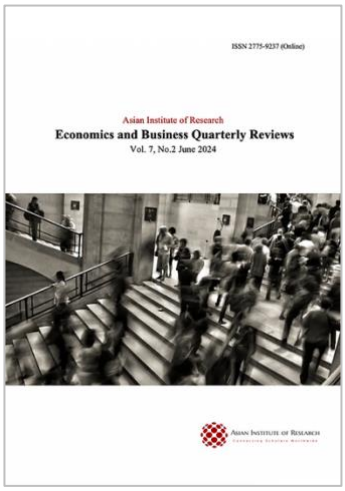

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The Effect of Digital Transformation on Saudi Economics Growth

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Abstract
The study measures the effect of digital transformation on Saudi Arabia's economy from 2001 to 2022. Descriptive-analytical and econometrics models are used through E-views to achieve this goal. Linear regression was used to test the model, and unit root "Dickey-Fuller" was used to test the durability of the study, co-integration of the "Johansson" validation model, and causality test of Granger; this shows an inversely significant relationship between the number of operations in sales points (POS) and the gross domestic product (GDP). A parallel relationship exists between fixed broadband subscriptions (BS), gross fixed capital formation (GFCF), and labor force (L). The study shows that the dependent variables, the number of POS, BS, GFCF, and L, are all significant factors for the independent variable, GDP, caused by forming an integration relationship between the long-term and short-term. Also, there is a two-way reciprocal causality relationship between GDP and POS and a one-way reciprocal causality between GDP and BS, GFCF, and L. The study recommends improving telecom infrastructure to increase the speed of Wi-Fi and make it available in each location at a low cost.

Keywords: Digital Economy, Digital Transformation, Economic Growth, Saudi Arabia

1. Introduction

The acceleration world is undergoing a revolution in information and communications technology (ICT), which has fundamentally altered lifestyles and the implementation of economic activities. This shift drives the economy towards a digital framework reliant on information technology and modern communications, positively affecting societal and economic interests (Al-Marhabi & Al-Bar, 2019). ICT has amplified the role of digital transformation across various sectors, enhancing worker productivity, efficiency, and competitiveness. The growth of the digital economy is closely tied to advanced technologies of the Fourth Industrial Revolution, such as artificial intelligence (AI), the Internet of Things (IoT), and cloud computing (El-Gohary & Radwan, 2023).

The COVID-19 pandemic demonstrated the importance of digital technology in achieving economic growth and overcoming the crisis that surprised countries without preparing for its challenges, as countries had no choice but to accelerate digital transformation in all fields (Osama, 2022). Countries have become dependent on digitalization,

forcing them to shift towards the digital economy as an indicator that contributes to achieving the highest economic growth rates away from the oil sector (Bassiouni, 2022).

Many previous studies have emphasized the impact of digital transformation in enhancing economic growth. Katz & Calorda (2017) concluded that with the increase in growth in per capita GDP by 0.13% for every 1% increase in digital ecosystem development indicators, the higher the level of digital transformation in a country has increased growth rate and per capita GDP (Council of Arab Economic Unity, 2021). In addition, the World Bank Report (2022) confirmed that the complete digital transformation of the economy is one of the main reasons for enhancing growth, as it can raise the per capita GDP to a rate of no less than 46% over 30 years.

In Arab countries, the digital economy's contribution does not exceed 4% of the GDP compared to the global average, which reached 22%, meaning that when taking advantage of the opportunities offered by the digital economy, the Arab world will achieve tremendous development leaps. The impact of the digital economy is estimated to be five times that of traditional methods in economic growth. According to studies and experiments, promoting economic growth is what makes it the most important accelerator of economic growth globally. (The Ministry of Digital Economy and Entrepreneurship, 2021).

Saudi Arabia launched the National Transformation Program in 2016 as the first of the Vision 2030 programs. The program aims to transform the Kingdom into a leading country ranked among the world's best.

Digital transformation is the most critical pillar of the national transformation program due to its reliance on the use and employment of modern technology that keeps pace with the digital age and the development of digital infrastructure to improve services, enhance innovation, achieve growth, increase employment opportunities, improve the quality of life of the individuals, both for citizens and residents, diversify sources of income, and enhance the digital economy (BBI website, 2024).

Because of this, improving the non-oil sector's activity is essential to diversifying the economy and creating an attractive investment environment, as Saudi Arabia aspires to raise the size of its economy to rank among the 15th in the world by 2030 (Digital Transformation Unit, MCIT).

Because the ICT sector is important for economic growth, this research is concerned with studying the impact of digital transformation on economic growth in Saudi Arabia.

2. Study Problem

Saudi Arabia is dependent on limited resources, and oil revenues have been the main source of income since the beginning of the seventies. Fluctuations in oil prices have led to instability in the Saudi economy, as oil is one of the exhaustible resources. Therefore, this will have a negative impact on the economy through its effects on oil exports and then on revenues and GDP (MCIT).

The government of Saudi Arabia has realized the importance of diversification away from oil to improve its economic strength. It has adopted national digital transformation strategies and seeks to achieve several goals, the most important of which are stimulating economic growth, creating more job opportunities, and supporting economic diversification (Abdel Hamid, 2018). Saudi Arabia launched Vision 2030 and prioritized the development of the ICT sector as one of the pillars supporting the economy. It also worked to create the appropriate environment for the technologies of the Fourth Industrial Revolution and the development of e-government. According to a digital economy report published by the Research and Information Center (2022) based on a field survey, 63.2% of participants agreed that Saudi Arabia faces the challenge of weak infrastructure for digital transformation.

Previous studies have emphasized the importance of digital transformation. Al-Sabbagh et al. (2013) studied the gross growth of the GDP per capita, which increases by 0.75% when the country's degree of digitalization increases

by 10%. Also, Baga (2019) concluded that digital transformation is one of the engines of growth in all economies, as it accelerates economic and social returns growth rate (Council of Arab Economic Unity, 2020).

As Al-Khouri (2020) explained in his study, there is a positive global certainty in the process of digital transformation on the GDP, including its per capita share, and he stated that the literature on the subject is that countries that Encourage digital transformation and be more prosperous compared to countries that fail to achieve it.

The transformation has become necessary to keep pace with global developments in the field of technology and meet the requirements of the times, thus avoiding marginalization and falling behind developed countries, as well as facing economic and social challenges (Arab Monetary Fund, 2020).

Therefore, the study problem appears in the following question:
To what extent does digital transformation impact economic growth in Saudi Arabia?

2.1 Objectives of the Study

The main goal is to measure the impact of digital transformation on economic growth in Saudi Arabia, and sub-goals fall under this primary goal are:
1. Explaining the concept of the digital economy and its importance.
2. Establish an econometrics model showing the impact of digital transformation on economic growth.
3. Highlighting the role of the digital sector in achieving economic growth.

2.2 Importance of the study

The study addresses a vital topic, which is digital transformation and its relationship to economic growth, and its importance lies in the following:

- This study is critical because it is consistent with Saudi Arabia's Vision 2030, which employs modern technologies to advance economic growth and achieve the primary goal of diversifying the economic base and building a prosperous economy.
- Digital transformation, or the digital economy, is one of the modern and essential topics resulting from the digital revolution, and many developed and developing countries are seeking to implement it, especially after the COVID-19 pandemic.
- Its importance lies in reviewing the theoretical literature on digital transformation and economic growth in Saudi Arabia.
- This study monitors the actual reality of digital transformation and studies economic growth. Therefore, the study results will help decision-makers by providing implications.

2.3 Study Hypotheses

The main hypothesis:
There is a direct relationship between digital transformation and economic growth in Saudi Arabia, and it consists of the following sub-hypotheses:

1. A statistically significant positive relationship exists between communications infrastructure (CI), an independent variable, and economic growth, as a dependent variable.
2. A statistically significant positive relationship exists between point-of-sale operations (POS) as an independent variable and economic growth as a dependent variable.
3. A statistically significant positive relationship exists between mobile phone users (MS) as an independent variable and economic growth as a dependent variable.
4. A statistically significant positive relationship exists between broadband subscribers (BS) as an independent variable and economic growth as a dependent variable.

2.4 Study Methodology

The study follows the descriptive analytical approach by reviewing the theoretical framework and previous studies within the framework of the study topic. It also follows the econometrics approach and will rely on the (E-views) program to analyze the relationship between the study variables and clarify the role of digital transformation in achieving economic growth in Saudi Arabia. During the period (2001-2022), the study conducted several tests necessary to achieve realistic results and a logical interpretation of economic variables.

The econometrics model is formulated as follows:

$$\text{GDP}=\beta_0 + \beta_1 \text{CI} + \beta_2 \text{POS} + \beta_3 \text{MS} + \beta_4 \text{BS} + B_5 \text{GFCF} + B_6 L + \varepsilon \quad (1)$$

Whereas:

$\boldsymbol{\beta_0}$= categorical

$\boldsymbol{\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6}$ model parameters

Dependent variable:

(GDP) represents economic growth.

Independent variables:

(CI)	Communications infrastructure.
(POS)	Point of sale operations.
(MS)	Number of mobile subscribers.
(BS)	Number of broadband subscribers.
(GFCF)	Gross fixed capital formation.
(L)	Total labor force.
$\boldsymbol{\varepsilon}$:	Random error.

3. Theoretical Framework

3.1 The Concept of the Digital Economy

The rapid spread of information technology and the use of electronic media led to a change in human lifestyles, which led to a change in the means of carrying out economic activities, followed by a new type of economy called the "digital economy," "internet age," or "information economy," which reflects a future vision of a world in which information is the fundamental element of the economy (Al-Sayed, 2020).

Many opinions have been expressed regarding a unified definition of the digital economy. Perhaps the most important of them are the following: Al-Khoury (2020, p. 175) describes the digital economy as "economic, social and cultural activities that depend on digital technologies to achieve the goals of sustainable development in its comprehensive and integrative sense.". As Al-Safi (2021, p. 27) puts it, it is "that part of the economy that specializes in everything related to information technologies and digital technologies."
It is defined as "an economy based on digital technologies." (Bukht & Heeks, 2018, p. 9).

3.2 The Importance of the Digital Economy

Digital transactions between businesses and consumers (B2C) have increased about three times daily in the last five years.[1] Therefore, the digital economy has become essential to the global economy (Siddiq, 2020). Hence, it has a significant role in building "smart societies" that enhance the capabilities of all parties within society and help governments improve the performance of their services provided to citizens, reduce inequality, and reduce and combat corruption through new technologies (Abdel-Al-Hassan, 2022).

[1] An abbreviation for Business-to-Consumer describes the commercial interaction between individual consumers and companies to meet their needs, such as retail stores, e-commerce, financial services, and others.

It also contributed to creating diverse and increasing opportunities, especially in fields that use advanced technologies, improving performance, raising productivity, and reducing production costs (Fawzi, 2017).

According to a report (2019) by the McKinsey Global Institute (MGI), it indicated the ability of the digital economy to create 60 to 65 million new job opportunities by 2025.

Economic importance is also reflected in the increased growth of the national economy, which contributes to enhancing the competition of the global economy and thus opens up commercial opportunities for international markets, reaching market sectors that were difficult to achieve; this leads to an increase in revenues, which increases the economy and the standard of living (Karim, 2022).

Abdel Jalil (2020, p. 8) pointed out that the importance of the digital economy stems from the following:

- It is an excellent tool for accessing global markets simultaneously at the lowest costs.
- It is an effective means of concluding deals between customers through direct electronic communication.
- It is a tool for exchanging interests between sellers and buyers and contributes to improving decision-making through timely information flow.
- It is a tool for project operations and organizations to achieve goals by eliminating delays.

3.3 The Impact of the Digital Economy on Economic Growth

Today's digital economy represents the most significant potential for the traditional economy, as it opens new horizons for the concept of added value through the distinctive tools and technologies of the Fourth Industrial Revolution, which represent a new addition to traditional economic resources. It has become more closely linked with the conventional economy, making it difficult to separate them. The digital economy has become the main driver of global economies. The rapid advancement of digital technology drives it as new economic concepts have emerged that affect, without exception, all sectors. The digital economy is also one of the world's fastest and most growing economies. It sometimes achieves five times the traditional economic growth rates, and this indicates that within ten years, the rate of the digital economy will reach about 50% of the total global economy (Al-Khoury, 2020).

Therefore, Saudi Arabia considers the development of the digital economy one of the most critical factors in enhancing the capabilities of the non-oil and promising sectors in achieving Vision (2030) and developing and diversifying the economy. (Digital Transformation Unit, MCIT, 2021). The Kingdom aims to push the digital economy forward by strengthening various sectors and achieving qualitative leaps. It also seeks to enhance the ICT sector as an essential means to achieve ambitious goals (MCIT, 2021), and it is also one of the sectors that are most rapidly developing and growing to keep pace with global changes (CST Annual Report, 2021).

Based on the importance of the digital economy in economic growth, Saudi Arabia gave this matter special attention and support until it was classified as the best country in digital performance among the G20 countries in the Digital Competitiveness Report (2021). Following that Vision, Saudi Arabia made significant progress in measuring digital transformation in 2022; It reached more than 80%, compared to 69% in 2021. (Digital Government Authority, 2023) Accordingly, the digital economy substantially boosted the GDP from 2017 to 2020. The digital economy's contribution to GDP was 11.6% in 2017 but increased to 14.5% in 2020, generating an estimated value of around SR 73 billion created for the Saudi economy.[2]

3.3.1 Real GDP

Since oil is the backbone of the economy in Saudi Arabia, the national economy still depends on oil revenues, and fluctuations in output and growth continue due to price changes. Despite this, the non-oil sector has shown clear

[2] Digitalization as a driver of economic resilience in Saudi Arabia during COVID-19 (2021).

and logical developments due to the efforts made in economic diversification and the transition to knowledge-based production, in addition to strengthening small and medium enterprises and the private sector. Since 2016, Saudi Arabia has sought to carry out economic reforms within the framework of the 2030 Strategic Vision, aiming to build a productive base for the Saudi economy and diversify sources of income to reduce dependence on oil revenues (Hariri, 2020).

Table 1 shows the increase in GDP in the past decades during the study period (2001-2022). The value of the GDP rose nearly double to reach SR 2.97 billion by the end of the year 2022, compared to SR 1.40 billion in 2001. By analyzing the GDP development over the period chosen in the study, a positive trend was found for the data from 2001 to 2022. This prosperity and progress faced a slight drop, such as in 2002. The value of the GDP dropped from SR 1.40 billion in 2001 to SR1.37 billion in 2002, then it grew in 2003, which is the highest rate of increase achieved during the study period, at a rate of 11.24%, benefiting from the improvement in oil prices in the global market and from the continued improvement of the local investment environment to enhance the contribution of the private sector (SAMA, 2005). It rose again until it reached SR1.93 billion in 2008 at a rate of 6.25%, then declined slightly, reaching SR1.89 billion in 2009.

Then, it returned to growth in 2018, which achieved a rate of 2.76%, reaching about 2.73 billion, compared to a decrease of 0.07% in 2017; this is attributed to the increase in the output of the oil sector by 3.1%, as well as the domestic product of the non-oil sector achieving a growth of 1.2%. Most economic activities grew at varying rates for the year 2018. (SAMA, 2019). The contraction at a rate of 4.34% in the year 2020 compared to the year 2019 turned into an increase, with the highest growth rate of 8.7% for the year 2022, the fastest growth rate in 11 years due to the noticeable expansion of oil activities by 15.4% and the continued recovery of non-oil activities by about 5.4% (Annual Report on the Status of the Saudi Economy, 2022). Transportation, storage, and communications activities reached the highest growth rates in non-oil activities at 9.1 % (GASTAT, website).

Table 1: Real GDP data from 2001-2022 (M SR.)

Year	Real GDP	Annual growth rate%	Year	Real GDP	an average Annual growth%
2001	1404870	-1.21	2012	2317863	5.43
2002	1365264	-2.82	2013	2383930	2.85
2003	1518748	11.24	2014	2479946	4.03
2004	1639617	7.96	2015	2596259	4.69
2005	1731006	5.57	2016	2657611	2.36
2006	1779274	2.79	2017	2655758	-0.07
2007	1812139	1.85	2018	2729117	2.76
2008	1925394	6.25	2019	2751831	0.83
2009	1885745	-2.06	2020	2632363	-4.34
2010	1980777	5.04	2021	2746242	4.33
2011	2198539	10.99	2022	2984636	8.74

Source: SAMA Annual Reports (2001-2022)

It is clear from the above the diversity of policies adopted by Saudi Arabia to support the national economy, as it diversified sources of income and provided the necessary environment to achieve the economic growth witnessed by the gross domestic product. (GASTAT Website)

3.3.2 Communications Infrastructure (CI)

The government of Saudi Arabia, in cooperation with the private sector, has improved the CI, Which has led to remarkable progress in the field of communications (Center Research and Information, 2022) as the readiness of the CI is the main factor in achieving the transition to the digital economy and implementing Vision 2030 providing the Internet and broadband to all of society, which constitutes the fundamental determinant in the development strategy and Vision 2030 of Saudi Arabia (Al-Harbi, 2020). As shown in Figure 1, the value of CI increased from

SR29.40 million in 2001 to SR177.13 million in 2019, reaching its highest value. It began to decline in 2020. It achieved SR164.22 million compared to the previous year and then rose in the last two years, 2021-2022. It reached SR197.36 million in 2022.

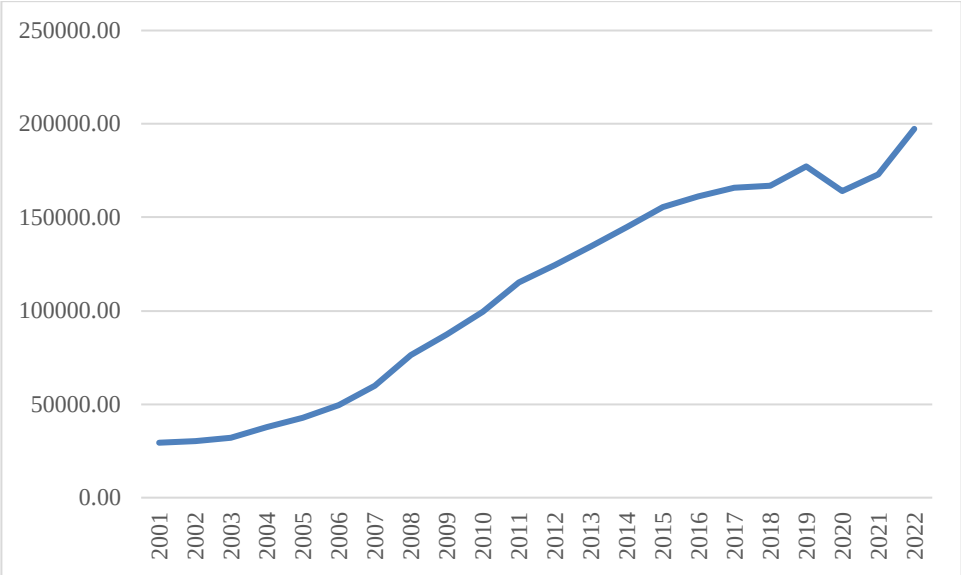

Figure 1: Communications Infrastructure (CI) in Saudi Arabia (2001-2022, M SR.)

Source: SAMA Annual Reports (2001-2022)

Regarding Internet service development, the Internet was introduced in Saudi Arabia in 1994. Educational, medical, and research institutions were granted permission to access the Internet, and then general users were able to access the Internet in 1999. In December 2000, the number of Internet users in Saudi Arabia was about 200 thousand, continuously increasing until it reached 27 million in 2018 (CST Website). Individuals' Internet use increased in 2022 to 94.3%, 1.4% over 2021 (Bulletin on Access and Use of Information and Communications Technology for Families and Individuals for 2022).

Because of enormous efforts to develop and expand CI, the Internet penetration rate has witnessed remarkable growth over the past years. This percentage increased from 93.3% in 2018 to about 98.6% in 2022, as shown in the following Figure 2:

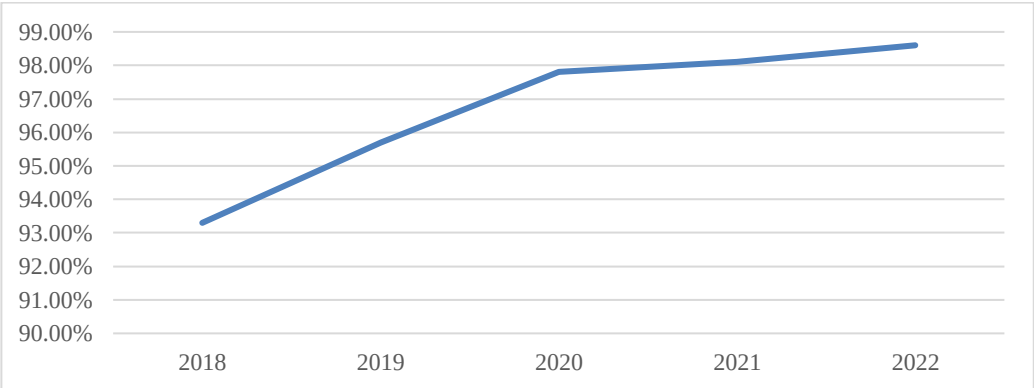

Figure 2: The Internet Penetration (IP) rate in Saudi Arabia during the period 2018-2022

Source: CST Annual Report 2021 and 2022

As Internet users increased, the need arose to improve data transfer capacity and speed to cover the number of new users (Al-Bishr & Nasr-al-Din, 2023). The average download speed for mobile Internet in Saudi Arabia in 2022 reached 180.21 MB per second, with an improvement rate estimated at 6.31%, compared to the same period of the previous year, 2021, while the average download speed for fixed Internet reached 107.80 MB per second in 2022, with an improvement rate estimated at 9.69%, compared to the same period in the year 2021, as shown Table 2:

Table 2: Average download speed for mobile and fixed Internet in Saudi Arabia

Period	Mobile Internet	Fixed Internet
2019	50.32 MB/s (Mbps)	50.03 MB/s (Mbps)
2020	97.54 MB/s (Mbps)	76.9 MB/s (Mbps)
2021	169.52 MB/s (Mbps)	104.19 MB/s (Mbps)
2022	180.20 MB/s (Mbps)	107.8 MB/s (Mbps)

Source: CST Annual Report for the years 2021 and 2022

3.3.3 Number of Mobile Subscribers

The mobile communications sector in the telecommunications market in Saudi Arabia is expected to grow significantly due to the spread of the Internet and smartphones; this aligns with the growing digital economy and Saudi Vision 2030 interest. In addition to the continuous efforts made by the CST and mobile network operators, 5G services are available, which has improved call quality and Internet speeds. As a result, the demand for mobile data and voice services has increased, and according to data issued by (GSMA Intelligence), mobile phone use is widespread, and there were more than 41 million mobile connections at the beginning of 2022. The COVID-19 pandemic has also stimulated growth in mobile data traffic due to increased online gaming, digital transactions, shopping, and downloading.

Additionally, the government has incentivized cashless transactions and helped develop the vast e-commerce market. These factors have positively impacted the growth of the mobile sector. (Mordor Intelligence Research, 2023)

As shown in Figure 3, during the period (2001-2015), the number of subscribers increased, reaching more than 52 million subscribers at the end of 2015, then it declined during the two years (2016-2017) to 40.2 million subscribers by the end of 2017; this is attributed to the fingerprint authentication campaign for subscribers to restrict the use of unregistered counterfeit cards that may threaten national security, which began in 2016 (Al-Jazira Capital, 2020), then 2018 witnessed the first increase in the number of subscribers since 2015 to exceed 41 million subscribers, and then the number began increasing in 2019 by about 43 million subscribers to 48 million subscribers in 2022, with an average growth rate of 3.96% over the past four years.

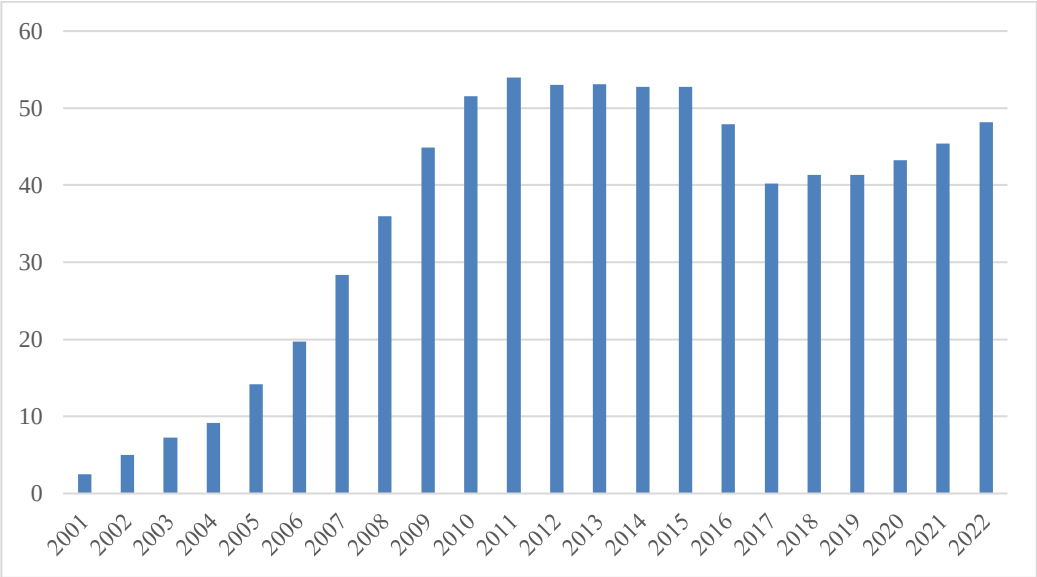

Figure 3: Mobile phone subscribers (MS) in Saudi Arabia (M)

Source: World Bank's World Development Indicators for the years 2001-2022

3.3.4 Number of Fixed Broadband Subscribers

Broadband networks have been recognized globally as essential infrastructure, clearly playing a prominent and increasing role in terms of promoting economic growth, changing growth engines, and improving competitiveness and continuity; the development of these networks has also become a significant measure of the state's strength in general (ITU, 2021). Through this, many countries became confident that the broadband Internet would effectively contribute to building a state and transitioning to a knowledge-based economy (Gelvanovska et al., 2014).

Studies show that Internet services will be the main factor for the growth of the ICT sector. They are also considered one of the most important sources of income for achieving the Ninth Development Plan; this includes striving towards a knowledge economy by applying electronic transactions and spreading their use in all regions of the Kingdom (Department of Economic and Market Studies (CITC, 2012).

Figure 4 shows the steady growth in the number of fixed broadband subscribers in the Kingdom during the study period (2001-2022), as the number of subscribers increased from 14 thousand in 2001 to 1.95 million subscribers by the end of 2011, with a penetration rate estimated at 33% at the residential level (CST, 2012). The number of subscribers increased further, reaching 6,33 million subscribers in 2015, in just four years, then a significant decline in the growth rate in the following five years until it reached 6,80 million in 2019. The number of subscribers increased during (2020-2022) from 7,89 million broadband subscribers in 2020 to 13,46 million during 2022.

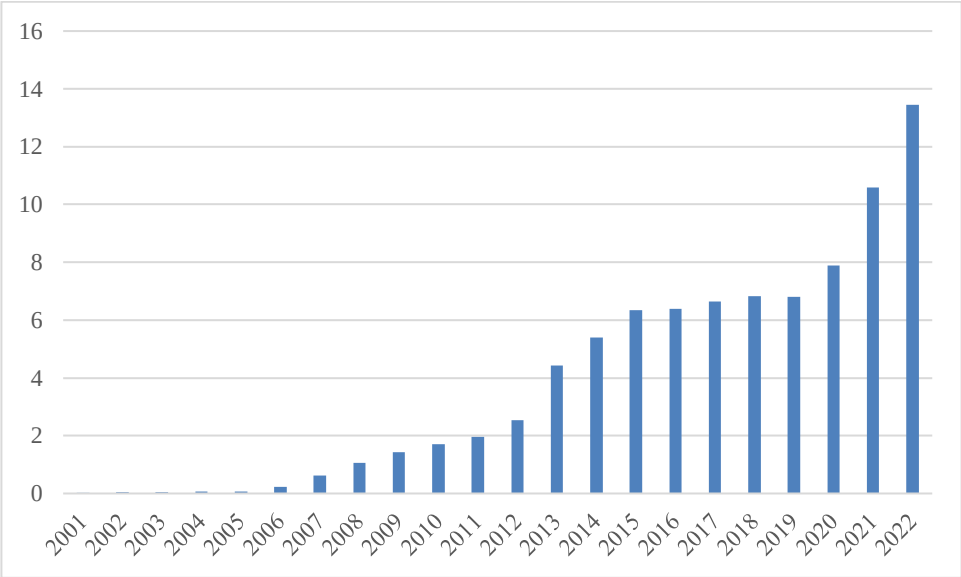

Figure 4: Fixed broadband subscribers (BS) in Saudi Arabia (M)

Source: ITU data for the years 2001-2022

3.3.5 Sale Points Operations

With the acceleration of technological development, the spread of the Internet, mobile devices, and electronic applications, and the inability of traditional financial solutions, the need for digital payments increased as many digital payment solutions and systems emerged (Al-Khoury, 2020).

The Kingdom's Vision 2030 aims to promote the transition to a society less reliant on cash, which is one of the main goals of the financial sector development program as part of Vision 2030, by providing multiple payment options for all individuals and companies to increase the share of digital payments in Saudi Arabia. To reach 70% of electronic payments by 2025, the development of electronic payment methods has motivated individuals to change their payments. Where they were previously accustomed to using cash to complete their transactions, they now rely on electronic means because they are more straightforward, safer, faster, and more efficient, leading to the share of electronic payments exceeding their monetary theory (SAMA, 2021).

Figure 5 clearly shows the growth in the number of sales. The number of transactions increased from 23.96 million in 2001 to 394.9 million in 2015. The technological development stage that began in 2016 showed that the growth rate increased by 32.83% compared to a rate of 20.76% in 2015. This growth is due to the launch of the "Mada Atheer" service, which witnessed great demand among Mada cardholders through NFC technology;[3] the possibility of making a payment process by simply passing the card in front of the point-of-sale operation; then the number of transactions began to increase by the end of the 2022 period by 40.4% to 7.26 billion transactions, compared to 5.17 billion transactions in 2021; this is attributed to the evident growth through several factors that contributed to this increase, the most important of which is the launch of many new payment methods, such as the "Mada PAY" service via "Mada Atheer" smart devices, as well as the near-field communication.

NFC technology allows the cardholder to perform operations through the service. Purchasing is possible by simply passing the card to the point-of-sale reader (SAMA, 2017). The COVID-19 pandemic has also helped push individuals to reduce reliance on cash, obliging all stores to provide point-of-sale devices (SAMA, 2021).

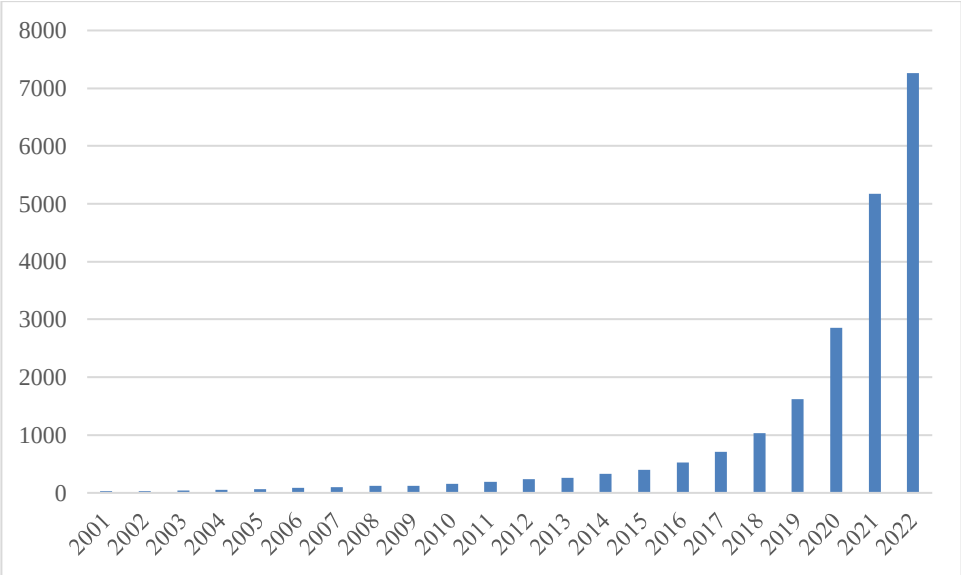

Figure 5: Point of sale operations (POS) in Saudi Arabia (M)

Source: SAMA for the years 2001-2022

4. Previous Studies

With the acceleration of the global trend towards digital transformation and its accompanying positive effects on all fields, the most important of which is the field of the economy, which has developed due to developments in the field of ICT, all of this has contributed to the interest of researchers in studying this transformation and its impact on economic growth (Bahrini & Qaffas, 2019, p2), as some studies have focused on the independent variables (CI, MS, BS, POS, GFCF, and L) also focused on studies revolving around the relationship of digital transformation and economic growth.

Donou-Adonsou et al. (2016) found that the Internet and mobile phones have contributed to economic growth. Increasing Internet and mobile phone use by one percentage point raises growth by 0.12% and 0.03 %, respectively. In addition, the study found that developing CI enhances economic growth in sub-Saharan Africa, with great scope to enhance the potential growth of telecommunications infrastructure.

Sepehrdoust and Ghorbanseresht (2018) studied the impact of ICT and financial development on developing economies in oil-exporting countries (OPEC) from 2002 to 2015, using the GMM-Panel model. The results showed that increasing the financial development and ICT variables by 1% increased economic growth by 4.8%.

[3] NFC is an abbreviation for Near Field Communication, a near-field communication technology similar to Bluetooth technology available for mobile devices.

The results also showed that labor force growth and total fixed capital formation growth positively impact countries' economic growth.

Majeed & Ayub (2018) analyzed the impact of ICT indicators at the local and global levels through the experimental study of ordinary least squares (OLS) techniques, and the generalized moments method (Gmm) helped determine that all information and communication technology indicators accelerate global and regional economic growth. However, some indicators, such as online service, CI, and e-government, are more suitable for promoting economic growth. On the other hand, the study results indicated that emerging and developing countries are acquiring a form of ICT more than developed countries, which confirms the argument that these economies are progressing through ICT. The study results also indicated that investment in ICT is necessary to achieve the goals of the knowledge-based economy in the twenty-first century.

Al-Hajj and Ben Jeddou's study (2019) used panel data to measure the impact of ICT infrastructure on economic growth in six Arab oil countries: Oman, Yemen, the United Arab Emirates, Saudi Arabia, Kuwait, and Algeria. After estimating the model using the generalized least squares method, they concluded that oil still mainly determines the economic growth of the six Arab countries because the impact of ICT in these countries has had a negative effect.

Haftu (2019) empirically analyzed the impact of mobile phones and the Internet on per capita income in sub-Saharan Africa from 2006 to 2015 using panel data from 40 countries and a powerful 2-step GMM method. The study found a growth in mobile phone penetration that has contributed significantly to the per capita GDP in the region after controlling for some other variables. It showed a 10% increase in mobile phone penetration, which resulted in a 1.2% change in GDP per capita.

Khandelwal and Agarwal (2020) examined the relationship between Internet broadband subscriptions and economic growth using World Bank data from 1998 to 2017 and a stochastic analysis model; this confirmed the study's findings, as broadband subscriptions positively impact economic growth.

Thoyibah & Sugiharti (2020) analyzed the impact of the percentage of individual Internet users, mobile cellular subscriptions (per 100 people), fixed broadband subscriptions (per 100 people), and employment on per capita of GDP in six ASEAN countries in the period 2011-2019, as the results of the study showed that the input of neoclassical growth theory is capital through telecommunications infrastructure consisting of the percentage of individual Internet users, and mobile cellular subscriptions (Per 100 people), fixed broadband subscriptions (per 100 people), telecommunications infrastructure based on indicators of the proportion of individual Internet users, and fixed broadband subscriptions (per 100 people), have a positive significance on economic growth. Surprising results on telecommunications infrastructure with indicators of mobile cellular subscriptions (per 100 people) significantly negatively impact economic growth. The labor force has no effect but is positive on economic growth.

Ibrahimi and Fetai (2022) examined the impact of ICT on the GDP growth in the Western Balkan countries from 2000 to 2019 by employing several tools. Various methods, such as pooled OLS, fixed effects, random Effects, and the Hausman-Taylor model with instrumental variables (IV), the study concluded that fixed-line telephone subscriptions and individuals' use of the Internet have a positive effect on GDP growth rates in contrast, broadband and mobile phone subscriptions have a negative impact on GDP growth.

Al-Hababi (2023) studied the relationship between the digital economy and economic growth from 2000 to 2020. The study relied on the autoregressive distributed lag (ARDL) model, and the results confirmed the digital economy's ability to enhance economic growth in Saudi Arabia. It also found that capital positively affects economic growth and has no significant effect on labor. The results are consistent with the endogenous growth model, assuming that technical progress drives economic growth.

5. Econometrics Analysis of the Study Variables

5.1 Introduction

This section aims to analyze the impact of the digital transformation variables under study, which are CI, number of POS, MS, BS, GFCF, and L as independent variables, and economic growth expressed as Real GDP as a dependent variable during the period (2001-2022), the data was analyzed by using the econometrics program E-views, by using the multiple linear regression method using the ordinary least squares (OLS) method, and several tests were conducted. Examining the quality of the model parameters used to explain the phenomenon under study is necessary.

5.2 Multiple Linear Regression Analysis

The model estimated the study period by adopting multiple linear regression using the OLS method, following the linear form of the function being estimated, and applying the necessary statistical tests for each to ensure that the estimated models are correct and free of measurement problems.

5.2.1 Results of Regression Analysis of the Linear Formula

The model was adopted by using the multiple linear regression method based on the linear formula by looking at equation (1) above, and the results appeared as in the estimated function (2):

GDP = 744545.500468 + 3.79158247814*CI - 1.27697862115e-05*POS - 0.0078383622691*MS - 0.00309465181283*BS + 1.48933244906*GFCF + 0.0514199 481064*L (2)

Table 3 shows the estimated model results through the coefficient of determination R^2 of 0.991, and the modified coefficient of determination R^2. Adj of 0.9887 explains the proportion of variation in the dependent variable (98.87%) predicted by the independent variables, while the remaining percentage (1.3) is due to the interpretation of random errors.

The high significant value of the "F" statistic, which reached 0.000, demonstrates the quality and suitability of the model for explaining the relationship between the independent and dependent variables.

The model estimation results showed that the probability values of the independent variables are statistically significant, except for the CI and the number of POS and BS.

It has been shown that the dependent variable, the GDP, has an inverse relationship with each of the following independent variables: the number of POS, MS, and BS. There is also a direct relationship between the GDP and the CI, GFCF, and L.

Table 3: Results of a linear regression model in linear form

Indep. Var.	Coefficient	t-stat.	p-value
C	7.45 E+11	3.834952	0.0016
CI	3.791582	1.503682	0.1534
POS	-12.76979	-0.566294	0.5796
MS	-7838.362	-3.201285	0.0059
BS	-3094.652	-0.124478	0.9026
GFCF	1489.332	4.161329	0.0008
L	51419.95	1.766177	0.0977

Some verification tests were used to verify that the constructed model was free of econometrics problems such as: Test the residuals to ensure no serial correlation and follow the normal distribution model. The value of Durbin - Watson (DW) was relied upon to test autocorrelation. The value of DW was 1.5037. Based on the tabular value,

it falls between (2.09 $d_u$and 0.77 d_l i) indicating that no decision can be reached because it falls between the two table values, making it inconclusive.

The Breusch-Godfray Lagrange multiplier (LM-Test) was tested, and the "chi-square" statistical value was 0.13, i.e., greater than 0.05, meaning there is no serial autocorrelation problem. Looking at Figure 6, the "Jarque-Bera" test for a normal distribution showed that it equals 0.176334, meaning it is greater than 5%. Therefore, the null hypothesis is accepted and follows a normal distribution.

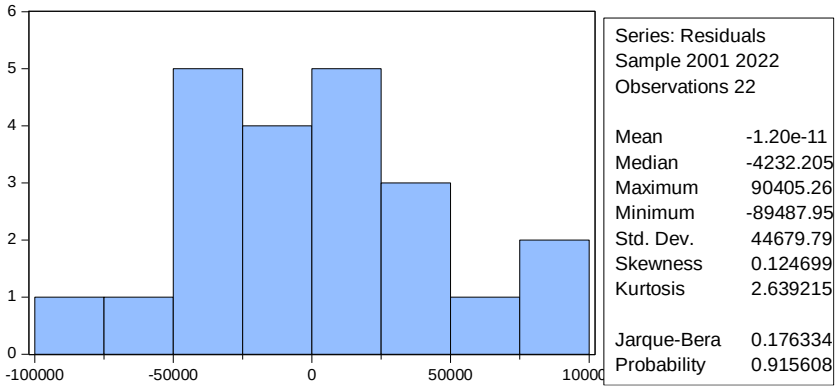

Figure 6: The natural probability of residuals

The correlation matrix must be verified to determine whether the problem of multicollinearity exists. Table 4 shows a high correlation between real GDP and CI.

Table 4: Correlation coefficients for linear function variables

	RGDP	**CI**	**POS**	**MS**	**BC**	**FGFC**	**L**
GDP	1.0000	0.9907	0.6128	0.7899	0.9199	0.9558	0.9810
CI	0.9907	1.0000	0.6078	0.8128	0.92089	0.9550	0.9860
POS	0.6128	0.6078	1.0000	0.2891	0.8389	0.5312	0.6567
MS	0.7899	0.8128	0.2891	1.0000	0.6010	0.9113	0.7699
BS	0.9199	0.9208	0.8389	0.6010	1.0000	0.8377	0.9295
GFCF	0.9558	0.9550	0.5312	0.9113	0.8377	1.0000	0.9240
L	0.9810	0.9860	0.6567	0.76993	0.9295	0.9240	1.0000

To improve the model result, some other independent variables, such as CI and the number of MS, were deleted to avoid the problem of linear correlation and enhance the results. Accordingly, a model was derived from model (1), thus obtaining the following model:

$$\text{RGDP}=\beta_0 + \beta_2\text{POS} + \beta_3\text{BS} + B_5\text{GFCF} + B_6 L + \varepsilon \quad (3)$$

Model (3) after deleting the variables CI and the number of MS:

GDP = 760964.345157 - 4.78799233196e-05*POS + 0.0522454273903*BS + 0.805867509364*GFCF + 0.0749649461714*L (4)

Table 5: Results of the linear regression model after deleting the two variables

Indep. Var.	**Coefficient**	**t-stat.**	**p-value**
C	760964.3	5.049689	0.0001
POS	-4.79 E-05	-2.600457	0.0187
BS	0.052245	2.972915	0.0085
GFCF	0.805868	3.929855	0.0011
L	0.074965	3.693447	0.0018

Table 5 shows that the general improvement in the model's performance is clear in terms of a high value of the coefficient of determination squared, which reached a value of 0.986, and the adjusted coefficient of the determination ($\boldsymbol{Adj.R^2}$) reached a value of 98.3%. The results of the overall significance of the model also indicate a high value of "F" of 305.13 with statistical significance = zero. As for the independent variables, the model estimation results showed that the probability value of the independent variables is statistically significant, and the sign appeared positive for the number of BS, GFCF, and L, and the economic theory agrees with this. Except for the independent variable, POS, the sign appeared negative, which contradicts the economic theory. Looking at the results of Table 6, it seems there is a problem of linear correlation between the variables, but there is no problem with multicollinearity.

Table 6: Variable correlation coefficients for a linear function

	GDP	**POS**	**MS**	**GFCF**	**L**
GDP	1.0000	0.6128	0.7899	0.9558	0.9810
POS	0.6128	1.0000	0.2891	0.5312	0.6567
BS	0.9199	0.8389	1.0000	0.8377	0.9295
GFCF	0.9558	0.5312	0.9113	1.0000	0.9240
L	0.9810	0.6567	0.7699	0.9240	1.0000

5.3 Estimating the Model Using the Co-integration Method

Integration is the association between two or more time series such that fluctuations in one cancel out fluctuations in the other, making the ratio between their values constant over time. Perhaps this means that time series data may be unstable if each is generated separately. Still, they are stable as a group, and, for example, this long-term relationship between a set of variables is useful in predicting the values of the dependent variable in terms of a set of independent variables and requires co-integration to occur if the two series are integrated of the first order separately. The model is estimated by following the following tests:

- Unit root test.
- Co-integration test.
- Test the error correction model.
- Causality test.

5.3.1 Unit Root Test

Several tests can be used to confirm the presence or absence of a unit root, that is, to determine the stability of the time series. The expanded Dickey-Fuller test (ADF) is among the most critical tests used in the unit root test. This test has three formulas:

1- The first formula (I) is without a fixed limit and has no time trend.
2- The second formula (II) includes a fixed term.
3- The third formula (III) comprises a fixed limit and a time trend.

The hypotheses to be tested are:

$H_0: P = 1$ The null hypothesis is that there is a unit root.

$H_1: P < 1$ The alternative says it does not contain the unit root.

They are as follows in Table 7:

Table 7: Expanded Dickey-Fuller unit root tests

	At the level			The differences are of the first order			Second-order differences		
variable	Conclusively	categorical and directional	without	Conclusively	categorical and directional	without	Conclusively	categorical and directional	without
GDP	0.8974	0.3955	0.9998	0.0094	0.0544	0.3395	0.0007	0.0058	0.0000
POS	1.0000	1.000	1.000	0.9996	0.0487	0.9996	0.0801	0.1047	0.0003
BS	0.9995	0.9020	0.9736	0.8469	0.1855	0.7150	0.0099	0.0306	0.0008
GFCF	0.7748	0.7447	0.9901	0.0432	0.1175	0.0301	0.0064	0.0373	0.0003
L	0.9717	0.4074	0.7636	0.0004	0.0032	0.6692	0.0006	0.0019	0.0000

The results showed that all-time series for all variables are not stationary at the 5% level of statistical significance, which indicates the instability and stationarity of the time series. However, after taking the first difference for the all-time series, the results show that most of the series have become stable at the first difference, except for the number of subscribers. Fixed broadband: Therefore, the second difference was taken for the all-time series, and therefore, the all-time series became stationary and stable at the first and second difference, and thus, they became integrated at the first difference and integrated at the second difference.

5.3.2 Co-integration Test

After conducting the unit root test (ADF), the time series of the model variables were integrated at the first and second degrees, and the "Johansson" method was used to test co-integration. The optimal lag period must be determined to conduct the Johansson co-integration test, determined by the vector autoregressive (VAR) model. The results of the comparison between the criteria become straightforward to decide on the most appropriate lag period for the model. The best optimal lag period is 2 log for the data of the variables and constructs. Therefore, the "Johansson" co-integration test was conducted, and it is clear from the results in Table 8 that it confirms the existence of three co-integration equations according to the impact tests and the maximum latent value test. Accordingly, the null hypothesis of no at least one co-integration equation was rejected at 5% significance, and the alternative hypothesis is accepted, which states that there is one co-integration equation, meaning there is at least one equilibrium relationship in the long run.

Table 8: Johansson co-integration test results

Number of vectors	Impact statistics	Critical value	Statistic Great values	Critical value
nothing*	129.3434	69.81889	63.72485	33.87687
1 at most*	65.61854	47.85613	30.07846	27.58434
2 at most*	35.54008	29.79707	21.69989	21.13162
3 at most	13.84018	15.49471	11.29754	14.26460
4 at most	2.542643	3.841466	2.542643	3.841466

5.3.3 Error Correction Form

The error VECM model is based on the assumption of a long-run equilibrium relationship. Since the stability of the series of estimation residuals has been proven and at least one co-integration equation exists, we can estimate the error correction model. Therefore, the study seeks to assess the long-run equilibrium equation and represent the error correction model. VECM ensures the possibility of evaluating the relationship between variables in the

long and short terms. The long-run equilibrium equation and the error correction equation are represented in the following two equations (5 and 6, respectively):

$$ECT_{t-1} = y_{t-1} - \beta_0 - \beta_{1xt-1} \quad (5)$$

$$\Delta y_t = ECT_{t-1} + \sum_{i=1}^{n} \beta_i \Delta y_{t-1} + \sum_{i=1}^{n} \delta_i \Delta x_{t-i} + \emptyset z_{t-1} + \mu_t \quad (6)$$

By estimating the error correction model, the results showed that the co-integration equation, which represents the long-run equilibrium equation, is as follows:

$$ECT_{t-1} = 1000GDP_{t-1} - 62.19338L_{t-1} + 467.6754GFCF_{t-1} + 0.673276POS_{t-1} - 0.955552BS_{t-1} + 25829873 \quad (7)$$

It is clear from the results that there is a statistically significant relationship for the long-term balance between the independent variables and the dependent variable, through which the error was corrected (17.27%), as the results of the Wald test showed. The absence of an equilibrium in the short run between the independent variables, which is equal to (0.0149), that is, accepting the null hypothesis that there is an equilibrium relationship in the short run and rejecting the alternative hypothesis that there is no equilibrium relationship in the short run, as the results of the LM test showed that there is no serial correlation problem; this is according to the listed results, which are equal to (0.4639), that is, rejecting the null hypothesis that there is a serial correlation problem and accepting the alternative hypothesis that there is no serial correlation problem, in addition to the stability of the model based on the CUSUM test as in Figure 7:

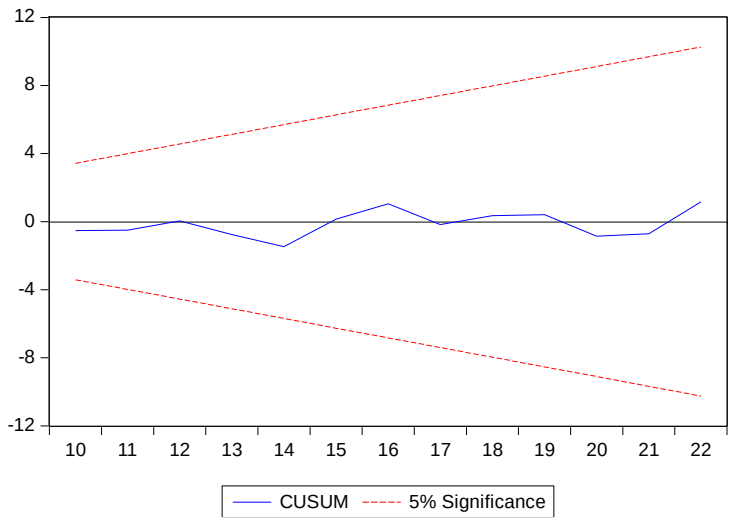

Figure 7: CUSUM structural stability test results

The error correction model parameters for the model are as follows:

$$\Delta GDP_t = -0.001727ECT_t - 0.051816GDP_{t-1} + 0.0022990POS_{t-1} + 0.055457BS_{t-1}0.877306GFCF_{t-1} - 0.190298L_{t-1} - 476710.5 \quad (8)$$

5.3.4 Causation Test

Granger causality is tested using Granger, which means there is a single causal relationship between the variables of the estimated model. Granger has interpreted a criterion for studying the correlation between two time series variables: To understand economic phenomena and distinguish between the dependent and independent phenomena that explain them (Shehi, 2011).

Table 9: Granger causality test

Variable	F statistic	Statistical significance
GDP does not cause POS	3.36025	0.0623
POS does not cause GDP	3.75699	0.0476
GDP does not cause BS	6.37388	0.0099
BS does not cause GDP	0.52397	0.6026
GDP does not cause GFCF	0.21636	0.8079
GFCF does not cause GDP	0.36608	0.6995
L does not cause GDP	8.77261	0.0030
GDP does not cause L	2.26071	0.1386

Given the F statistic value in Table 9, it is noted that there is a causal relationship between the dependent variable and the independent variables, which is a reciprocal relationship that extends from the number of point-of-sale operations (POS) to the gross domestic product (GDP) at a 10% significance level, and from the variable the number of subscribers Broadband (BS) and the total workforce (L) to the GDP variable, and this is achieved at a 5% level of significance. Regarding the causality of the independent variables, there is a unidirectional relationship that extends from the number of POS to the variable number of BS and GFCG at a 10% significance level. In addition to a reciprocal relationship between the L, the variable number of POS and GFCF are at a significance level of 10%.

6. Results and Recommendations

This research sought to measure the impact of digital transformation on economic growth in Saudi Arabia during the period (2001-2022). Through previous econometrics results, the following was concluded:

- A statistically significant inverse relationship (0.0187) exists between the number of point-of-sale operations (POS) and the real GDP. That is, whenever the number of point-of-sale operations (POS) increases by one unit, the real GDP decreases by about SR4.79 million.
- A direct, statistically significant relationship (0.0085) exists between the number of fixed broadband subscribers (BS) and the real GDP. That is, whenever the number of fixed broadband subscribers increases by one unit, the real GDP increases by about 0.0522 million riyals.
- A direct, statistically significant relationship (0.0011) exists between gross fixed capital formation (GFCF) and real GDP. Whenever gross fixed capital formation increases by one unit, the real GDP increases by about SR0.805 million.
- There is a direct, statistically significant relationship (0.0018) between the total labor force (L) and the real GDP, meaning that whenever the total labor force increases by one unit, the real GDP increases by about SR0.074 million.
- The results of the Dickey-Fuller unit root tests made it clear that the time series for all model variables are not stationary at the level, just as the all-time series were not stationary after taking the first difference. After taking the second difference, all model variables became stationary, indicating that they were integrated from the second degree, confirming the completion of the co-integration test.
- Two integration equations emerge based on the maximum latent value and the impact test through the Johansen co-integration test. Accordingly, it was revealed that there is a long-term equilibrium relationship between the independent variables and the dependent variable, which is the real GDP in Saudi Arabia; this indicates that digital economy indicators explain the long-term economic growth of Saudi Arabia.
- The error correction model confirmed the existence of an equilibrium relationship in the long run and the short run between the independent variables and the dependent variable, which is the real GDP, based on the Wald test. Based on the model, the rate of explaining imbalances and correcting errors in the short run was shown quickly (17.27%) during equilibrium in the long run.
- Granger causality test showed a reciprocal relationship between point-of-sale operations and GDP at a 10% significance level. In comparison, a unidirectional relationship extended from fixed broadband subscribers and the total labor force to the total GDP at a 5% significance level.

6.1 Recommendations

- Intensify endeavors to advance the CI by offering high-speed fixed and mobile Internet services and ensuring widespread availability at a reasonable cost throughout all urban and rural areas.
- Adhere to precise procedures for incorporating digital applications into all field operations.
- Foster awareness and promote a culture among persons regarding the imperative of recognizing and effectively utilizing ICT in diverse business sectors, particularly in light of its crucial role in addressing and surmounting emergencies such as the COVID-19 epidemic.
- Promote consciousness and incentivize consumers to make payments at retail locations to bolster economic growth.

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