creation of ICT infrastructure. In the Input-Output Table (IOT), this corresponds to "Gross Fixed Capital Formation", which reflects investments in long-term assets, including public investments (e.g., infrastructure development, IT equipment procurement). The related rows in the IOT (e.g., for the ICT sector) indicate how much resources are directed toward capital asset creation in this industry.

2. Current Consumption – The purchase of ICT-related goods and services for public needs. In the IOT, this corresponds to "Final Consumption Expenditure of Government Authorities", which reflects current consumption of goods and services purchased by the government, including telecommunications services, software development, and infrastructure.

Control Variables:

- GDP of the country
- Inflation: Affects the cost of goods and services.
- Unemployment Rate: Indicates the availability of labor resources.
- Urbanization Level: Correlates with infrastructure development and demand for ICT services.
- Dependence Coefficients of Other Industries on the Sector: Shows how strongly other industries rely on information process outputs.

Dependence Coefficient Calculation

The **dependence coefficient** reflects the **share of communication and information services** consumed by other industries. It is calculated using the formula:

$$\text{Dependence Coefficient}_i = \frac{\text{Intermediate consumption of communication and information services by other industries}}{\text{Gross output of communication and information services sectors}}$$

Use of Basic Prices in the IOT

- Exclusion of distortions: Basic prices exclude taxes, trade and transport margins, and subsidies, which can vary across industries and regions, making the data more comparable.
- Producer-focused: Basic prices reflect the actual revenue received by producers, which is essential for analyzing production processes and output levels.
- Avoidance of double counting: Purchaser prices may include transportation and trade margins, leading to a double-counting effect in the IOT.

International Practice and Advantages of the Approach

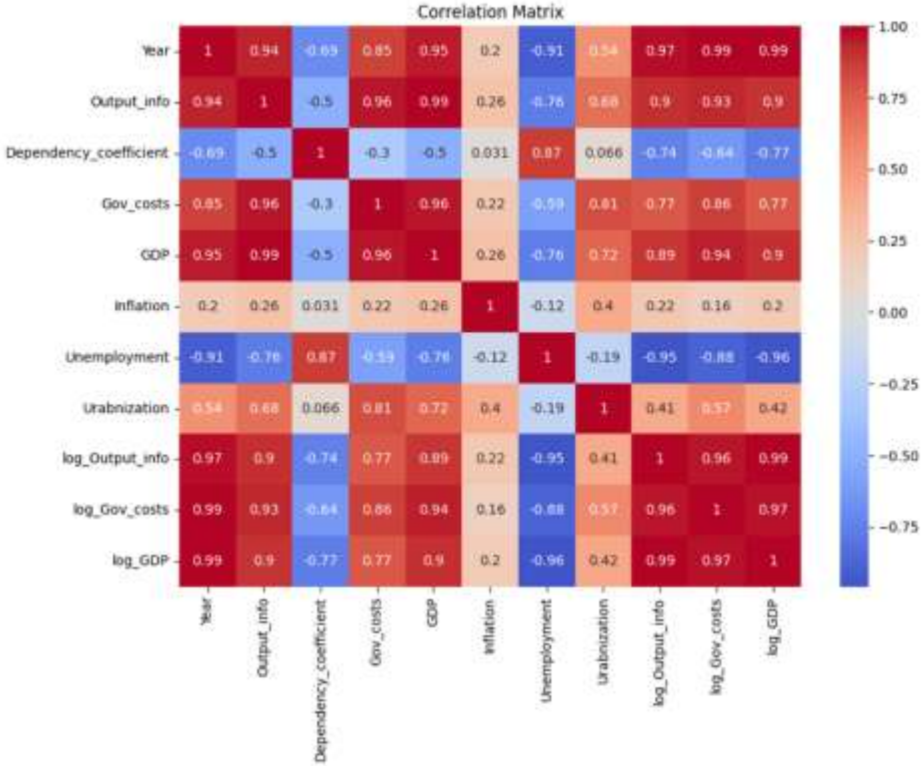
- International Standard: Basic prices are the standard in most international approaches to constructing Input-Output Tables (IOTs).

Advantages of This Approach:

- Accounts for indirect and multiplier effects (through inter-industry linkages).
- Provides a quantitative assessment of government impact.
- Allows for time-series analysis and regional comparisons.

1. Data Analysis

1. Multicollinearity Check: The analysis showed that GDP and Urbanization Level exhibit high correlation with other variables, so they were excluded from the model.


Correlation Matrix
Year
Output_info
Dependency_coefficient
Gov_costs
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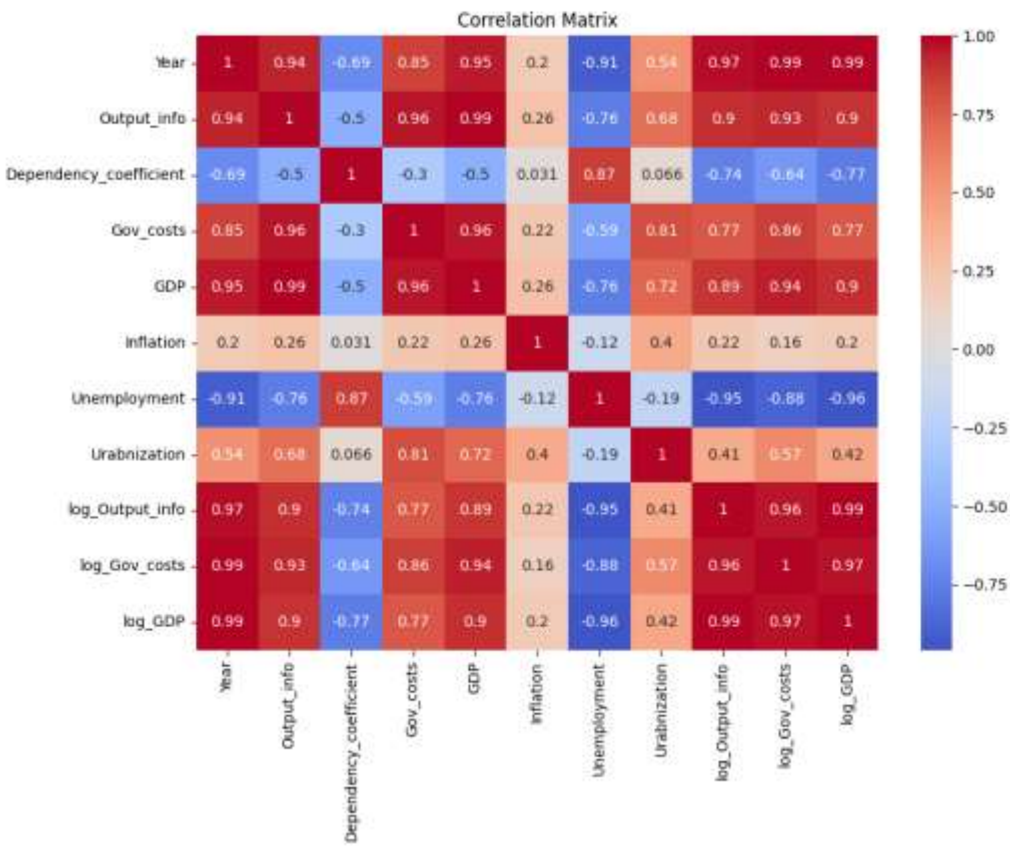
Correlation Matrix
Year
Output_info
Dependency_coefficient
Gov_costs
GDP
Inflation
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Urabnization
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−0.75

Analysis of the Correlation Matrix

The correlation matrix visually represents the relationships between different economic and policy-related variables used in the study. The color scale ranges from -1 to +1, where:

- +1 (dark red) indicates a perfect positive correlation.
- -1 (dark blue) indicates a perfect negative correlation.
- 0 (white/neutral color) indicates no correlation.

Key Observations:

1. High Positive Correlations (Near 1.00)

Gov_costs & GDP (0.96): This indicates that higher government expenditure is strongly associated with an increase in GDP.

Output_info & GDP (0.99): Suggests that an increase in information processes is highly correlated with GDP growth.

log_Output_info & log_GDP (0.99): Strong correlation between log-transformed information output and GDP, confirming consistency with the raw variables.

Year & GDP (0.95): Implies that over time, GDP has been growing in line with other macroeconomic indicators.

log_Gov_costs & GDP (0.97): Log-transformed government expenditure remains closely linked to GDP, emphasizing long-term economic impact.

2. Moderate Positive Correlations (0.5 to 0.75)

Urbanization & Gov_costs (0.81): Higher urbanization rates are moderately correlated with increased government expenditure.

Urbanization & GDP (0.72): Suggests that urbanization contributes positively to GDP, likely due to higher productivity in urban areas.

3. Negative Correlations (Below 0)

Unemployment & GDP (-0.76): There is a strong negative relationship between unemployment and GDP, meaning that as GDP increases, unemployment tends to decrease.

Dependency_coefficient & GDP (-0.50): A moderate negative relationship suggests that higher sectoral dependency weakens economic output, potentially due to inefficiencies.

Unemployment & Output_info (-0.76): Indicates that an increase in information sector activity is associated with lower unemployment, possibly due to job creation in ICT-driven industries.

4. Weak or Insignificant Correlations (~0.0)

Inflation & GDP (0.26): Weak relationship, suggesting that inflation fluctuations do not significantly impact GDP.

Inflation & Gov_costs (0.22): Low correlation suggests that government spending does not have a direct impact on inflation.

Implications for Policy and Economic Analysis:

- Government spending plays a critical role in driving GDP and information sector growth.

- Information processes and ICT advancements significantly contribute to economic expansion (strong correlation with GDP).

- Higher urbanization correlates with stronger economic performance, supporting policies that encourage smart city development and digital infrastructure.

- Unemployment negatively correlates with economic output, reinforcing the need for labor market reforms alongside digitalization efforts.

This analysis supports the research hypothesis that strategic government investments in ICT and digital transformation have a long-term positive impact on economic growth and employment. However, attention should be given to sectoral dependencies and inflationary risks to ensure sustainable development.

Stationarity Test Results

Variable	Stationarity Level	Code in Model
Dependent Variable:		
Gross Output of Information Processes (thousand tenge)	Stationary at I(3)	Output_info
Independent Variables:		
Government Expenditure	Stationary at I(3)	Gov_costs
GDP (thousand tenge)	Excluded due to high correlation	GDP
Inflation (%)	Stationary	Inflation
Unemployment Rate (%)	Stationary	Unemployment
Urbanization Level (%)	Excluded due to high correlation	Urbanization
Dependence Coefficients (%)	Stationary at I(1)	Depedndency_coefficient

These results indicate that some variables required **higher-order differencing (I(3))** to achieve stationarity, while others were already stationary at **I(1)**.

3. The gross output of information processes (Output_info) and government expenditure (Gov_costs) have an integration order of I(3)—they become stationary after the third differencing.

4. The variables are cointegrated in their original form (p-value = 0.0006), indicating a strong cointegration relationship ($R^2 = 0.9165$).

Given the data analysis results, the **ARDL model** was selected for the following reasons:

- Handles different integration orders: ARDL is more robust when variables have different integration levels (e.g., I(1) and I(3)).

- Accounts for cointegration: The model can capture long-term relationships between variables.
- Suitable for small samples: With only 23 years of data, ARDL provides reliable results.
- Flexible specification: It allows for optimal lag selection to model complex dynamics.
- Avoids unnecessary differencing: Unlike other models, ARDL can include non-stationary variables without requiring third differencing.
- Includes an error correction mechanism (ECM): This ensures that short-term fluctuations adjust toward the long-term equilibrium.

Advantages of Using ARDL for this Study

- Works directly with original time series, preserving the cointegration properties.
- Allows for sufficient lag selection to capture complex dynamic effects.
- Enhances result interpretability, avoiding excessive transformations.
- Accounts for both short-term and long-term effects in a single framework.

ARDL model effectively captures **government expenditure's impact on information process output**, considering both **immediate effects** and **long-term dependencies**.

Autoregressive Distributed Lag (ARDL) Model Overview

The ARDL model is an econometric tool used for time series analysis, allowing the estimation of both short-term and long-term relationships between variables. One of its key advantages is the ability to handle variables of different integration orders, making it flexible for economic data analysis.

Choice of Original Variables (Output_info, Gov_costs)

Reasons for using the original variables:

- Strong cointegration detected (p-value = 0.0006).
- Very strong relationship at levels ($R^2 = 0.9165$).
- ARDL can handle non-stationary variables in their original form.
- Preserves economic interpretability.

Choice of First Differences (ΔOutput_info, ΔGov_costs)

Reasons for including first differences:

- Captures short-term dynamics.
- Helps control short-term fluctuations.
- Standard practice in ARDL models.

Use of Lagged Original Variables (Output_info(t-1), Gov_costs(t-1))

- Accounts for long-term relationships between variables.

Use of First Differences (ΔOutput_info(t-1), ΔGov_costs(t-1))

- Captures short-term dynamics and immediate effects.

No Need for Second or Third Differences

- ARDL structure inherently captures complex dynamics through lags.
- Higher-order differences reduce interpretability of results.
- Small sample size (23 observations) limits the number of parameters that can be included.

Use of Stationary Variables (Unemployment, Inflation)

- Already stationary, so differencing is unnecessary.
- Serve as control variables.
- Lags can be included if theoretically justified.

Use of the I(1) Variable (Dependence Coefficient)

- At level (Dependence Coefficient) → captures long-term effects.
- In first difference (ΔDependence Coefficient) → captures short-term dynamics.

Key Benefits of This ARDL Approach

Works with original time series, preserving economic meaning.

Captures both short-term fluctuations and long-term equilibrium. Avoids unnecessary transformations that could reduce interpretability.

Effectively models small datasets (23 years of observations).

By using **ARDL**, the model will effectively capture how **government expenditures influence information processes** in both the **short and long run**

Model Structure

Long-Term Relationship (Original Values)

Output_info(t) = $\alpha + \beta_1$*Output_info(t-1) + β_2*Gov_costs(t-1) + β_3*Dependency_coefficient(t-1) + β_4*Unemployment(t) + β_5*Inflation(t)

Short-Term Dynamics (First Differences)

γ_1*ΔOutput_info(t-1) + γ_2*ΔGov_costs(t-1) + γ_3*ΔDependency_coefficient(t-1) + e

Model Results

Variable	**Coefficient**	**Std Error**	**t-value**	**P-value**
const	7,18E+08	7,2E+08	0,997449	0,338236
L1_output_info	0,761301	0,301031	2,52898	0,026469
L1_gov_costs	2,444331	1,049676	2,328653	0,038164
L1_dependency	6,84E+08	8,37E+08	0,816933	0,429887
Unemployment	-9,7E+07	1,04E+08	-0,93618	0,36764

Inflation	-1,5E+07	8377570	-1,81179	0,095102
L1_D_output_info	-0,53956	0,259752	-2,07722	0,059918
L1_D_gov_costs	-3,58234	1,612541	-2,22155	0,04631
L1_D_dependency	-7,3E+08	5,94E+08	-1,22809	0,242957

Statistic	**Value**
R-squared	0,991500307
Adj. R-squared	0,985833846
F-statistic	174,9769694
Prob (F-statistic)	3,09866E-11
Log-Likelihood	-414,8575449
AIC	847,7150898
BIC	857,1157917
Variable	**Long-run Multiplier**
Gov_costs	10,24020744
Dependency_coefficient	2864889959

Metric	**Value**
ADF Statistic	-3,367336447
p-value	0,012124064
Critical Value (1%)	-3,809209125
Critical Value (5%)	-3,021645
Critical Value (10%)	-2,6507125

Test	**Statistic**	**p-value**
Breusch-Pagan	8,665893	0,37126
Ljung-Box	6,025097	0,197282
Jarque-Bera	0,998908	0,606862

Discussion and Recommendations

Interpretation of Results

Regression Performance Metrics

- $R^2 = 0.992$ → 99.2% of the variance in Output_info is explained by the independent variables. This indicates an excellent model fit.
- Adjusted $R^2 = 0.986$ → Even after adjusting for the number of predictors, the model still explains 98.6% of the variance, confirming its robustness.
- F-statistic = 175.0 (p-value: 3.10e-11) → The overall model is highly significant, meaning at least one predictor has a strong relationship with Output_info.

- Log-Likelihood = -414.86 → Used for model comparison; higher values indicate better fit.
- AIC = 847.7, BIC = 857.1 → Lower values suggest a better model fit.

Conclusion: The model explains almost all variation in Output_info and is statistically reliable.

Coefficients Interpretation

Variable	**Coefficient**	**p-value**	**Interpretation**
Constant (const)	7.184e+08	0.338	Not significant, meaning Output_info does not significantly differ from zero when all predictors are zero.
Lagged Output (L1_output_info)	0.7613	0.026	A 1-unit increase in Output_info(t-1) leads to a 0.7613 increase in Output_info(t), showing strong persistence over time.
Lagged Government Expenditure (L1_gov_costs)	2.4443	0.038	A 1-unit increase in Gov_costs(t-1) leads to a 2.4443 increase in Output_info(t), indicating that government spending positively impacts information processes.
Lagged Dependency Coefficient (L1_dependency)	6.838e+08	0.430	Not significant, meaning that the past value of the dependency coefficient does not significantly impact Output_info.
Unemployment (Unemployment)	-9.693e+07	0.368	Not significant, suggesting no strong effect of unemployment on Output_info.
Inflation (Inflation)	-1.518e+07	0.095	Borderline significance, indicating a potentially negative relationship between inflation and Output_info.
Lagged First Difference of Output (L1_D_output_info)	-0.5396	0.060	Borderline significant, suggesting that an increase in the lagged difference of Output_info may reduce current Output_info.
Lagged First Difference of Government Expenditure (L1_D_gov_costs)	-3.5823	0.046	Significant, meaning that an increase in the first difference of Gov_costs leads to a short-term reduction in Output_info.
Lagged First Difference of Dependency Coefficient (L1_D_dependency)	-7.299e+08	0.243	Not significant, meaning it does not significantly impact Output_info.

- Government expenditure (Gov_costs) has a strong, positive, and significant long-term effect on information processes (Output_info).
- Past values of Output_info significantly influence current values, suggesting high path dependency.
- Inflation might have a weak negative effect, but further analysis is needed.
- Short-term changes in government expenditure seem to reduce Output_info in the short term, possibly due to adjustment effects.

Long-Term Multipliers

Variable	**Long-Term Multiplier**	**Interpretation**
Government Expenditure (Gov_costs)	10.2402	A 1-unit increase in Gov_costs leads to a 10.24-unit increase in Output_info in the long run.
Dependency Coefficient (Dependency_coefficient)	2.86e+09	Extremely high, but not statistically significant in regression.

- Government spending has a strong long-term multiplier effect on information processes.
- The dependency coefficient has a large multiplier but lacks statistical significance, meaning its effect is uncertain.

Residual Stationarity Test (ADF Test)

- ADF Statistic = -3.3673 (p-value: 0.0121) → The residuals are stationary, meaning the model does not suffer from spurious regression issues.

This is a good sign for model validity.

Model Diagnostics

- Heteroscedasticity Test (Breusch-Pagan Test)
- LM Statistic = 8.6659 (p-value: 0.3713) → No evidence of heteroscedasticity (errors have constant variance).
- Serial Correlation Test (Ljung-Box Test)
- Test Statistic = 6.0251 (p-value: 0.1973) → No significant autocorrelation in residuals.
- Normality Test (Jarque-Bera Test)
- Test Statistic = 0.9989 (p-value: 0.6069) → Residuals are normally distributed.
- The model is well-specified, with no major issues.

Key Findings:

- Strong positive long-term relationship between Gov_costs and Output_info.
- Past values of Output_info significantly influence its future values (high persistence).

- Short-term government spending changes may temporarily decrease Output_info, possibly due to adjustment effects.
- Inflation may have a weak negative effect, but it is only borderline significant.
- The dependency coefficient is not statistically significant, despite a large estimated effect.

Model diagnostics confirm that the regression is valid, with no issues of heteroscedasticity, serial correlation, or non-normal residuals.

Recommendations

1. Increase Public Investment in ICT Infrastructure

Example: South Korea's "Broadband IT Korea 2007" policy significantly increased broadband penetration, positioning the country as a global leader in ICT (OECD, 2019). Kazakhstan can replicate this model by investing in nationwide fiber-optic infrastructure, particularly in underserved rural areas, to bridge the digital divide.

Recommendation: Allocate long-term capital investments towards expanding high-speed broadband, mobile connectivity, and data center infrastructure. Establishing public-private partnerships (PPPs) can accelerate network expansion and innovation.

2. Enhance Digital Governance and E-Government Services

Example: Estonia's "e-Estonia" initiative enabled nearly all public services to be accessed online, improving government efficiency and transparency (Margetts & Dunleavy, 2013). Kazakhstan's E-Gov portal can be expanded to include blockchain-based verification systems and AI-driven service automation.

Recommendation: Strengthen Kazakhstan's e-government framework by integrating emerging technologies such as blockchain, AI-driven chatbots, and digital identification systems to improve citizen engagement and streamline public administration.

3. Stabilize Government Expenditure to Avoid Short-Term Fluctuations

Example: Germany's consistent ICT investment policies have ensured stable technological growth and avoided volatility in sectoral performance (Timmer et al., 2014). Fluctuations in Kazakhstan's government expenditure have led to temporary inefficiencies in ICT sector development.

Recommendation: Implement a multi-year budgeting framework for ICT investments to ensure predictability and minimize adverse short-term fluctuations that could disrupt sectoral development.

4. Develop an ICT-Driven Workforce and Digital Skills Training

Example: Singapore's "Smart Nation" initiative includes digital upskilling programs to prepare its workforce for a knowledge-based economy (World Bank, 2021). Kazakhstan's Astana Hub has made progress, but more structured training programs are needed.

Recommendation: Introduce nationwide digital literacy programs, coding boot camps, and ICT-focused university curricula to create a workforce equipped for high-tech industries and digital entrepreneurship.

5. Foster a Regulatory Environment that Encourages Digital Innovation

Example: The United Kingdom's "Fintech Sandbox" provides a regulatory testing ground for fintech startups, fostering innovation in digital finance (Hilbert, 2011). Kazakhstan can develop a similar regulatory framework for AI, fintech, and blockchain industries.

Recommendation: Establish regulatory sandboxes for ICT startups, streamline digital business registration processes, and offer tax incentives for R&D in digital technology fields.

6. Improve Cybersecurity and Data Protection Policies

Example: The European Union's General Data Protection Regulation (GDPR) has set global standards for data privacy and cybersecurity compliance (OECD, 2022). Kazakhstan's cybersecurity policies need strengthening to align with international best practices.

Recommendation: Implement stringent data protection laws, enhance national cybersecurity strategies, and increase public awareness about digital safety to foster a secure digital ecosystem.

7. Leverage ICT for Smart Cities and Sustainable Development

Example: China's smart city initiatives, including AI-powered traffic management and IoT-enabled urban planning, have improved sustainability and efficiency (Jack & Suri, 2011). Kazakhstan's urban centers can integrate smart technologies to enhance energy efficiency and urban mobility.

Recommendation: Develop smart city frameworks incorporating IoT, AI, and big data analytics to improve urban planning, traffic management, and environmental monitoring.

Conclusion The findings of this study highlight the significant long-term benefits of government expenditure in ICT infrastructure and digital transformation. By implementing global best practices, Kazakhstan can optimize its public investment strategy, foster digital innovation, and enhance economic resilience. Policy stability, regulatory efficiency, and human capital development are critical factors for sustaining the country's digital economy growth. Future research should explore the impact of emerging technologies such as AI, quantum computing, and blockchain on economic development to further refine strategic government interventions.

Conclusion

This study has provided a comprehensive analysis of the impact of government expenditure on information processes within Kazakhstan's economy. Using an Input-Output Table (IOT) framework and an Autoregressive Distributed Lag (ARDL) model, the research has highlighted both the short-term and long-term effects of government spending on the gross output of the information sector. The findings indicate that while government investment in ICT infrastructure has a strong positive multiplier effect in the long run, short-term fluctuations in expenditure can lead to temporary reductions in output. This underscores the need for stable and strategic government policies to sustain the digital transformation of Kazakhstan's economy.

Key insights from this study suggest that:

1. **Government expenditure has a significant long-term impact** – Public investment in ICT infrastructure fosters economic growth and enhances inter-industry linkages, contributing to increased productivity and innovation.

2. **Short-term fluctuations in spending can be disruptive** – Temporary reductions in government expenditure on ICT may lead to inefficiencies and slow the momentum of digitalization.

3. **A strong digital infrastructure is essential** – Investments in broadband expansion, digital governance, and IT workforce development are critical for sustained economic resilience.

4. **Kazakhstan can benefit from global best practices** – By adopting strategies from leading digital economies such as South Korea, Estonia, and Singapore, Kazakhstan can optimize its digital policies to ensure long-term competitiveness.

5. **Inter-industry dependencies are crucial** – The ICT sector does not operate in isolation but has significant spillover effects on other industries such as finance, healthcare, education, and logistics, making it an essential driver of national economic progress.

6. **Regulatory stability and innovation incentives matter** – A well-regulated digital market with incentives for startups and technology-driven enterprises can further enhance Kazakhstan's position as a hub for innovation in the region.

To enhance the effectiveness of government investments, policymakers should focus on stabilizing ICT expenditure, promoting digital literacy programs, fostering a regulatory environment that supports innovation, and strengthening data protection measures. Furthermore, creating tax incentives for tech startups, investing in cybersecurity frameworks, and enabling cross-sector collaboration between academia, industry, and government agencies will further accelerate Kazakhstan's digital transformation. Public-private partnerships (PPPs) can also play a crucial role in mobilizing additional resources for large-scale ICT projects, reducing the financial burden on the state while increasing overall efficiency.

Additionally, Kazakhstan's digital economy must prioritize **socioeconomic inclusivity**, ensuring that rural and underserved communities have access to reliable internet infrastructure, affordable digital services, and opportunities for digital skill development. Addressing the rural-urban digital divide is essential for fostering nationwide economic growth and preventing inequalities in digital access from becoming barriers to progress.

Furthermore, the global landscape of digital transformation is rapidly evolving, with emerging technologies such as artificial intelligence (AI), blockchain, and quantum computing reshaping economic interactions. Future research should explore the role of these technologies in enhancing Kazakhstan's economic competitiveness. Understanding the interplay between government ICT expenditure and private sector innovation will be key to developing a resilient and adaptable digital economy.

Kazakhstan is at a pivotal moment in its digital transformation journey. By leveraging insights from this study and aligning its ICT policies with global best practices, the country has the potential to establish itself as a regional leader in digital innovation. A sustained commitment to strategic investments, regulatory modernization, and workforce development will enable Kazakhstan to fully harness the benefits of digitalization, ultimately fostering long-term economic growth and global competitiveness.

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