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The impact of digital economy indicators on economic growth in Türkiye for the period (2004-2024)

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Abstract
This research aims to study the impact of digital economy indicators on economic growth in Turkey during the period 2004-2022 using an Autoregressive Distributed Lag (ARDL) model, based on World Bank data. The independent variables include ICT exports, R&D spending, and patent applications filed by residents, while GDP is used as the dependent variable to represent economic growth. The findings reveal a long-term cointegration relationship between the variables. Short -term estimates indicate that ICT exports and resident patent applications have a statistically significant positive impact on economic growth, while R&D spending shows a negative impact. However, in the long term, the variables do not show any statistically significant impact, suggesting structural distortions and inefficiencies in harnessing the inputs of the digital economy within the Turkish economy over the long term. The study concludes that the digital economy is a major driver of economic growth in the short term. However, achieving sustainable growth requires strengthening innovation systems, improving R&D frameworks, and developing the readiness of digital infrastructure to meet the requirements of a knowledge-based economy. Accordingly, the study recommends adopting more integrated policy strategies to maximize the returns of the digital economy and accelerate its contribution to economic growth in the medium and long term.

Keyword: Digital economy, economic growth

Introduction
In recent decades, the world has witnessed a radical transformation in the nature of economic activity due to the digital revolution, which has reshaped the concepts of production, trade, and services and become a fundamental pillar for achieving growth and sustainable development. The digital economy is one of the most important features of this transformation, as it relies on employing digital technology and information and communication networks in various economic processes. This has contributed to increased productivity, reduced costs, improved service quality, and enhanced national competitiveness. In this context, Turkey is among the countries that have increasingly focused on developing their digital infrastructure over the past two decades, investing in technological infrastructure, supporting innovation and entrepreneurship, and expanding the scope of e-government and commercial services. These efforts have been reflected in macroeconomic indicators, with the Turkish economy experiencing improved growth rates and an increase in the volume of technology exports. Increased spending on research and development suggests a potential link between the development of the digital economy and economic growth. This underscores the importance of studying the impact of the digital economy on economic growth in Turkey by analyzing the contribution of digital indicators such as technology exports, research and development, patents, and internet usage to GDP and sustainable economic development. This study also aims to provide a quantitative analysis clarifying the relationship between digital innovation and short- and long-term economic growth rates, thereby contributing to the formulation of effective economic policies that promote digital transformation in Turkey.

First-Research Problem
Despite the remarkable progress in digital economy indicators in Turkey, the relationship between the digital economy and economic growth is still unclear, and to what extent have digital economy indicators impacted economic growth in Turkey during the study period?

Second-Research objective: This research aims to analyze and measure the impact of the digital economy on economic growth in Turkey.

Thirdly-Research Hypothesis: The research hypothesis was formulated as follows: The development of digital economy indicators contributes positively to enhancing economic growth in Turkey in the short and long term.

Fourth-The importance of the research: The importance of this research stems from the fact that it deals with a contemporary topic that intersects with the trends of the global economy towards digitalization and reveals the extent of the impact of the digital economy in supporting economic growth within one of the important emerging economies.

Fifth: Research Methodology: The research relied on the analytical method based on data issued by the World Bank, in addition to the quantitative method to estimate the size of the impact between the variables of the digital economy and the gross domestic product.

- **Sixth: Research Structure**: In order to achieve the research objective and prove its hypothesis, it was divided into three sections.
- **First topic:** The Digital Economy-Concept-Importance-Characteristics-Indicators
- **Two topic Two:** Economic Growth-Concept-Importance-Characteristics-Indicators-The Relationship Between the Digital Economy and Economic Growth:
- **Third topic:** The standard model for the impact of digital economy indicators on economic growth:

First topic: The Digital Economy-Concept-Importance-Characteristics-Indicators

First: The concept of the digital economy: The digital economy is defined as an internet-based economy that relies on digital products, e-commerce platforms, and smart infrastructure. It encompasses all activities conducted using digital media and communication technologies. It represents a contemporary economic model based on technology and knowledge, contributing to accelerated development, enhanced innovation, and improved economic performance. The digital economy is characterized by the integration and interaction of information and communication technologies with independent local and sectoral organizations. It aims to enhance the speed of business processes and economic participation by facilitating financial decisions and providing accurate and timely data (Al-Adhari & Al-Mousawi, 2025, p. 107) [4]. It is also a branch of modern economics that relies on knowledge and technological data as the ultimate digital productive resources, not just traditional resources, and is characterized by its radical impact on economic change and organization (Kafi, 2013, p. 35) [5]. The digital economy is based on knowledge acquired through skills and experience, which constitutes the main digital engine of economic growth. It is also viewed as an information economy where information is radically reshaped and shapes social and economic relations within a smart environment with a high-capacity infrastructure to support various commercial, industrial, and other activities (Al-Adhari, 2024, pp. 10-11) [5].

Second: The importance of the digital economy

The digital economy is now a key benchmark for measuring a country's progress and the development of its economic sectors. It represents a pivotal source of wealth creation and promotes economic and social development, reflecting the scale of spending on information and communication technologies, innovation, and e-commerce. This underscores countries' recognition of its importance despite its high costs and long-term risks. The digital economy contributes to economic growth by enabling sectors to expand, automate routine tasks, and increase productivity through the adoption of digital technologies and the internet in service delivery, thus overcoming geographical barriers (Hajij, 2022, pp. 21-23) [7]. Furthermore, the digital economy creates new job opportunities. It transforms the nature of jobs to require modern digital skills, reduces transaction costs, and increases the inclusion of marginalized groups in the labor market. It also contributes to enhanced competitiveness by lowering production costs. Expanding markets this intensifies price competition between digital and traditional companies. Furthermore, the digital economy is an effective tool for achieving the UN Sustainable Development Goals by enabling innovation, improving services, and accelerating transformation across various vital sectors. Therefore, the digital economy is a key driver of inclusive economic growth, a catalyst for innovation and productivity, and a supporter of sustainable development. The added value increases with the technological intensity of economic processes, making it a basis for progress and global competitiveness.

Third: Characteristics of the digital economy

The digital economy is not merely a digital model, but rather the creation of an entity that leverages technological information and possesses numerous fundamental characteristics that shape the structure of economic activity. Because it is not limited by population density or geographic location, it is driven by the dynamics of rapid digital movements, making efficient economic processes a dynamic and competitive environment both locally and globally (Li & Liu, 2021) [20]. It also reduces transaction and production costs, especially fixed costs, while providing high flexibility for expansion without a corresponding increase in variable costs, thus supporting digital and convergent commerce (Kraus *et al*, 2022, 3-5) [14]. In addition, the digital economy facilitates manufacturing by enabling the immediate identification and processing of data. And empowering its creators through printing and artificial intelligence on a comprehensive level, production began and new players emerged as a result of adjusting operational barriers with a radical shift from the traditional economy to a data-driven model. (Nambisan *et al*., 2019, 2-4) [8].

Fourth: Digital Economy Indicators: Digital economy indicators are among the most important tools used to analyze the extent of development of the digital economic infrastructure of any country and to measure its level of integration into the global knowledge and technology-based economy. The most prominent of these indicators can be summarized according to the following Table (1):

Table 1: Description of Digital Economy Indicators

Description And importance	Index
Measure side The material (Such as equipment) and the aspect Digital (Such as software), And include quality Services Internet And covering it And its speed. It represents Column vertebrae For the economy digital	Structure Infrastructure For technology Information Communications
Reflects level Link digital For the population and extent Link In society Digital, And contributes directly in Activation Activities Economic Digital.	spread Use Internet and phones smart
It measures the volume of digital exports of services, software and communications devices, and reflects the integration of the economy into global digital markets.	Information and Communication Technology Exports
Measures level Transformation digital in Services public and interaction between the government and citizens and companies, Which Reflects efficiency sector The year.	Services Government and electronic
Reflects size Production intellectual And the ability on transformation Innovation to Origins Economic Reserve Legally, In what Enhances Value Commercial For knowledge And contributes in attract Investment in Industries Technology	Patent applications for residents within the country
This index reflects the extent of the state's or private sector's commitment to digital innovation, technological development, and evaluation. level Investment in Structure cognitive And represents ratio allocated from Output Local To support Innovation And determines capacity State on possession Components Evolution Technician locally Don Accreditation The whole on Importing.	Spending on research and development

Martens, B. (2021) [22]. The Digital Economy and Productivity Growth. Journal of Productivity Analysis, 55 24-25).
Bukht, R., & Heeks, R. (2018) [21]. Measuring the Digital Economy: Progress and Prospects. Oxford University Press. p.22).

Section Two: Economic Growth-Concept-Importance-Characteristics-Indicators-The Relationship between the Digital Economy and Economic Growth

First: The Concept of Economic Growth: In modern economic literature, economic growth is defined as a sustained increase in real GDP or real per capita income over an extended period, excluding the effects of inflation to ensure the measurement of real, non-monetary growth. This concept is not limited to the quantitative aspect but also includes profound structural transformations manifested through improved productive capacity and increased resource efficiency. The main drivers of growth include the accumulation of physical and human capital, technological advancements, and innovation. These are crucial practical factors for improving long-term productivity and are cumulative, reflected in the expansion of the economy's overall productive capacity, which contributes to raising living standards, creating jobs, and increasing national income (Mankiw, 2024, p. 233) [11]. Performance is typically measured by the real GDP growth rate or the per capita GDP growth rate, along with indicators of total factor productivity. It is important to distinguish between economic growth, a quantitative concept focusing on income and production indicators, and economic development, a broader concept encompassing qualitative improvements in institutional and social structures and income distribution. The importance of growth lies in its role as a key driver for enhancing competitiveness, financing public services, and investing in infrastructure, thereby promoting social and economic stability and supporting Inclusive and sustainable development (Todaro & Smith, 2020, 18) [15].

Second: The importance of economic growth: Economic growth is a fundamental pillar of comprehensive development, contributing to raising living standards and increasing average per capita income by expanding the economy's productive capacity. This enables individuals to access high-quality goods and services and improves social welfare (Al-Hayali, 2022, p. 30) [1]. Economic growth also serves as an effective tool for achieving economic stability by reducing unemployment rates, expanding job opportunities, and lowering poverty levels. Furthermore, it contributes to maintaining price stability and mitigating economic fluctuations (Al-Shammari, 2023, p. 115) [2]. In addition, Growth enhances a country's competitiveness by increasing the productivity of factors of production and improving the efficiency of human and material resources. This, in turn, strengthens the economy's ability to compete in international markets and increases its contribution to global trade. Economic growth also contributes to increased government revenues resulting from expanded economic activities. This allows for the allocation of greater resources to finance infrastructure projects and public services such as education, health, and transportation, thus promoting long-term development (Kandil, 2022, p. 58) [3]. Furthermore, growth is a major attraction for both domestic and foreign investment. Countries that achieve stable and sustainable growth rates are better positioned to create a favorable investment environment, which in turn boosts investment flows and increases opportunities for economic expansion (Vîrjan *et al*., 2023, p. 146) [16]. The importance of economic growth lies in raising living standards and increasing per capita income. Sustainable growth leads to an improved quality of life, the provision of better goods and services for the population, and the achievement of economic stability. Economic growth also contributes to reducing unemployment and poverty rates and promotes price stability. Furthermore, economic growth enhances competitiveness, increases the productivity of human and material resources, strengthens a country's position in global markets, and increases government revenues contribute to better funding of infrastructure projects and public services, encouraging domestic and foreign investment. Countries with sustainable growth attract greater investments due to their expectations of stable returns. (Rodrik, 2023, pp. 55-57) [12].

Third: Characteristics of Economic Growth: Economic growth is characterized by several key features that determine its strength and sustainability in any economy, as follows: (Mankiw, 2020, p. 78) [10]. (Romer, 2019, p. 45) [13].

1. Sustainability: Sustainable economic growth means the

ability of an economy to achieve a continuous increase in GDP over the long term without negatively impacting natural resources, the environment, or macroeconomic stability. 2. Productivity Expansion: Economic growth refers to an increase in the overall productivity of resources, meaning the ability to produce more goods and services with the same or lesser amount of resources, reflecting improved economic efficiency.

2. Increased per capita income

Economic growth leads to higher per capita income and improved living standards as families and communities benefit from increased economic opportunities and a better distribution of income.

3. Economic diversification: A growing economy is characterized by diversification in economic activities and sectors, which reduces dependence on a single sector and increases the economy's resilience to shocks.

4. The ability to attract investment: Economic growth enhances the ability to attract local and foreign investments and increases confidence in the economy, which leads to an increase in capital and stimulates more productive projects.

Fourth: Economic growth indicators

These are a set of indicators that measure the extent of development and use of digital technology in the economy, as follows:

Table 2: Describes economic growth indicators

Description	The indicator
It represents the total value of final goods and services produced within the borders of the country during a specific period of time, and is the primary indicator for measuring the size of economic activity and the level of growth.	GDP Total
It measures the percentage change in real GDP from year to year, reflecting the extent of economic expansion and overall improvement in performance.	Economic growth rate
It expresses the average per capita income in a country and is used as an indicator of the level of well-being and quality of life.	Per capita GDP
The size of investments in fixed assets such as infrastructure and equipment is reflected and is considered a key driver of long-term growth.	Total investment rate
It shows the ratio of unspent income to GDP, and is an indicator of the economy's ability to finance investments domestically.	Domestic savings rate
It measures the rate of change in the general price level, and reflects the stability of the economy and the strength of aggregate demand.	Inflation rate
It represents the ratio of the unemployed workforce to the total workforce, and is an indicator of labor market efficiency.	Unemployment rate
It reflects the economy's ability to compete internationally and generate foreign currency, which is one of the drivers of economic growth.	Total exports

Source Sajjad Kadhim Al-Alawi, (2021). Per capita GDP and its impact on the level of economic well-being: An analytical study of selected experiences. Journal of the College of Administration and Economics for Economic, Administrative and Financial Studies, University of Kufa, Volume 13, Issue 2. 78. Iraq

Al-Humaidi, Zahraa Fadhil. (2023). Local investment and its role in stimulating sustainable economic growth. Journal of Economic and Administrative Sciences, University of Baghdad, Volume 29, Issue 134, pp. 105-127. Iraq.

Fifth: The relationship between the digital economy and economic growth according to modern economic theories:

1. **Intrinsic Growth Theory:** This theory asserts that technology, innovation, and knowledge are intrinsic drivers of growth, and that the digital economy promotes growth through the accumulation of knowledge capital, digital innovation, and increased productivity of production factors. (Agion and Hoyt, 2018, 414) [17].
2. **Total Factor Productivity Theory (Total Factor Productivity Model/Improved Solow Model):** This theory posits that growth results not only from increased capital and labor but also from improved efficiency through the use of digital technologies (automation, artificial intelligence, and big data), leading to increased productivity. College. (Jones and Vollrath, 2020, 116) [19].
3. **Theory of the knowledge economy and innovation:** This theory considers data and digital innovation as economic assets that generate increasing returns. This theory argues that the digitization of the economy accelerates spread and reduces transaction costs, thus promoting long-term growth. (Brinolfson and McAfee, 2014, 72) [18].

According to the aforementioned theories, the digital economy has a role and relationship in economic growth by improving productivity, encouraging innovation, and increasing resource efficiency, thereby boosting GDP and creating new opportunities for markets and employment.

Third topic: The standard model for the impact of digital economy indicators on economic growth:

First: Data on the studied variables

Table (3) shows the data for the selected variables for the period (2004-2023), where each represents (information and communication technology exports, Expenditure on research and development (% of GDP) and patent applications, per resident (thousand applications) are the explanatory variables, while (GDP) is the dependent variable.

Table 3: Some indicators of the digital economy and GDP in Turkey for the period (2004-2022)

Years	I information and Communication Technology Exports (One million dollars)	Spending on research and development (% of GDP)	Patent registration applications, for residents (1000 applications)	Gross domestic product (One million dollars)
2004	293963	0.49713	682	408876
2005	323118	0.56381	928	506308
2006	318386	0.55292	1072	557058
2007	289187	0.68616	1810	681337
2008	241390	0.68741	2221	770462
2009	202657	0.80362	2555	649273
2010	209706	0.79369	3180	776993
2011	223654	0.79393	3885	838763
2012	265518	0.82595	4434	880556
2013	278736	0.81206	4392	957783
2014	313552	0.8564	4766	938953
2015	272763	0.87689	5352	864317
2016	221401	1.11979	6230	869693
2017	220446	1.17632	8175	858996
2018	220876	1.27174	7156	778472
2019	209417	1.32146	7871	759937
2020	172968	1.36757	7920	720289
2021	201134	1.40352	8234	819035
2022	225414	1.68955	8956	885423

Source: World Bank data published on the bank's website on 9/6/2023

Second: Describing the research variables

This research examines the relationship between digital economy indicators and economic growth. A set of independent variables representing digital development indicators was selected, namely (ICT exports, R & D spending, and patent applications by residents). Gross Domestic Product (GDP) was used as a dependent indicator to measure economic growth. To achieve data consistency and reduce variance, the Double -log Model was adopted, allowing the coefficients to be interpreted as relative rates of change (elasticities). The model equation takes the following form:

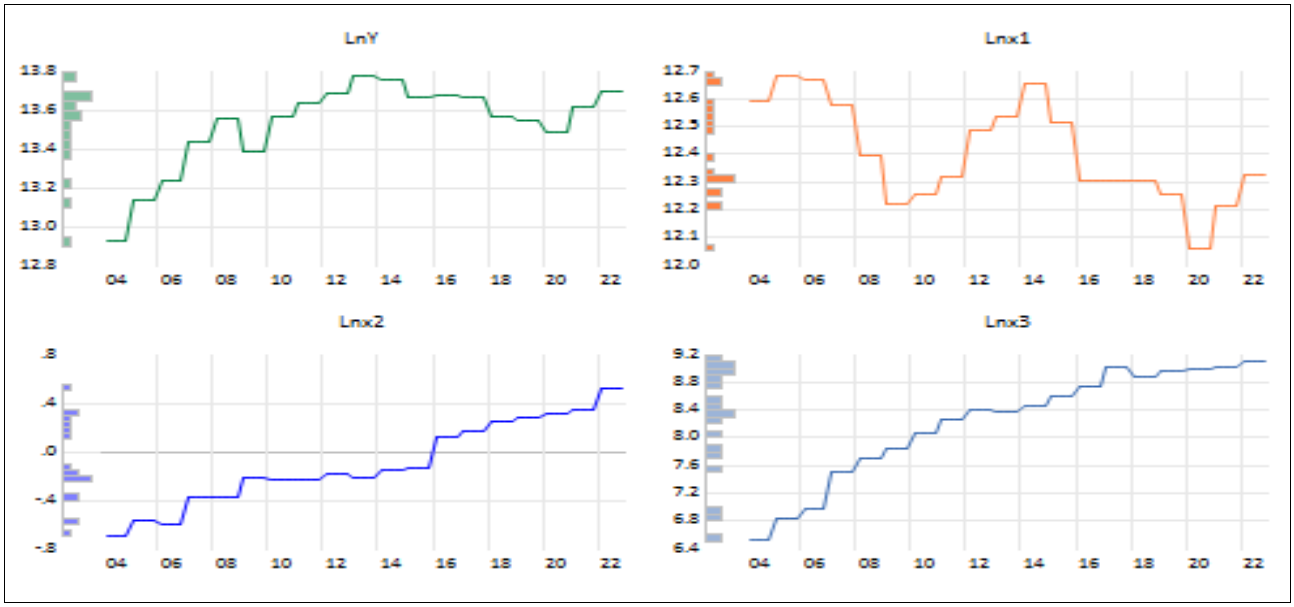
$$Ln(y)=B_0+B_1 Ln(X_1)+B_2 Ln(X_2)+B_3 Ln(X_3)+u$$

Third

Drawing the study variables

Before proceeding to build and estimate the standard model, it is necessary to conduct stationary tests. To assess the stationarity of the time series of the research variables, the visual method is used by drawing the research variables, considering that the graph is an important tool for exploring the movement of the time series initially.

Through Figure (1), it is clear that the selected research variables are not stationary, which necessitates that we conduct more accurate tests such as the extended Dickey-Fuller test (ADF) to confirm the nature of the stationarity in a formal statistical manner.



Source: Prepared by the researcher using the statistical program (EViews.12)

Fig 1: Diagram of search variable

Fourth: The quiescence test using the (Extended Dickey-Fuller ADF)

Passing this test is a prerequisite for ensuring the validity and integrity of the standard model based on time series data. After applying this test to the studied research variables, it was found that all variables were not stationary at the initial level, but became stationary after the first difference was calculated, indicating that the variables are stationary at the first difference level and at a significance level of (5%). See table (4).

Table 4: Dickey-Fuller Test Expanded ADF

	Unit Root Test Table (ADF)				
	At Level				
		LNY	**LNX1**	**LNX2**	**LNX3**
With Constant	t-Statistic	-2.8662	-1.6277	-0.4655	-2.6250
	Prob.	0.0542	0.4636	0.8912	0.0928
		*	n0	n0	*
With Constant & Trend	t-Statistic	-2.3158	-1.8108	-2.9656	-1.6729
	Prob.	0.4202	0.6897	0.1488	0.7530
		n0	n0	n0	n0
Without Constant & Trend	t-Statistic	1.5814	-0.5309	-1.3207	1.8157
	Prob.	0.9713	0.4837	0.1711	0.9826
		n0	n0	n0	n0
		d(LNY)	d(LNX1)	d(LNX2)	d(LNX3)
With Constant	t-Statistic	-8.7989	-8.5153	-9.5084	-3.2529
	Prob.	0.0000	0.0000	0.0000	0.0210
		***	***	***	**
With Constant & Trend	t-Statistic	-9.1041	-8.4730	-9.4427	-3.9387
	Prob.	0.0000	0.0000	0.0000	0.0153
		***	***	***	**
Without Constant & Trend	t-Statistic	-8.5440	-8.5440	-8.5440	-2.4783
	Prob.	0.0000	0.0000	0.0000	0.0138
		***	***	***	**

Notes: (*) Significant at the 10%; () Significant at the 5%; (*) Significant at the 1%; and (n0) Not Significant MacKinnon (1996) one-sided p-values, ***Source*:** Prepared by the researcher using the statistical program (EViews.12)

Fifth: Initial assessment of the (ARDL) model

The initial model estimate contributes to a preliminary diagnosis of the estimated model, demonstrating its validity before in-depth analysis. The results in Table (5) show the validity of the estimated model, as the explanatory power of the coefficient of determination reached (97.3%). This indicates that the independent variables influence (97.3%) of the changes occurring in the dependent variable (GDP), while the remaining influences are due to factors outside the model. Similarly, the corrected coefficient of determination reached (97.1%), and the F -statistic shows it to be significant at the (1%) level. See Table 5.

Table 5: Initial Estimate of the (ARDL) Model

Dependent Variable: LNY
Method: ARDL
Date: 03/21/25 Time: 21:35
Sample (adjusted): 2004Q2 2022Q4
Included observations: 75 after adjustments
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (1 lag, automatic): LNX1 LNX2 LNX3
Fixed regressors: C
Number of models evaluated: 8
Selected Model: ARDL(1, 1, 1, 1)

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.***
LNY(-1)	0.892546	0.058271	15.86145	0.0000
LNX1(-1)	0.357463	0.072156	4.954055	0.0000
LNX1	-0.331331	0.074369	-4.455221	0.0000
LNX2	0.242286	0.109482	2.213011	0.0303
LNX2(-1)	0.214441	0.115642	1.854363	0.0681
LNX3	0.473199	0.059081	8.009274	0.0000
LNX3(-1)	-0.438087	0.063282	-6.922772	0.0000
C	0.838731	0.561854	1.492932	0.1411
Statistic	Value	Statistic		Value
R-squared	0.973934	Mean dependent var		13.53369
Adjusted R-squared	0.971210	S.D. dependent var		0.207659
S.E. of regression	0.035235	Akaike info criterion		-3.753034
Sum squared resid	0.083179	Schwarz criterion		-3.505835

Log likelihood	148.7388	Hannan-Quinn criter.	-3.654330
F-statistic	357.6215	Durbin-Watson stat	1.972306
Prob(F-statistic)	0.000000		

***Source*:** Prepared by the researcher using the statistical program (EViews.12)

Fifth: Cointegration Test (F-Bound Test)

The test for the existence of a long-term equilibrium relationship between the independent and dependent variables is done through the F-Bound Test. The results of the test in Table (3) showed the existence of a long-term cointegration relationship between the research variables, as the statistical value reached (5.299), which exceeds its minimum and maximum values at a significance level of (5%). Therefore, we reject the null hypothesis (H0) and accept the alternative hypothesis (H1).

Table 6: Cointegration Test (F-Bound Test)

F-Bounds Test	**Null Hypothesis: No levels relationship**			
Test Statistic	**Value**	**Significance**	**I(0)**	**I(1)**
F-statistic	5.299321	10%	2.37	3.20
k	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66

***Source*:** Prepared by the researcher using the statistical program (EViews.12)

Sixth: Assessing the short-term and long-term relationship. Table (7) shows the short-term and long-term relationship between the digital economy indicators (ICT exports, R&D spending, and patent applications by residents) as independent variables and (GDP) as a dependent variable.

Table 7: Short-term and long-term relationship assessment (ARDL)

ARDL Long Run Form and Bounds Test Dependent Variable: D(LNY) Selected Model: ARDL (1,1,1,1) Case 2: Restricted Constant and No Trend Date: 03/21/25 | Time: 21:36 Sample: 2004Q1-2022Q4 Included observations: 75				
Conditional error correction regression				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	0.836731	0.561854	1.489232	0.1411
LNY(-1)	-0.107454	0.056271	-1.909568	0.0605
LNX1(-1)	0.026132	0.036417	0.717572	0.4755
LNX2(-1)	-0.027844	0.056366	-0.493988	0.6229
LNX3(-1)	0.035113	0.034974	1.003958	0.3190
D(LNX1)	0.357463	0.072156	4.954055	0.0000
D(LNX2)	-0.242286	0.109482	-2.213011	0.0303
D(LNX3)	0.473199	0.059081	8.009274	0.0000
*p-value incompatible with t-Bounds distribution				
2. Levels Equation **Case 2: Restricted Constant and No Trend**				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LNX1	0.243189	0.322107	0.754994	0.4529
LNX2	-0.259126	0.436171	-.594092	0.5545
LNX3	0.326770	0.187313	1.744515	0.0857
C	7.786871	4.124515	1.887948	0.0634
EC=LNY−(0.2432*LNX1−0.2591*LNX2+0.3268×LNX3+7.7869)				

***Source*:** Prepared by the researcher using the statistical program (EViews.12)

Table (7) shows the following

1. Short-term relationship

- There is a positive and significant relationship at a significance level of (5%) between the exports of information and communication technology (X1) and between the gross domestic product, as the increase Information and communication technology exports (X1) at a rate of (1%) lead to an increase in GDP by (0.35%). This is consistent with the research hypothesis and economic logic.
- There is a negative and significant relationship at a significance level of (5%) between spending on research and development (X2) and the gross domestic product, as an increase in spending on research and development (X2) by (1%) leads to a decrease in the gross domestic product by (0.24%), and this is not consistent with the research hypothesis and economic logic.
- There is a positive and significant relationship at the (5%) significance level between patent applications for residents (3X) and the gross domestic product, as an increase in patent applications for residents (3X) by

(1%) leads to an increase in the gross domestic product by (0.47%), and this is consistent with the research hypothesis and economic logic.

ECOM error correction parameter reached (0.0605-), which is a negative and non-significant value at a significance level of (5%). This means that there is a process to correct the imbalances and return to the equilibrium state, but within a specific timeframe and at a specific speed.

2. Long-term relationship

The relationship between the variables in the long term did not differ from that in the short term in terms of its direction, but it was not significant at the (5%) significance level. The lack of long-term significance means that the independent variables (ICT exports, R & D spending, and patent applications by residents) do not play an important role in explaining the permanent changes in the dependent variable (GDP), indicating the absence of a stable economic equilibrium between the variables during the research period. This result contradicts the study's hypothesis and economic logic. The reason for the weak relationship between the research variables may be due to the fact that the Turkish economy underwent continuous changes during the research period, in addition to other economic variables that were not included in the model.

Seventh: Standard Problem Tests

1. Autocorrelation Test (LM): The results in Table (8) show that there is no autocorrelation problem because the value of (F) was not significant, which amounted to (0.0754%) at a significance level of (5%). Therefore, we accept the null hypothesis (H0), which states that there is no autocorrelation problem.

Table 8: Test (LM) for the problem of self-association

Breusch-Godfrey Serial Correlation LM Test: Null Hypothesis: No serial correlation at up to 2 lags			
F-statistic	0.003676	Prob. F(2.65)	0.9963
Obs*R-squared	0.008483	Prob. Chi-square(2)	0.9958

Source: Prepared by the researcher using the statistical program (EViews.12)

2. Error Variance Homogeneity Test (ARCH)

The results in Table (6) showed that there is no error variance homogeneity problem due to the insignificance of the value of (F), which amounted to (0.2485%) at a significance level of (5%). Thus, we accept the null hypothesis (H0), which states that the estimated model is free of standard problems.

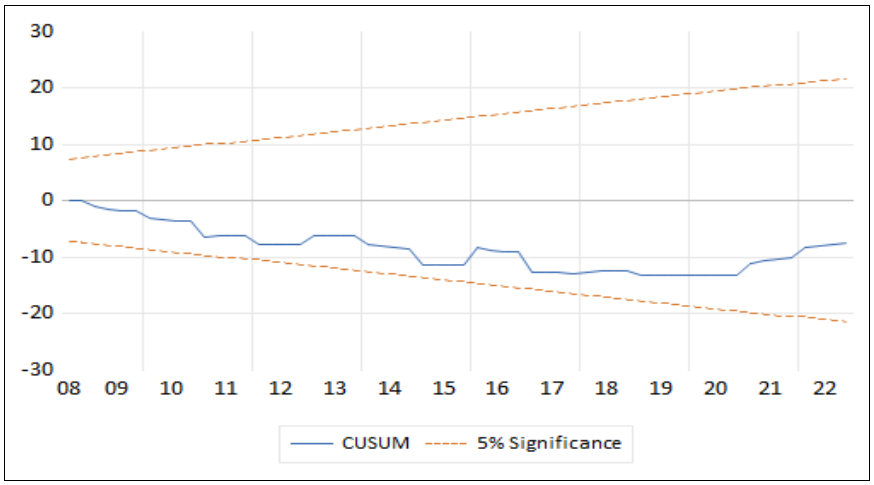
Table 9: ARCH Test For the problem of inhomogeneity of error variance

Heteroscedasticity Test: ARCH			
F-statistic	1.353525	Prob. F(1,72)	0.2485
Obs*R-squared	1.365454	Prob. Chi-Square(1)	0.2426

Source: Prepared by the researcher using the statistical program (EViews.12)

3. Structural Tests

The results of the CUSUM and CUSUM of Squares tests in Figures (2) and (3) indicate that the model exhibits a high degree of stability throughout most of the study period, thus enhancing the reliability of the estimates. However, the breach of the critical limits in the CUSUM of Squares test during 2016 suggests a possible structural change in the equation's variance. This is attributed to the political unrest in Turkey that year, which negatively impacted economic variables.



***Source*:** Prepared by the researcher using the statistical program (EViews.12)

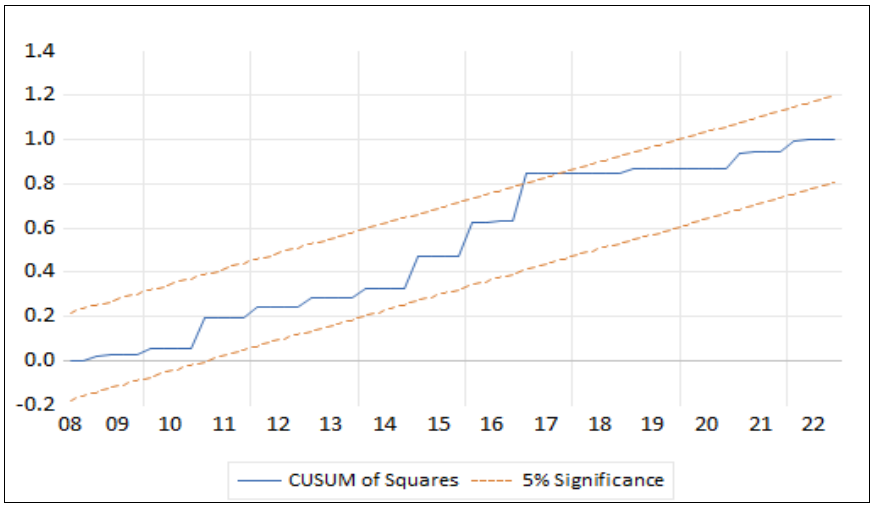
Fig 2: Structural Tests CUSUM

Results and Recommendations

Results

1. The study results showed a positive and significant relationship between the digital economy and economic growth in Turkey in the short term, as ICT exports and patents contributed to an increase in GDP, demonstrating their effective role in supporting knowledge-based and technology-driven economic growth.
2. The results showed that spending on research and development had a negative impact in the short term, indicating that this spending is not managed efficiently and is not sufficiently linked to market needs or to achieving product innovation capable of promoting economic growth.
3. The cointegration test confirmed the existence of a long-term equilibrium relationship between the variables of the digital economy and economic growth, but the relationship

in the long term was not statistically significant, reflecting that the current digital impact on growth is unstable and does not translate into a sustainable structural developmental impact.



***Source*:** Prepared by the researcher using the statistical program (EViews.12)

Fig 3: Structural tests of squares CUSUM

Recommendations

1. The need to raise the efficiency of spending on research and development by directing it towards applied projects that serve the productive sector and linking it to universities and companies, and transforming it from public spending to spending based on marketable innovation.
2. Strengthening the innovation system and protecting intellectual property by facilitating patent registration procedures and providing incentives for companies and individuals who develop innovations of economic value.
3. Working to transform digital impacts from short-term to long-term by adopting consistent and stable digital strategies that are not affected by economic and political fluctuations.
4. Developing digital infrastructure and increasing support for technology sectors, while encouraging partnership between the government and the private sector to expand investment in the digital economy and promote high-value digital exports.

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