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THE INTERSECTION OF DIGITAL TRANSFORMATION AND ECONOMIC DEVELOPMENT: A CLOSER LOOK AT ASIAN NATIONS

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Abstract

This research aims to explore the impacts of the digital transformation on the economic growth in the 46 Asian countries in the period from 2000 to 2022. The variable that measures the economic growth is the natural logarithm of the GDP per capita, while the independent variables including the two main groups, which are Digital Economy Infrastructure and the Digital Economy Openness, containing the statistically significant variables (ICT exports, secure Internet servers, fixed broadband subscriptions, mobile cellular subscriptions, and individuals using the Internet). The data supporting the topic was collected from the World Bank before fixing by the authors to reduce the variance and errors. The feasible generalized least squares method was used to analyze the result after regression analysis. The results that the research collected are the significance of the model, the significance of the coefficients for the variables of ICT exports, fixed broadband subscriptions, mobile cellular subscriptions, and individuals using the Internet for the increasing relationship, and secure Internet servers for the negative relationship with the natural logarithm of GDP per capita. Following the normal assumption about the digital transformation, the signs of the coefficients are clearly explained and interpreted because they explain the sharp relation between the two target objectives (digital transformation and economic growth). After the results are presented, the authors come to the recommendation for the policy makers and the government

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to enact the suitable policies and use the national budget to invest in the data collection, supporting it for scientific purposes.

Keywords: Digital transformation, Economic growth, Digital Economy Infrastructure, Digital Economy Openness, Asia.

MỐI TƯƠNG QUAN GIỮA VIỆC CHUYỂN ĐỔI SỐ VÀ PHÁT TRIỂN NỀN KINH TẾ: MỘT GÓC NHÌN CẬN CẢNH VÀO CÁC QUỐC GIA CHÂU Á

Tóm tắt

Bài nghiên cứu được thực hiện nhằm tìm hiểu tác động của chuyển đổi số đến tăng trưởng kinh tế ở 46 quốc gia châu Á trong giai đoạn từ năm 2000 đến năm 2022. Biến đo lường tăng trưởng kinh tế là logarit cơ số tự nhiên của GDP bình quân đầu người, còn các biến độc lập bao gồm hai nhóm chính là Cơ sở hạ tầng nền kinh tế số và Độ mở nền kinh tế số, bao gồm các biến số có ý nghĩa thống kê (xuất khẩu CNTT-TT, máy chủ Internet bảo mật, thuê bao băng thông rộng, thuê bao di động và cá nhân sử dụng Internet). Số liệu của đề tài được thu thập từ World Bank và được cân đối để giảm bớt sự sai lệch và sai sót. Phương pháp bình phương tối thiểu tổng quát khả thi được sử dụng để phân tích kết quả sau khi phân tích hồi quy. Kết quả thu được bao gồm ý nghĩa của mô hình, ý nghĩa của các hệ số đối với các biến xuất khẩu CNTT-TT, thuê bao băng thông rộng, thuê bao di động và cá nhân sử dụng Internet có tác động tích cực và bảo mật máy chủ Internet có tác động tiêu cực tới logarit cơ số tự nhiên của GDP bình quân đầu người. Theo giả định thông thường về chuyển đổi số, dấu của các hệ số được giải thích và diễn giải rõ ràng vì chúng giải thích mối quan hệ chặt chẽ giữa hai mục tiêu mục tiêu (chuyển đổi số và tăng trưởng kinh tế). Sau quá trình nghiên cứu, các tác giả gợi ý rằng các nhà hoạch định chính sách và Chính phủ cần ban hành các chính sách phù hợp và sử dụng ngân sách quốc gia hợp lý để đầu tư vào việc thu thập dữ liệu, hỗ trợ cho mục đích khoa học.

Keywords: Chuyển đổi số, Tăng trưởng kinh tế, Cơ sở hạ tầng nền kinh tế số, Độ mở nền kinh tế số, Châu Á.

1. Introduction

The Fourth Industrial Revolution, which will be typified by digitalization and the capitalization of the Internet of Things (IoT) and drastically alter how industrial value chains do business, is about to occur in the modern world (Parida et al. 2019; Rojko 2017). Especially, "Concerned with the changes digital technologies can bring about in a company's business model or organizational structures,"(Hess et al. 2016, p. 124). According to the Economic and Social Commission for Asia and the Pacific, massive investments and growth in the digital sector are occurring in the Asia-Pacific region. Moreover, McKinsey Global Institute' s research which was written by Janet Bush (2021) revealed that Asia is growing rapidly which is home to more than half the world's population, the region has gone from low to middle income in just one generation. By 2040, it is predicted that this region will be able to generate more than 50% of world GDP and could account for nearly 40% of global consumption.

Therefore, through the scenario of development of Asia, it is found a close relation between the digital transformation and the economic growth. The research by Parviainen et al. (2017) found that digitization is associated with modest economic growth. Consequently, nations in the most advanced level of digitalization get a 20% increase in economic gains compared to those in the earlier stages. According to academics, digitization is beneficial for raising citizen access to public services, lowering unemployment, and improving quality of life. They claimed that it enables governments to function with more efficiency and transparency, which positively affects the nation's economic progress.

Researching similar topics, Raeskyesa and Lukas (2019) carried out a panel regression study with a dependent variable of GDP per capita growth and independent variables of physical capital, human capital, and ICT indicators after conducting a descriptive analysis of eight ASEAN middle-income nations. According to their findings, ICT indicators significantly improve economic growth as well as people and physical capital. In addition, their analysis demonstrated that the degree and manner in which ICT is used have greater consequences than its availability.

According to Maiti et al. (2019), a key tactic for resolving issues with social inclusion and economic growth is the digitalization of the sector. According to their research, quicker adoption of ICT increases economic efficiency and production, increases openness in the provision of public services and welfare programs, lowers corruption, connects rural areas with urban areas, and raises democratic participation. Erumban and Das (2020) have noted that the primary cause of the paucity of information regarding the influence of ICT on the economic growth of India is the absence of precise data on ICT in the selected economy.

Besides, the impact of the digital transformation on North and Central Asian nations - Turkmenistan, Azerbaijan, Tajikistan, Georgia, the Russian Federation, et al. - is examined by A. S. Nechaev et al. (2022). It is evident that the use of digital solutions across diverse industries has a noteworthy effect on the population's social well-being, employment prospects, and productivity.

Meanwhile, studies on the impact of digital transformation on economic growth are limited in a regional scope which almost analyze the contexts of one country or one region such as ASEAN or EU. Consequently, research exploring the direct impact of digital transformation on economic growth is limited, especially in the Asian region.

Moreover, in the studies (Raeskyesa and Lukas, 2019; Maiti et al., 2019; Erumban and Das, 2022; A. S. Nechaev et al., 2022), ICT is often selected as a representative indicator of digital transformation, but not as the theoretical framework for an academic unification in the research landscape. Up to now, the main research had mainly focused on analyzing the impact of digital transformation of selected countries over the past few years that could not examine the convulsion in the impact of transformation in detailed aspects. Thus, research on the impact of digital transformation on economic growth in Asia is limited in quantity and lacks the examination of changing Asian scenarios, especially during and after the COVID-19 pandemic.

Based on the existing literature and current situation, the relationship between digital transformation and economic growth, especially in Asian countries, is still ambiguous and requires more in-depth investigation. Therefore, this research has been designed to make following contributions for current research about this field - exploring the impact of digital transformation on the economic growth in 46 Asian countries from 2000 to 2022.

2. Theoretical framework of economic growth, digital transformation

For Paul Romer (2007), economic growth reorganizes resources to make them become more valuable. It can also be considered as an increase in the quantity and quality of the economic commodities produced by a society (Roser, 2021). Therefore, the economic growth might illustrate the rise in the amount of transactions of economic goods and services within the economy (Chen et al., 2021). Moreover, economic growth is represented through the rise in average incomes and the reduction in poverty (World Bank). To sum up, the main identical features of economic growth is the increase in the production of an economy.

The definition regarding economic growth is often confused with economic development; although they do not have the same meaning, they have a close association with each other. While economic growth concentrates on the quantity of production of goods and services in a short-term period (Flammang, 1979), economic development focuses on the overall quality of human society (Todaro & Smith, 2020) and the process of structural changes in a long-term period (Flammang, 1979). To be more specific, economic development consists of the general improvement of aspects related to living conditions of people, which comprises economic growth. Therefore, even though there are differences between economic growth and economic development, they tend to have something in common.

Regarding digital transformation, it is a topic of popular discussion in recent years due to its great invasion into our daily lives, our politics, economy and environment,... Digital transformation in entrepreneurship and enterprises is conceptualized to be a critical step toward streamlining the process of breaking into new markets, creating online stores, managing production and sales, or making dealings with the government easier (Viktorovich, 2020). Nonetheless, no official definition for this term has been confirmed and literature has also been reviewed a lot about this topic.

In early days of the Internet era, Stolterman (2004) and Martin (2008) had conducted a study about digital transformation, asserting that digital transformation is the application of information and communication technology into business, public administration, and the lives of individuals and society at large; in other words, every change impacted by technology, rather than routine automation at that time is stated to constitute digital transformation. To call it into a word, digital transformation is given a concept called “an organizational change”, illustrating the change from the core - the way an economy organizes in 2011 (Liu, Chen, & Chou, 2011).

Four years later, another theory had been developed, supplementing a novel sphere in the definition of digital transformation, as digital transformation is not only a change occurred by the replacement of physical activities with advanced technology, but it also gives rise to an expansion in the scope or performance of an organization, according to Westerman and Bonnet (2015). Fitzgerald and Sois (2014) also conducted two research and concurred with this view, while detailed the digital technologies that are frequently utilized in streamlined operations, new business models and enhanced customer experiences, including but not limited to social media, mobile technology, analytics and embedded devices.

Research has pointed out a different sphere of digital transformation, which is not about technological change or advancements. He said that digital transformation is a combination of the interconnectedness of all sectors in an economy and the requirement of active adjustments from both individuals and entities to the novel circumstances presented by the digital economy. As for the former phrase, there needs to be a cohesive integration of digital technologies across various economic domains to foster an ecosystem, while the adaptation means a willingness to embrace digital tools, modify existing practices and cultivate a growth mindset that aligns with the opportunities and requirements emerging in the era of digital technology (Bondar, Hsu, Pfouga, & Stjepandić, 2017). Finally, Hinings (2018), also found out something relatively similar to Bondar, as he affirmed that digital transformation is about changing the mindsets of people in this era, as digital innovations make changes not only to the economy in general, but also to the principles and norms underlying the economy. In other words, digital transformation introduces a novel way of thinking, which drives significant changes or advancements in the economy.

Research on the outcomes, implications, and constituents of digital transformation, including artificial intelligence (AI), big data, cloud computing,... was conducted in the past. These days, researchers are focusing more on deeper domains, primarily two: economic consequences and drivers. The components of the internal drivers were intelligence technology and customized demands, while the external drivers were organizational learning capabilities and dynamic capability. In the meanwhile, research indicates that the degree of corporate governance and the digital economy are positively correlated (Kun & Huang, 2023).

One theory studying the impacts of digital transformation on firm innovation shows a positive correlation between the two because of one overall factor: the Internet. Thanks to the Internet, companies witness an increase in online communication, expand integration, speed up the process of shaping and sharing knowledge of innovation; thereby helping the economy to make progress since each enterprise of a country accounts for a part of the national economy. Or in other words, it can be understood that the Internet will help accelerate the speed of digital communication and acknowledgement of innovation for employees in an economy, depicting a positive relationship between the booming of digitalization and the continuous development of an economy (Li et al., 2023).

Widening from the previous theory about the effects of the Internet on firms, digital technology in general positively influences the supply and demand of the digital economy.

Regarding the supply side, the provision of digital platforms lays a foundation in forming a brand new tight relationship between suppliers and consumers, facilitating the convenience in exchanging goods and services, which not only benefits the supply chain, but it also enhances the economic structure, contributing directly to overall high-quality economic development. The second reason is the increasing improvement in supply efficiency, all coming back to the help of digital technology through the tactics of optimization. In particular, the latest technology is utilized and optimized to turn into the most productive force in labor work, which helps the economy significantly in using internal resources, including human and finance, more wisely, increasing productivity and overall enhancing production efficiency.

As for the demand side, the influence is more profound since it cuts down on information asymmetry and increases transparency. In other words, the digital economy is addressing this issue through creating a digital platform where data is clearly assessed and insights are easily available for businesses to lower their risks and make more accurate decisions. Communication mechanisms, in fact, are one kind of powerful tool to make this happen, as just by some digital channels such as: social media, email, instant messaging,... can enterprises receive feedback and respond quickly to consumers' opinions, which foster a much more dynamic economic environment. Additionally, innovation is the core of digital transformation in an economy since technology has been leveraging the spiritual and functional values of products, leading to more and more common customer-centricity among producers. In short, the interplay between supply and demand is dynamic, overall fostering a high-quality economic development (Zhang et al., 2022).

Another paper collects various perspectives on the impacts of digital technology on economic growth. In contrast to some updated views that Information and Communication Technology (ICT) fosters innovation thanks to business-to-business transactions and production spillovers, some traditional thinkers researched that though economic growth can be driven by increased investment in ICT, this kind of purchase stems primarily from falling prices of ICT equipment. Other studies exploring the impacts of ICT presenting that ICT, by assisting in communication spread, have a negative effect on labor productivity in small and medium enterprises (SME) due to a lagged effect; meanwhile, there are some who argue that ICT still has a positive but small impact in lowering business costs, facilitating communication and empowering citizens by providing access to online education.

Additionally, this research also posits that more factors should be taken into consideration to avoid overestimating the relationship between ICT and economic growth. One of those is the economy, since assumption has been made that ICT has more positive impacts on ICT-growing economies than ICT- advanced ones, or some other also pivotal factors should be taken into account such as real GDP, energy consumption and changes in market conditions. Overall, this research illustrates a multifaceted view on the influences of ICT on economic growth, comprising both traditional and non-traditional perspectives and considering many spheres to assess the issue (Solomon & van Klyton, 2020).

The study of digital transformation is extensively explored in developing countries, since though the impacts lower transaction costs, raise capital and labor productivity, they pose some challenges for both developed and developing ones. New growth opportunities are created thanks to digitalization; nonetheless, they are also factors in a decline in manufacturing sector employment, highlighting a global trend. To illustrate, the opportunity mentioned above can be attributed to the transformative role of technology, and it is expected to be transferred to developing countries; however, the reality is pointed out to fail to meet the expectations and the number of employees in the aforementioned region had already decreased.

E-commerce can also be considered as a global opportunity and a unique chance for SME companies, simultaneously., in accessing international markets and promoting their brands to the world to boost profits of the companies. Nevertheless, the reality is hindered by a lot of challenges, such as digital divide, higher ICT costs, institutional barriers, a lack of reliable power supply or infrastructure limitations.

To conclude, this research, though still pointed out the positive development of digital transformation, acknowledged that to achieve the full potentials, some challenges should be addressed, otherwise, they could become a disadvantage, rather than an opportunity to grow (Myovella, Karaçuka, & Haucap, 2020).

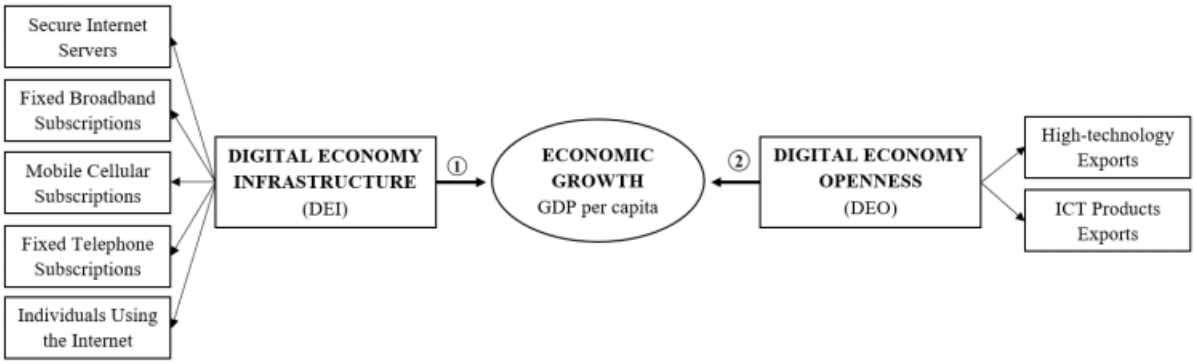

Figure 1: Theoretical framework of the impacts of digital transformation on the economic growth in Asia

Sources: Authors (2024)

According to Zhang et al. (2022), the research indicates that digital transformation of an economy is affected through two main indicators, which are (1) Digital Economy Infrastructure (DEI) and (2) Digital Economy Openness (DEO). Due to the existing literature, these factors are optimal measurements for the performance of a digital economy. This framework will assist this research to appropriately determine impacts of digital factors on the level of digital transformation, thereby affecting the economic growth of Asian countries.

Regarding the DEI (arrow 1), it represents the fundamentals and practical uses of technology. The DEI comprises five different indicators for the application of digital technology, which are

Secure Internet Service, Fixed Broadband Subscription, Mobile Cellular Subscriptions, Fixed Telephone Subscriptions and Individuals Using the Internet. DEI is the platform where various fields can apply, thereby increasing the economic activity in the economy (Kim, 2006).

In terms of the DEO (arrow 2), it illustrates the performance of a nation's ICT sector in the global market share competition, DEO also attempts to indicate the level of improvement on the digital economy's external connections. It consists of two factors, which are High-tech Exports and ICT Product Exports. DEO can assist the economy to interact with other countries and increase transactions of both digital economy and financial economy.

3. Research Methodology

3.1. Research data

Data from 46 Asian countries from 2000 to 2022 was collected for this research paper. A total of 1058 samples were collected for all the variables. Nevertheless, as the amount of data available for the countries was not synonymous, the regression sample size was narrowed to 399 samples from all 46 countries. Data used for this research paper was collected through the World Bank database.

3.2. Research method

All of the data in this research paper was processed using Stata software. Specifically, Stata was used to conduct regression analysis, VIF variance analysis, Hausman test, and White test. The following equation is used for regression analysis in this research paper (Zhang et al., 2022).

$$\log(gdp)=\beta_0+\beta_1 tele+\beta_2 mobi+\beta_3 inte+\beta_4 hite+\beta_5 ict+\beta_6 secu+\beta_7 brb$$
$$+\beta_8 \log(imex)+\beta_9 \log(gov)+\beta_{10} inf+\beta_{11} infl+\beta_{12} outfl+\beta_{13} \log(nni)$$

For the model aforementioned, the relationship between the variables expected to be explored by the regression model. Before the regression is conducted, the researchers need to evaluate the impact of the independent variables on the dependent variable. The variables are listed in Table 1.

Table 1. Variables declaration

Variables	Description	Research Source	Expected Signs	Data Source
Dependent variable				

Variables	Description	Research Source	Expected Signs	Data Source
gdp	The natural logarithm of GDP per capita (USD)	Zhang et al. (2022), Mura and Donath (2023), Yagubov et al. (2021), Hornungová and Kateřina (2022), Ding et al. (2022)		World Bank
Independent variables				
tele	Fixed telephone subscriptions (per 100 people)	Zhang et al. (2022), Yagubov et al. (2021)	+	World Bank
mobi	Mobile cellular subscriptions (per 100 people)	Mura and Donath (2023), Yagubov et al. (2021)	+	World Bank
inte	Individuals using the Internet (% of population)	Zhang et al. (2022), Hornungová and Kateřina (2022)	+	World Bank
hite	High-technology exports (% of the manufactured goods exports)	Zhang et al. (2022), Hornungová and Kateřina (2022)	+	World Bank
ict	ICT product exports (% of total product exports)	Zhang et al. (2022), Hornungová and Kateřina (2022)	+	World Bank
secu	Secure Internet servers (per million people)	Zhang et al. (2022), Hornungová and Kateřina (2022)	+	World Bank

Variables	Description	Research Source	Expected Signs	Data Source
brb	Fixed broadband subscriptions (per 100 people)	Mura and Donath (2023), Yagubov et al. (2021)	+	World Bank
Control variables				
imex	The natural logarithm of total imports and exports (% of GDP)	Zhang et al. (2022), Hornungová and Kateřina (2022)	+	World Bank
gov	The natural logarithm of government consumption (USD)	Zhang et al. (2022), Hornungová and Kateřina (2022)	+	World Bank
inf	Annual inflation rate (%)	Zhang et al. (2022), Mura and Donath (2023), Yagubov et al. (2021)	-	World Bank
infl	Foreign direct investment, net inflows (% of GDP)	Zhang et al. (2022), Mura and Donath (2023), Yagubov et al. (2021)	+	World Bank
outfl	Foreign direct investment, net outflows (% of GDP)	Mura and Donath (2023), Yagubov et al. (2021)	+	World Bank
nni	The natural logarithm of net national income (USD)	Zhang et al. (2022), Hornungová and Kateřina (2022)	+	World Bank

Sources: Authors (2024)

With a comprehensive overview of factors under consideration, the foundation for a nuanced understanding of the expected impacts of digital transformation on economic growth in Asian countries are set as outlined in Table 2 below.

Table 2: Expected correlation between dependent variable and other variables

Types of Variable	Variables	Unit	Variables' Description	Expected correlation with dependent variable
Dependent Variable	gdp		Natural logarithm of GDP per capita	
Independent Variables	hite	%	High-tech Exports	+
	ict	%	ICT Product Exports	+
	secu	‰	Secure Internet Services	+
	brb	%	Fixed Broadband Subscriptions	+
	mobi	%	Mobile Cellular Subscriptions	+
	tele	%	Fixed Telephone Subscriptions	+
	inte	%	Individuals Using the Internet	+

Types of Variable	Variables	Unit	Variables' Description	Expected correlation with dependent variable
Control Variables	imex	%	Natural logarithm of total Imports - Exports	+
	gov		Natural logarithm of Government Consumption	+
	inf	%	Inflation Rate	-
	infl	%	Foreign direct investment, net inflows	+
	outfl	%	Foreign direct investment, net outflows	+
	nni		Natural logarithm of Net National Income	+

Sources: Authors (2024)

4. Results and Discussion

4.1. Summary and brief the data collected

Data were collected from 48 Asian countries, with seven independent variables, six control variables, and one dependent variable. As previously stated, the variables were collected between the years 2000 and 2022. As a result, the estimated total number of expected observations is 1104. However, as the previous study was conducted in the EU, when applied to Asia, there was some blank data, resulting in fewer observations than expected.

The table below shows the summary of the data collected by the researchers. With the measurement of the previous research of Zhang et al. (2022) about the similar topic, the authors fixed certain adjustable mistakes of Asian data, including extreme values and some mistakes led by the manual collection, and generated them into the final file for the regression analysis.

Table 3: Variable summary

Variable	Obs	Mean	Std. dev.	Min	Max
gdp	1,051	3.780093	1.165863	2.118827	8.984091
tele	1,043	-.1523444	.1449762	-.6115257	-.0001873
mobi	1,040	.8454649	.6272404	0	4.409483
inte	1,033	.3444373	.3082615	0	1.036655
hite	605	-.1572019	.1787032	-.7054424	.1289696
ict	1,013	7.803178	13.58874	-5.034395	98.42675
secu	598	4.423651	2.883906	-3.907905	11.80779
brb	894	.0600987	3.888662	-66.61044	3.908295
imex	821	1.827222	1.031313	-1.06343	4.45501
gov	934	1.203645	1.807746	-2.52354	12.38321
inf	985	.0458363	1.000791	-.029601	.043319
infl	1,006	3.826304	7.009019	-.35987	.5775941
outfl	926	2.055668	5.66281	-.31787	.48538

Variable	Obs	Mean	Std. dev.	Min	Max
nni	1,012	24.62543	2.44684	.17553	.31194

Sources: Authors (2024)

For the model aforementioned, the relationship between the variables expected to be explored by the regression model. Before the regression is conducted, the researchers need to evaluate the impact of the independent variables on the dependent variable. The below table is constructed to illustrate the expectation of these impacts due to the economic theories mentioned in the literature review.

4.2. Regression results and interpretations of the coefficients

With this model, the authors have some practical interpretation of each coefficient demonstrated in the table below.

Table 4: Regression results

Variables	Model (1) No interaction variables	Model (2) Have interaction variables
tele: Fixed telephone subscriptions (per 100 people)	.4339623	1.439648
	(.4653326)	0.6957959
mobi: Mobile cellular subscriptions (per 100 people)	0.5431747	0.5531078
	(0.1731654)	0.1771341
interuse: Individuals using the Internet (% of population)	2.204062***	2.330826
	(0.3573218)	0.3556466
c.hightech#c.ict: The interaction variable of high-technology product exports and ICT exports		4.247075
		2.352954
hightech: High-technology exports (% of the manufactured goods exports)	0.3087703	0.7554398
	(0.6093059)	
ict: ICT product exports (% of total product exports)	1.51513	
	(.8437242)	
secu: Secure Internet servers (per million people)	- 0.1844125***	-0.2075682

Variables	Model (1) No interaction variables	Model (2) Have interaction variables
	(0.0318765)	0.0326337
brb: Fixed broadband subscriptions (per 100 people)	.2243065***	0.2570728
	(.065417)	0.0670103
imex: The natural logarithm of total imports and exports (% of GDP)	0.0235124**	0.848584
	(0.0452304)	0.0492339
gov: The natural logarithm of government consumption (USD)	0.0915412**	0.0084308
	(0.0458414)	0.0492339
inf: Annual inflation rate (%)	0.100083**	0.0063764
	(0.0469472)	0.0481728
infl: Foreign direct investment, net inflows (% of GDP)	0.0106997*	0.0110404
	(0.0084402)	0.0083807
outfl: Foreign direct investment, net outflows (% of GDP)	0.0386258**	0.0240282
	(0.0198994)	0.0208426
nni: The natural logarithm of net national income (USD)	0.0397263**	0.0683232
	(0.0249315)	0.252715
_cons	1.649128	1.013778
	(0.6885174)	0.7021404
Observations	330	330
Number of ctr	37	37
R-squared	0.4195	0.4207

Robust standard errors in parentheses

**** p<0.01, ** p<0.05, * p<0.1*

Source: The authors (2024)

The regression results displayed in Table 4 shows that economic growth is enhanced by levels of digitalisation, represented by DEI and DEO. Specifically, Table 4 shows that DEI as an independent variable positively impacts the economic growth of a nation. This means that higher levels of digitization of the infrastructure of a nation will lead to an increase in its economic output. This result is as expected as the global economy is heading towards digitalization. This finding aligns with previous literature of Kim (2006), Kun and Huang (2023), Mura and Donath (2023), Myovella et al (2020), Ma and Lin (2023), Zhang (2021), and Khaouani (2019). DEI as an independent variable consists of 5 main indicators. The indicator telephone fixed subscriptions proved to be statistically insignificant through analysis. This finding is unsurprising as more and more people are moving away from fixed telephone lines to mobile devices. In addition, the indicator of secure internet servers, although part of DEI, negatively impacted economic growth. This can be explained by the unstable nature of the Internet's impact on the economy. It can be said that in recent years, the Internet has been a double-edged sword as it offers unlimited opportunities but can turn counterproductive in the wrong hands. Meanwhile, the mobile phone subscriptions indicator has a positive impact on the economic growth of a nation. This finding is predicted as the cellular phone is an indispensable communication instrument that facilitates many aspects of life, especially the business and economy side. Similarly, the remaining two indicators: the number of individuals using the Internet and fixed broadband subscriptions both displayed a positive correlation with economic growth, especially the former indicator. In detail, Internet users displayed the highest level of correlation to the independent variable. Overall, this signifies the important role of access to the Internet and the Internet itself in boosting the economic growth of a nation. This finding echoes the research of Maurseth (2018).

Subsequently, the research also studies the impact of DEO, measured by two variables hightech and ict, on economic growth, implying that in recorded Asian countries, when high-technology exports of the nation increase, the GDP per capita will also increase. This also aligns with the empirical finding of Sofuoğlu, Kızılkaya, & Koçak (2022), as the paper affirms that all types of countries, including high, middle, and low technology-export ones, reap huge, though different, benefits from high-tech exports. As for the latter variable ict, the result also points out that this variable has an even much more positively significant effect on a nation's GDP, greatly corresponding to the study of Phan & My (2022). The literature said that digital transformation is showing its potential to contribute to the economic growth of a nation.

After adding to the model an interaction variable between ICT and high-technology exports, the variable high-technology exports, which was not statistically significant in model 1, becomes statistically significant. According to Zheng (2023), the authors pointed out that when there is an interaction between two variables, the autocorrelation phenomenon decreases, leading to an increase in the statistical significance of the regression coefficient.

From:

log(gdp)=1.649128+0.4339623tele+0.5431747mobi+2.204062inte+0.3087703hite

+1.51513ict +(0.1844125)secu+0.2243065brb+0.0235124log(imex)+0.0915412log(gov)

+0.100083inf+0.0106997infl+0.0386258outfl+0.0397263log(nni)

The model becomes:

log(gdp)=1.013778+1.439648tele+0.5531078mobi+2.330826inte-4.247075hite*ict

+1.783836ict + 0.7554398hit-0.2075682secu+0.2570728brb+0.0848584log(imex)

+0.0084308log(gov) +0.0063764inf+0.0110404infl+0.0240282outfl+0.0683232log(nni)

The research of Zheng (2023) showed the positive correlation between the ICT product exports and high-technology exports with the economic growth in the European Union. However, both models show statistical insignificance, which requires the authors to have a solution. Thus, the authors chose the interaction variable between these two variables to ensure the significance of the whole model. With this change, the authors find the relationship between ICT product exports and economic growth, high-technology exports and economic growth, as well as ICT product exports and high-technology exports. According to the research of Sofuoğlu, Kızılkaya, & Koçak (2022) and Zheng (2023), the researchers come to the conclusion that with the shown model, a change of ict (or hite) cause a change of gdp by an amount of (4.247075hite+1.783836) units (or (4.247075ict+0.7554398) units) respectively. This model, reflecting in reality, illustrates the rigid correlation between the exportation of technological products corresponding with the growth of the economy as depicted by the coefficients as above.

Finally, the control variables studied, including the logarithm of total imports and exports as a share of GDP, natural logarithm of government consumption, inflation rate, foreign direct investment net inflows and net outflows, natural logarithm of NNI, also exert positive influences upon Asian countries' economic growth, totally aligning with the results of the studies of Zhang et al. (2022) and Pavlovic and Krstić (2020). These variables also act as surrounding factors in the study to avoid being biased towards only DEO and DEI.

5. Conclusion

5.1. Conclusion

This research investigates the impact of digital transformation on the economic growth of Asia; main Asian economy indicators between 2000-2022 were analyzed. The finding is that economic growth as measured by GDP per capita is boosted by levels of digitalisation.

The research paper used two main independent variables consisting of smaller indicators to measure a nations' digitalization level: digital economy infrastructure and digital economy openness. The regression results showed that digital economy infrastructure (DEI) and digital economy openness (DEO) both affected the economy.

In detail, DEI was measured by five indicators, 3 of which positively impacted the independent variable. Although one indicator of DEI (secure internet servers) showed a negative correlation with GDP per Capita and another (fixed telephone subscriptions) was statistically insignificant,

DEI as an independent variable displayed a positive correlation with GDP per Capita. These results signify that the more digitized a country is through its underlying infrastructure, the better off its economy is.

Furthermore, the authors also posit a positive correlation between DEO and the economy of a nation. Specifically, the authors found that ICT product exports had a significant positive correlation with the GDP per capita as shown in the regression results. This reaffirms the fact the more digitized a country is shown through its exports, the better its economy is. Nevertheless, it is important to note that the High-tech exports indicator was statistically insignificant in the regression model.

Both of these findings are novel in Asia as a whole. Previously, research on digitization and economic growth were only conducted in more developed countries in Europe with detailed indexes and in China where there were also specific indicators of measurement. Thus, this research paper has filled out the gap in literature by conducting research on Asia as a whole, including not only developed countries but also developing countries.

To obtain statistically significant results through 46 countries in Asia with varying levels of development, the authors included control variables which played a crucial role in assuring that the results of the regression are not influenced by relevant unobserved economic factors.

Nevertheless, the research faced methodological challenges such as multicollinearity and heteroscedasticity which was dealt with through factor analysis and application of the generalized least squares model. However, the availability of data is very limited in some less developed countries in Asia, but still our model has strong explanatory power which signifies the importance of these factors for digital transformation as determinants for economic output.

5.2. Recommendation

Digitalization is a process that involves many stages and takes a lot of time. As such, it necessitates a long-term vision but should be broken down into smaller components for implementation. This means that while complexity can be introduced, it must not become too abstract, nor can it get overly simplified since the building blocks of digital transformation are inextricably woven together. Digital transformation implies changing the communities' governance into digital ones, as well as focusing on the digital economy and digital society. Consequently, the place-based successes that have been achieved in digitized localities play an important role in national digitalization.

Firstly, it is essential to concentrate on the beginning - cognitive transformation which is also known as digital awareness. A sense of belongingness during digitalization is essential; before embarking upon it one has to go through cognitive transformation. The government should come up with policies that will enhance citizens' and businesses' knowledge about digitalization in general. The most crucial factor behind accelerating cognitive transformation is understanding rather than treating it like some kind of distant abstract concept, if the authors refer to good leadership as a critical contributor to this process at all.

Secondly, developing digital infrastructure which are in the form of digital platforms. The actualization of development on digital infrastructure and platforms is an important and innovative way to enhance the progress of digital government; it also speeds up the shift into a digital economy and society. This includes all the segments of digital infrastructure that perform complex functions concerning e-government like communication connectivity coupling IT infrastructures with legal enforcement. When implementing digital transformation, the governments have to perceive that this process starts from building modernized elementary infrastructures. These plans must be developed on the basis of preserving existing ones; they need to define objectives, priorities, resource allocation, etc., in order to ensure the simultaneous implementation of critical IT infrastructure elements such as broadband infrastructure, Internet of Things (IoT) infrastructure; cloud computing infrastructure; new generation Internet Protocol (IPv6) applications, Integrated data centers, Intelligent operations centers, Information security monitoring centers; integrated platforms, provincial-level data sharing; Safety monitoring and network security operations centers; online payment platforms, mobile…

Thirdly, building and developing digital data. A critical element of any digital transformation process is the digital data. Without digital data, one cannot determine models for digitized operations and hence undertake any digital transformation. Every locality that undertakes data building in its implementation of successful digital transformation must use specific strategies that are consistent with national ones as prescribed in national plans to enable a once-only principle of data collection- it implies a possession by government agencies, citizens and businesses after which they will not be required to furnish it again. The steps involved in deploying, building and developing Digital Data are: Defining usage purposes for data; sourcing inventive sources for data collection; making the collected information into digits; installing systems such as communication links from the systems; standardizing operational databases within local authorities (LGSP) - integrated data sharing systems (NGSP), platforms at national level through local (LGSP); generating shared repositories at local level via providing data to support ongoing digital transformation in different fields and also exploiting it directly for new areas' movement into the digital world.

Finally, the shift to digitalization has raised concerns among economies due to the emergence of competition challenges so that it is necessary to enhance the ICT sector in one nation as well as among the nations. The integration of fixed line, wireless and broadcasting communication technologies in delivering Internet services has prompted countries to reassess their frameworks and public policy goals. This reassessment aims to encourage all participants in the market to continue innovating, promote competition and invest in the Information and Communication Technology (ICT) sector. Adjustments to competition laws may be necessary such as recognizing data and its analysis as assets in certain markets, redefining market boundaries and key players in innovative ways and fostering collaboration among competition authorities. Tools designed to understand competition intricacies in the realm would prove beneficial.

APPENDIX

Appendix 1: Variables' Declaration

```
. sum lngdppcap tele mobi interuse hightech ict secu brb lnimex lngov INF infl outfl lnnni
```

Variable	Obs	Mean	Std. dev.	Min	Max
lngdppcap	1,051	3.780093	1.165863	2.118827	8.984091
tele	1,043	-.1523444	.1449762	-.6115257	-.0001873
mobi	1,040	.8454649	.6272404	0	4.409483
interuse	1,033	.3444373	.3082615	0	1.036655
hightech	605	-.1572019	.1787032	-.7054424	.1289696
ict	1,013	7.803178	13.58874	-5.034395	98.42675
secu	598	4.423651	2.883906	-3.907905	11.80779
brb	894	.0600987	3.888662	-66.61044	3.908295
lnimex	821	1.827222	1.031313	-1.06343	4.45501
lngov	934	1.203645	1.807746	-2.52354	12.38321
INF	985	.0458363	1.000791	-2.960157	4.331963
infl	1,006	3.826304	7.009019	-35.98763	57.75941
outfl	926	2.055668	5.66281	-31.78786	48.53864
lnnni	1,012	24.62543	2.44684	17.55361	31.19411

Sources: Authors (2024)

Appendix 2: Regression Result with merely discrete variables

```
.   reg lngdppcap tele mobi interuse hightech ICT secu brb lnimex lngov INF infl outfl lnnni
```

Source	SS	df	MS	Number of obs	=	330
				F(13, 316)	=	17.56
Model	150.569068	13	11.582236	Prob > F	=	0.0000
Residual	208.39818	316	.659487911	R-squared	=	0.4195
				Adj R-squared	=	0.3956
Total	358.967248	329	1.09108586	Root MSE	=	.81209

lngdppcap	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
tele	.4339623	.4653326	0.93	0.352	-.4815794	1.349504
mobi	.5431747	.1731654	3.14	0.002	.2024719	.8838775
interuse	2.204062	.3573218	6.17	0.000	1.501031	2.907092
hightech	.3087703	.6093059	0.51	0.613	-.8900388	1.507579
ICT	1.51513	.8437242	1.80	0.073	-.1448972	3.175157
secu	-.1844125	.0318765	-5.79	0.000	-.2471296	-.1216955
brb	.2243065	.065417	3.43	0.001	.0955986	.3530145
lnimex	.0235124	.0452304	0.52	0.604	-.0654784	.1125031
lngov	.0915412	.0458414	2.00	0.047	.0013483	.181734
INF	.100083	.0469472	2.13	0.034	.0077145	.1924515
infl	.0106997	.0084402	1.27	0.206	-.0059064	.0273059
outfl	.0386258	.0198994	1.94	0.053	-.0005261	.0777778
lnnni	.0397263	.0249315	1.59	0.112	-.0093264	.088779
_cons	1.649128	.6885174	2.40	0.017	.2944708	3.003786

Sources: Authors (2024)

Appendix 3: Correlation Matrix

```
. corr tele mobi interuse hightech ICT secu brb lnimex lngov INF infl outfl lnnni
(obs=330)
```

	tele	mobi	interuse	hightech	ICT	secu	brb	lnimex	lngov	INF	infl	outfl	lnnni
tele	1.0000												
mobi	-0.1017	1.0000											
interuse	-0.5850	0.5472	1.0000										
hightech	0.2240	-0.1637	-0.2460	1.0000									
ICT	0.1838	-0.1073	-0.2710	0.8871	1.0000								
secu	-0.4451	0.5176	0.8029	-0.3065	-0.2574	1.0000							
brb	-0.6394	0.4451	0.7968	-0.3050	-0.3474	0.7286	1.0000						
lnimex	0.0153	0.0725	0.0325	-0.0447	-0.0508	-0.0379	-0.0417	1.0000					
lngov	-0.1896	0.1002	0.2010	-0.0374	0.0387	0.1675	0.1565	-0.0403	1.0000				
INF	0.0315	-0.0412	-0.0490	-0.0286	-0.0360	-0.0343	-0.0207	0.0949	-0.0109	1.0000			
infl	-0.0026	0.1360	0.0406	-0.2499	-0.1997	0.1593	0.0280	0.0780	0.0295	-0.0345	1.0000		
outfl	-0.3262	0.2697	0.3320	-0.4367	-0.3804	0.3647	0.2792	0.0856	0.0633	0.0359	0.4681	1.0000	
lnnni	-0.3064	0.0010	0.2106	-0.2498	-0.2458	0.2187	0.3391	-0.1267	0.0002	0.0525	-0.2697	0.1187	1.0000

Sources: Authors (2024)

Appendix 4: Value of Inflation of the variables

```
. vif
```

Variable	VIF	1/VIF
ICT	5.98	0.167285
hightech	5.95	0.168154
interuse	5.02	0.199395
brb	4.11	0.243371
secu	3.62	0.275969
tele	2.40	0.417205
mobi	1.84	0.542396
outfl	1.81	0.553387
infl	1.59	0.628522
lnnni	1.44	0.696123
lngov	1.09	0.915713
lnimex	1.07	0.937557
INF	1.03	0.974458
Mean VIF	2.84	

Sources: Authors (2024)

Appendix 5: White test result

```
. imtest, white

White's test
H0: Homoskedasticity
Ha: Unrestricted heteroskedasticity

  chi2(104) = 198.09
Prob > chi2 = 0.0000

Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	198.09	104	0.0000
Skewness	63.73	13	0.0000
Kurtosis	8.65	1	0.0033
Total	270.48	118	0.0000

Sources: Authors (2024)

Appendix 6: Robust regression analysis

```
. reg lngdppcap tele mobi interuse hightech ICT secu brb lnimex lngov INF infl outfl lnnni, robust

Linear regression                               Number of obs     =        330
                                                F(13, 316)        =      37.36
                                                Prob > F          =     0.0000
                                                R-squared         =     0.4195
                                                Root MSE          =     .81209
```

lngdppcap	Coefficient	Robust std. err.	t	P>|t|	[95% conf.	interval]
tele	.4339623	.537911	0.81	0.420	-.6243774	1.492302
mobi	.5431747	.270714	2.01	0.046	.010545	1.075804
interuse	2.204062	.4664886	4.72	0.000	1.286246	3.121878
hightech	.3087703	.4288329	0.72	0.472	-.5349581	1.152499
ICT	1.51513	.6537524	2.32	0.021	.2288721	2.801387
secu	-.1844125	.0388876	-4.74	0.000	-.2609238	-.1079013
brb	.2243065	.053857	4.16	0.000	.1183428	.3302702
lnimex	.0235124	.0464553	0.51	0.613	-.0678884	.1149132
lngov	.0915412	.0464181	1.97	0.049	.0002136	.1828687
INF	.100083	.0560754	1.78	0.075	-.0102453	.2104112
infl	.0106997	.0070396	1.52	0.130	-.0031508	.0245502
outfl	.0386258	.0171032	2.26	0.025	.0049754	.0722763
lnnni	.0397263	.0304017	1.31	0.192	-.0200892	.0995417
_cons	1.649128	.8237676	2.00	0.046	.0283661	3.269891

Sources: Authors (2024)

Appendix 7: FEM regression analysis

```
. xtreg lngdppcap tele mobi interuse hightech ICT secu brb lnimex lngov INF infl outfl lnnni, fe

Fixed-effects (within) regression               Number of obs      =       330
Group variable: group_id                        Number of groups   =        31

R-squared:                                      Obs per group:
     Within  = 0.1902                                         min =         1
     Between = 0.0050                                         avg =      10.6
     Overall = 0.0090                                         max =        13

                                                F(13,286)          =      5.17
corr(u_i, Xb) = -0.0566                         Prob > F           =    0.0000
```

lngdppcap	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
tele	.0974994	.2526323	0.39	0.700	-.399755	.5947539
mobi	.1681822	.0414919	4.05	0.000	.086514	.2498504
interuse	-.3087523	.0854293	-3.61	0.000	-.4769022	-.1406024
hightech	.6593362	.2133803	3.09	0.002	.2393412	1.079331
ICT	.0260031	.2498267	0.10	0.917	-.4657292	.5177354
secu	.0186891	.0078209	2.39	0.018	.0032953	.034083
brb	.0260668	.0228428	1.14	0.255	-.0188946	.0710282
lnimex	.0021677	.0074158	0.29	0.770	-.0124288	.0167643
lngov	-.006516	.0069191	-0.94	0.347	-.0201348	.0071029
INF	-.005751	.0068301	-0.84	0.400	-.0191947	.0076926
infl	.0003322	.0016083	0.21	0.837	-.0028334	.0034978
outfl	.0030718	.0040012	0.77	0.443	-.0048038	.0109474
lnnni	.0018341	.0067132	0.27	0.785	-.0113794	.0150476
_cons	3.794307	.1892191	20.05	0.000	3.421868	4.166746
sigma_u	1.2163421					
sigma_e	.11696721					
rho	.99083739	(fraction of variance due to u_i)				

Sources: Authors (2024)

Appendix 8: REM regression analysis

```
. xtreg lngdppcap tele mobi interuse hightech ICT secu brb lnimex lngov INF infl outfl lnnni, re

Random-effects GLS regression                   Number of obs      =       330
Group variable: group_id                        Number of groups   =        31

R-squared:                                      Obs per group:
     Within  = 0.1897                                         min =         1
     Between = 0.0111                                         avg =      10.6
     Overall = 0.0177                                         max =        13

                                                Wald chi2(13)      =     65.33
corr(u_i, X) = 0 (assumed)                      Prob > chi2        =    0.0000
```

lngdppcap	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
tele	.1400139	.2527899	0.55	0.580	-.3554453	.635473
mobi	.1724018	.0420824	4.10	0.000	.0899217	.2548818
interuse	-.299067	.086643	-3.45	0.001	-.468884	-.1292499
hightech	.6203203	.2153669	2.88	0.004	.1982089	1.042432
ICT	.0347498	.2528052	0.14	0.891	-.4607393	.530239
secu	.0180949	.0079235	2.28	0.022	.0025652	.0336246
brb	.0295605	.0231036	1.28	0.201	-.0157218	.0748428
lnimex	.0023268	.0075304	0.31	0.757	-.0124325	.0170862
lngov	-.006319	.0070298	-0.90	0.369	-.0200972	.0074591
INF	-.0057183	.0069392	-0.82	0.410	-.0193188	.0078823
infl	.000432	.0016327	0.26	0.791	-.0027681	.0036321
outfl	.0031708	.004061	0.78	0.435	-.0047886	.0111302
lnnni	.0013984	.0068081	0.21	0.837	-.0119454	.0147421
_cons	3.884028	.2687613	14.45	0.000	3.357266	4.410791
sigma_u	1.0464508					
sigma_e	.11696721					
rho	.98766048	(fraction of variance due to u_i)				

Sources: Authors (2024)

Appendix 9: Hausman test (1)

```
. hausman fem1 rem1

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fem1         rem1       Difference          Std. err.
-------------+------------------------------------------------------------
        tele |   .0974994     .1400139       -.0425144                .
        mobi |   .1681822     .1724018       -.0042196                .
    interuse |  -.3087523     -.299067       -.0096853                .
    hightech |   .6593362     .6203203        .0390159                .
         ICT |   .0260031     .0347498       -.0087468                .
        secu |   .0186891     .0180949        .0005943                .
         brb |   .0260668     .0295605       -.0034937                .
      lnimex |   .0021677     .0023268       -.0001591                .
       lngov |   -.006516     -.006319       -.0001969                .
         INF |   -.005751    -.0057183       -.0000328                .
        infl |   .0003322      .000432       -.0000998                .
       outfl |   .0030718     .0031708        -.000099                .
       lnnni |   .0018341     .0013984        .0004358                .
------------------------------------------------------------------------------
                           b = Consistent under H0 and Ha; obtained from xtreg.
            B = Inconsistent under Ha, efficient under H0; obtained from xtreg.
```

Sources: Authors (2024)

Appendix 10: Hausman test (2)

```
Test of H0: Difference in coefficients not systematic

   chi2(13) = (b-B)'[(V_b-V_B)^(-1)](b-B)
            =   8.36
Prob > chi2 = 0.8193
(V_b-V_B is not positive definite)
```

Sources: Authors (2024)

Appendix 11: Chi-square test

```
. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

        lngdppcap[group_id,t] = Xb + u[group_id] + e[group_id,t]

        Estimated results:
                         |       Var     SD = sqrt(Var)
                ---------+-----------------------------
                lngdppcap |   1.091086       1.044551
                        e |   .0137168       .1171189
                        u |   1.024077       1.011967

        Test: Var(u) = 0
                                  chibar2(01) =   775.44
                              Prob > chibar2 =   0.0000
```

Sources: Authors (2024)

Appendix 12: GLS regression

```
. xtgls lngdppcap tele mobi interuse hightech ICT secu brb lnimex lngov INF infl outfl lnnni, panels(heteroskedastic)

Cross-sectional time-series FGLS regression

Coefficients:  generalized least squares
Panels:        heteroskedastic
Correlation:   no autocorrelation

Estimated covariances      =        31          Number of obs     =       330
Estimated autocorrelations =         0          Number of groups  =        31
Estimated coefficients     =        14          Obs per group:
                                                              min =         1
                                                              avg =   10.64516
                                                              max =        13
                                                Wald chi2(13)     =    661.41
                                                Prob > chi2       =    0.0000
```

lngdppcap	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
tele	-.876276	.2102092	-4.17	0.000	-1.288278	-.4642735
mobi	.1321142	.0832075	1.59	0.112	-.0309695	.2951979
interuse	.840006	.1877985	4.47	0.000	.4719277	1.208084
hightech	.1147459	.205396	0.56	0.576	-.2878228	.5173146
ICT	.3132632	.304021	1.03	0.303	-.2826071	.9091335
secu	-.0206598	.014592	-1.42	0.157	-.0492596	.0079401
brb	.0881201	.0297119	2.97	0.003	.0298859	.1463543
lnimex	.0185876	.019348	0.96	0.337	-.0193338	.056509
lngov	.0133095	.0192833	0.69	0.490	-.024485	.051104
INF	.0124724	.0200864	0.62	0.535	-.0268962	.0518409
infl	.0017936	.0045624	0.39	0.694	-.0071486	.0107358
outfl	.0432214	.0097543	4.43	0.000	.0241034	.0623395
lnnni	.0138354	.0108892	1.27	0.204	-.007507	.0351778
_cons	2.583053	.3086659	8.37	0.000	1.978079	3.188027

Sources: Authors (2024)

Appendix 13: Factor Analysis

```
. factor tele mobi interuse hightech ICT secu brb lnimex lngov INF infl outfl lnnni, pcf mineigen(1)
(obs=330)

Factor analysis/correlation                    Number of obs    =        330
    Method: principal-component factors        Retained factors =          4
    Rotation: (unrotated)                      Number of params =         46
```

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	4.12297	2.32130	0.3172	0.3172
Factor2	1.80167	0.32811	0.1386	0.4557
Factor3	1.47356	0.39302	0.1134	0.5691
Factor4	1.08055	0.09635	0.0831	0.6522
Factor5	0.98420	0.11406	0.0757	0.7279
Factor6	0.87014	0.03764	0.0669	0.7949
Factor7	0.83250	0.20910	0.0640	0.8589
Factor8	0.62340	0.19496	0.0480	0.9068
Factor9	0.42845	0.09018	0.0330	0.9398
Factor10	0.33827	0.12793	0.0260	0.9658
Factor11	0.21034	0.05219	0.0162	0.9820
Factor12	0.15814	0.08234	0.0122	0.9942
Factor13	0.07580	.	0.0058	1.0000

```
    LR test: independent vs. saturated:  chi2(78) = 2031.80 Prob>chi2 = 0.0000
```

Sources: Authors (2024)

Appendix 14: Factor loadings (pattern matrix) and unique variances

Factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
tele	-0.6558	-0.2762	0.1604	0.0103	0.4678
mobi	0.5474	0.1543	0.4476	0.1175	0.4624
interuse	0.8491	0.3403	0.1434	0.0797	0.1364
hightech	-0.6026	0.6306	0.3056	0.0793	0.1396
ICT	-0.5770	0.6177	0.3612	0.0477	0.1528
secu	0.8244	0.2361	0.1733	0.0048	0.2346
brb	0.8491	0.3094	-0.0563	0.0420	0.1784
lnimex	0.0186	-0.2317	0.2771	0.6650	0.4269
lngov	0.2128	0.2385	0.1808	-0.1432	0.8446
INF	-0.0195	-0.1234	-0.1501	0.7346	0.4222
infl	0.2290	-0.5629	0.5514	-0.2096	0.2827
outfl	0.5857	-0.4328	0.2053	-0.0420	0.4257
lnnni	0.3667	0.1584	-0.7012	0.0421	0.3470

Sources: Authors (2024)

Appendix 15: Rotation matrix

```
. rotate, kaiser blanks(0.5)

Factor analysis/correlation                       Number of obs    =        330
    Method: principal-component factors           Retained factors =          4
    Rotation: orthogonal varimax (Kaiser on)      Number of params =         46
```

Factor	Variance	Difference	Proportion	Cumulative
Factor1	3.39667	0.95166	0.2613	0.2613
Factor2	2.44501	0.91754	0.1881	0.4494
Factor3	1.52747	0.41787	0.1175	0.5669
Factor4	1.10960	.	0.0854	0.6522

LR test: independent vs. saturated: chi2(78) = 2031.80 Prob>chi2 = 0.0000

Sources: Authors (2024)

Appendix 16: Rotated factor loadings (pattern matrix) and unique variances

Rotated factor loadings (pattern matrix) and unique variances

Variable	Factor1	Factor2	Factor3	Factor4	Uniqueness
tele	**-0.6330**				**0.4678**
mobi	**0.6614**				**0.4624**
interuse	**0.9144**				**0.1364**
hightech		**0.9191**			**0.1396**
ICT		**0.9103**			**0.1528**
secu	**0.8483**				**0.2346**
brb	**0.8423**				**0.1784**

Sources: Authors (2024)

Appendix 17: Regression analysis with interaction variable

```
. reg lngdppcap mobi interuse ICT secu brb tele hightech c.tele#c.hightech lnimex lngov INF infl outfl lnnni
```

Source	SS	df	MS	Number of obs	=	330
				F(14, 315)	=	16.34
Model	151.001684	14	10.7858346	Prob > F	=	0.0000
Residual	207.965564	315	.660208138	R-squared	=	0.4207
				Adj R-squared	=	0.3949
Total	358.967248	329	1.09108586	Root MSE	=	.81253

lngdppcap	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
mobi	.5531078	.1771341	3.12	0.002	.2045923	.9016232
interuse	2.330826	.3556466	6.55	0.000	1.631083	3.030569
ICT	1.783836	.8361999	2.13	0.034	.1385934	3.429079
secu	-.2075682	.0326337	-6.36	0.000	-.2717757	-.1433607
brb	.2570728	.0670103	3.84	0.000	.1252286	.3889171
tele	1.439648	.6957959	2.07	0.039	.0706534	2.808643
hightech	.7554398	.6683114	1.13	0.259	-.5594786	2.070358
c.tele#c.hightech	4.247075	2.352954	1.80	0.072	-.382417	8.876567
lnimex	.0848584	.0492339	1.72	0.086	-.0120105	.1817273
lngov	.0084308	.0481728	0.18	0.861	-.0863503	.1032119
INF	.0063764	.0453753	0.14	0.888	-.0829006	.0956534
infl	.0110404	.0083807	1.32	0.189	-.0054488	.0275296
outfl	.0240282	.0208426	1.15	0.250	-.0169802	.0650365
lnnni	.0683232	.0252715	2.70	0.007	.0186009	.1180455
_cons	1.013778	.7021404	1.44	0.150	-.3676999	2.395256

Sources: Authors (2024)

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