Measuring the impact of technological development on economic growth (1990 - 2025) Egypt is a Model

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Abstract

The research aims to measure the impact of technological development on the economic growth of Egypt as a model A theoretical framework is provided.

The research relied on the descriptive approach, as a general presentation of the different concepts of technological development and its role in economic growth. In this paper, two methods have been applied. Auto Regressive Moving Average (ARIMA) and the proposed model. The ARIMA model after considering the optimum values provides a nice expectation. The results show that the proposed method outperform the ARIMA model. The results of the proposed model showed that the value of (F) is 13.53 and this proves the importance of the model as a whole. The research indicated that the coefficient of determination is 62.6% of the increase in the economic growth rate of the State of Egypt resulting from the approved variables that express technological development

Keywords: ***Technological development, economic growth, economic indicators, research and development, Spending on research.***

1. Introduction

1.1 Theoretical Background

Technological progress is widely recognized as one of the defining characteristics of the contemporary era. Rapid advancements in technology have fundamentally transformed many aspects of human life, making technology afundamental component of modern societies. Today, it is increasingly difficult to imagine economic and social activities without relying on technological tools. The widespread adoption of technological innovations has facilitated the performance of numerous tasks across various sectors, including healthcare, science, arts, and economics. These developments have significantly improved productivity and efficiency, enabling individuals and institutions to accomplish complex activities within shorter periods of time (Ferreira et al., 2019).

In the economic sphere, information and communication technology (ICT) plays a particularly important role in supporting institutional efficiency and knowledge management systems. Within the banking sector, for example, ICT contributes to improving the management, storage, and dissemination of information, which strengthens organizational decision-making and operational performance. In the Syrian banking system, ICT resources have been shown to enhance knowledge management capabilities, which represent a vital element of the country’s economic structure. This improvement in institutional efficiency can indirectly contribute to overall economic growth (Almeshref & Khwanda, 2022).

Furthermore, the relationship between ICT development and economic growth has been widely examined in empirical studies. Research focusing on developing Asian countries during the period 1990–2016 indicates that information and communication technologies contribute to economic expansion, particularly in countries with higher levels of human development. The findings reveal that improvements in the Human Development Index (HDI) and the widespread use of mobile phones positively influence economic growth. However, the impact of internet usage appears less significant in some cases. The results also emphasize that human development itself is a key determinant of economic performance, as higher levels of education, health, and living standards enhance the ability of societies to benefit from technological innovations. These findings were derived using advanced panel data estimation techniques capable of addressing cross-country heterogeneity and interdependence, which increases the reliability and robustness of the empirical results (Zhang, 2019).

1.2 Materials and methodology:

The concept of technology is one of the concepts discussed by many researchers and thinkers, and they differed in their view of it due to the difference in their specialization and the development of the characteristics of the technology itself, it was considered one of the means that man discovered when he primitively adapted nature, and after that, it became a tool used by him to serve him and help him to fulfill his growing needs, Then its use developed and spread to the point where it became very important in his public and private life. Which made some thinkers believe that it is responsible for most of the changes that occur within contemporary society, as for the word itself, it was mentioned in some sources that the first appearance of the term technology was in Germany in the year (1770) AD, it is a compound of two syllables (techno, which means in the Greek language art or handcraft and logic which means science or theory . The combination of the two syllables results in the meaning of the science of making systematic knowledge in the arts of industry or applied science. It does not have an original equivalent in the Arabic language) rather it was Arabicized by transcribing its pronunciation literally Technologie *(Alanne, 2019)*. Technology can also be described as the collective body of knowledge, capabilities, practical experience, instruments, and techniques that individuals utilize to make effective use of environmental resources. It includes the scientific, technical, and administrative approaches that enable humans to adapt natural resources and available energies to meet their needs. Through these methods, technology assists people in performing various tasks and activities in everyday life, whether in professional work or daily practices, with the aim of fulfilling both material and social needs at the level of individuals and society as a whole *(Almunawar, 2012)*. In the issue of explaining the technological transformation, many researchers focus on deepening capital, diversifying its material equipment, and developing knowledge of performance in the so-called residual element as one of the most important elements of the production function in its dynamic form. Technological transformation is defined as an advance in the technical method or method used in the production or provision of goods or services *(Schatzberg, 2018)*. Through the previous definitions, we conclude that technology needs knowledge acquired by individuals through technical and scientific training, as well as infrastructure and advanced equipment.

1.3 Importance of Technology

Technology plays a crucial role in many aspects of modern society, particularly in education, communication, healthcare, and economic development. In the educational sector, technological advancements have significantly improved learning methods by enabling distance education through the internet. This form of learning became especially widespread during the COVID-19 pandemic. Today, students frequently rely on digital tools in classrooms to enhance their learning experience. For instance, tablets and other smart devices are used to present visual materials and interactive lessons, which increases student engagement and makes the learning process more effective and enjoyable. In addition, modern educational technologies promote independent learning, allowing students to acquire knowledge and develop skills autonomously (Waxman et al., 2013). Communication has also been transformed by technological progress. Individuals can now easily interact, collaborate, and exchange information with others across the globe through various digital platforms. This rapid connectivity has strengthened global cooperation and facilitated the exchange of ideas and knowledge in ways that were not previously possible.

Another major contribution of technology is its impact on the labor market. Technological innovation has created a wide range of new employment opportunities, particularly in fields related to the development, management, and maintenance of advanced technological systems. As a result, modern economies increasingly require skilled professionals capable of working with emerging technologies in both domestic and professional environments.

The healthcare sector has also benefited greatly from technological development. Modern hospitals have incorporated advanced technologies into surgical procedures and medical diagnostics, which has contributed to reducing human error that may occur due to fatigue or work pressure. Moreover, the expansion of digital health technologies has enabled the development of mobile applications that allow individuals to monitor their health conditions, track weight changes, and manage physical fitness more efficiently (Ferreira et al., 2019).

In the economic and industrial fields, technology has improved business efficiency and simplified production processes. The use of modern technologies in manufacturing has enhanced productivity while reducing operational costs and production waste. Consequently, technological progress contributes to improving product quality and lowering prices for consumers (Chaguar & Briones, 2022).

1.4Theoretical Relationship between Technological Development and Economic Growth

Traditional economic activities alone are often insufficient to sustain long-term economic growth. Instead, technological advancement plays a crucial role in transforming production processes and improving the efficiency of both physical and human resources. Through innovation and the adoption of new technologies, economies can enhance the quality and diversity of goods and services while increasing productivity. Technological progress is a continuous process, requiring societies to understand and integrate emerging technologies into everyday economic activities.

Many modern technological innovations rely on sophisticated scientific and mathematical foundations. As a result, advanced technologies are sometimes controlled or developed by large multinational corporations with significant research capabilities. For this reason, effective collaboration between research institutions, universities, laboratories, and innovation centers becomes essential. Such cooperation facilitates the transfer of knowledge, helps explain technological developments, and supports their practical application in economic and social activities (Zhang, 2019).

The experience of Poland provides a clear example of how technological adoption can contribute to economic transformation. Following the collapse of the Soviet Union in the early 1990s, Poland implemented major political and economic reforms that opened its economy to international markets. An important factor behind the country’s economic progress was its ability to adopt advanced imported technologies, particularly from Germany. These technological transfers significantly improved productivity and industrial capacity. Furthermore, Poland’s accession to the European Union in 2004 strengthened its integration into the European economic system and accelerated technological diffusion. Today, Poland has become one of the largest economies in Europe, ranking sixth in terms of economic size (Guloglu & Tekin, 2012).

1.5 Our contribution to this research is

1- that we deal with several explanatory variables together, such as industrial value added/GDP, research and development expenditure/GDP, foreign direct investment/GDP, and variables technological. Development and changing affiliates. The economic growth expressed (GDP growth rate), which was not found in other research, as well as what characterizes the study of its period. Undoubtedly, what most distinguishes the modern era is the rapidly growing technological development, where technology is one of the most important elements important life in this era in which we live, as it has become difficult to do without this development.

2- We use ARIMA model to perform the expected value of GDP and to be a base value so we compare the proposed method results with.

The rest of this paper is organized as follows: in Section 2 we discuss the system model where we have the ARIMA method and the proposed one. In Section 3 we discuss the results from both methods. Then we summarize in Section 4.

The standard aspect of technological development in Egypt

First: The model description stage:

At this stage, the economic variables to be included in the econometric model are identified, based on the theoretical framework and previous studies relevant to the research topic. Accordingly, the functional relationship between the dependent variable and the independent variables is formulated, so that the econometric model takes the following general form:

$$\boldsymbol{Y = f(X1, X2, X3, X4) \ldots\ldots\ldots\ldots\ldots..\ldots\ldots..(1)}$$

Since:

Y: represents the dependent variable, expressed as the GDP growth rate.

X1: represents industrial value added.

X2: represents goods exports to high-income countries.

X3: R&D spending as a share of GDP.

X4: represents foreign direct investment as a proportion of GDP.

Second: The stage of estimating the model parameters:

At this stage, the standard model's coefficients are estimated using the Autoregressive Distributed Lag (ARDL) method, a modern standard technique developed within the framework of cointegrating boundary testing. This method was introduced by Pesaran and Shin (1999) and later further developed within the framework of analyzing long-term relationships between economic variables.

The importance of this model lies in its high flexibility when dealing with time series data, as it allows for the estimation of economic relationships even when the degrees of integration of the variables vary. In other words, it can be applied when the variables are stationary at level I(0), stationary after the first difference I(1), or a combination of both, provided that there are no second-order integrals I(2) within the model.

To verify the stability of the variables, unit root tests are performed to confirm the properties of the time series before proceeding with the standard estimation process. This step is essential to avoid obtaining misleading standard results that may arise from data instability.

$$\boldsymbol{\begin{aligned} Ln(Y_t) = \alpha_0 &+ \beta_1 Ln(Y_{t-1}) + \beta_2 Ln(X1_{t-1}) + \beta_3 Ln(X2_{t-1}) \\ &+ \beta_4 Ln(X3_{t-1}) + \beta_5 Ln(X4_{t-1}) + \sum_{i=1}^{p} \gamma_1 \Delta Ln(Y_{t-i}) \\ &+ \sum_{i=1}^{p} \gamma_2 \Delta Ln(X1_{t-i}) + \sum_{i=1}^{p} \gamma_3 \Delta Ln(X2_{t-i}) \\ &+ \sum_{i=1}^{p} \gamma_4 \Delta Ln(X3_{t-i}) + \sum_{i=1}^{p} \gamma_5 \Delta Ln(X4_{t-i}) + \emptyset ECM_{t-i} \\ &+ \varepsilon_t \ldots\ldots\ldots..(2) \end{aligned}}$$

Where:

Δ denotes the first difference (change) in the variables, while (t) refers to the time period.
α0 represents the intercept or constant term of the model.
p indicates the number of lagged periods included in the model.
βi denotes the long-run coefficients, reflecting the long-term relationships between the variables.
γi represents the short-run coefficients, capturing the short-term dynamics among the variables.
ECM refers to the Error Correction Mechanism, which measures the speed at which deviations from the long-run equilibrium are corrected.
Finally, εt represents the stochastic disturbance term, commonly referred to as the random error term in the model

Third: Applying the model and interpreting the results:

First: Stability Test Results (Unit Root Test)

Before estimating the standard model, it is essential to verify the characteristics of the time series of the variables used in the study to avoid obtaining inaccurate or misleading standard results. For this purpose, the Phillips-Perron test was conducted, a common test in time series analysis used to detect the presence of a unit root and determine the degree of integration of economic variables.

The Akaiki Information Criterion (AIC) was also used to determine appropriate lag intervals, aiming to reduce the autocorrelation problem at the random error threshold and improve the efficiency of the test results.

The unit root test is based on two fundamental hypotheses. The null hypothesis states that the time series contains a unit root, meaning the variable is statistically unstable. The alternative hypothesis states that the time series is stable and does not suffer from the unit root problem.

The test results, shown in Table (1), indicate that the dependent variable exhibits stability at the 0.1 level. This leads to the rejection of the null hypothesis and the acceptance of the alternative hypothesis, meaning that this time series is free of a unit root.

The remaining variables in the study were found to be unstable at the 5% significance level, as the calculated t-values were lower than the tabulated values. This supports the null hypothesis that a unit root exists in these time series.

However, these variables became stable after the first difference was calculated, indicating that they are first-order integrals (I(1)), meaning their statistical stability is achieved after the first difference of the time series is taken into account.

Table (1): Results of the stationary test (unit root) for the model variables

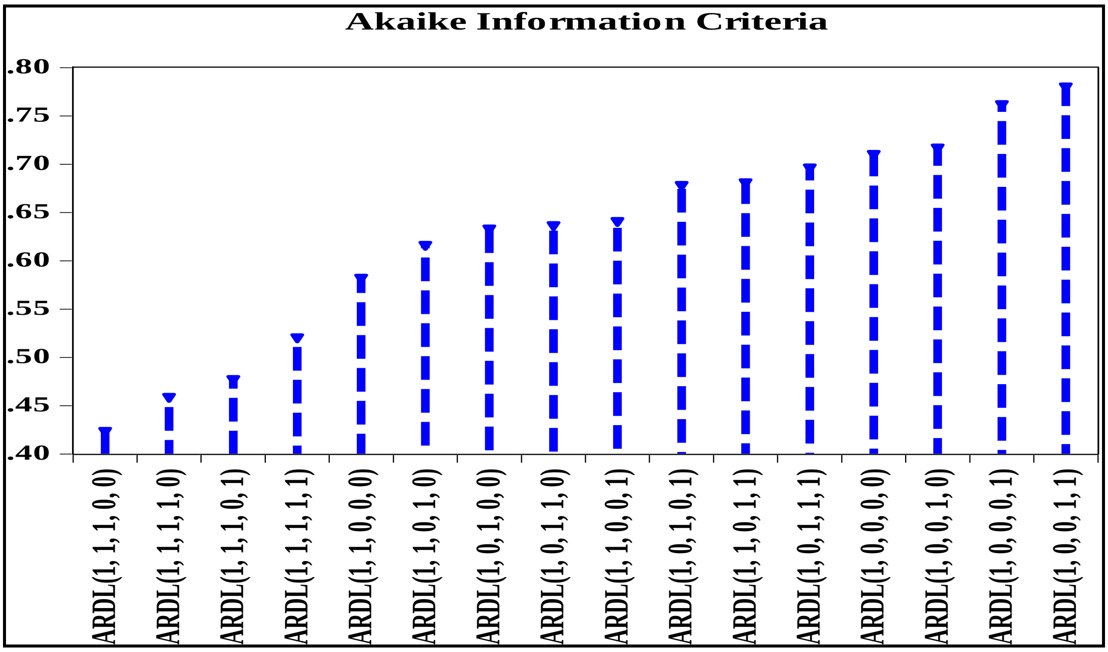
Variables	Philips Perron Test (PP)			
	At Level		At First Difference	
	Intercept	Trend and Intercept	Intercept	Trend and Intercept
LnY Prob.	-3.8914 (0.0058)***	-3.8420 (0.0279)**	-9.4206 (0.0000)***	-9.3244 (0.0000)***
LnX1 Prob.	-2.2348 (0.1988)n.s	-1.8482 (0.6558)n.s	-5.2997 (0.0002)***	-5.2473 (0.0011)***
LnX2 Prob.	-1.4375 (0.5507)n.s	-2.1597 (0.4936)n.s	-6.4863 (0.0000)***	-6.5260 (0.0000)***
LnX3 Prob.	-1.8928 (0.3310)n.s	-2.5672 (0.2965)n.s	-7.8702 (0.0000)***	-9.6837 (0.0001)***
LnX4 Prob.	-2.6698 (0.0910)*	-3.0023 (0.1481)n.s	-6.3639 (0.0001)***	-6.2340 (0.0000)***
Notes: a: (*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1% and (n.s) Not Significant.				

2. Determine the optimal lag period:

The appropriate number of lag periods was identified using the Akaike Information Criterion (AIC). According to this criterion, the preferred specification of the model is ARDL (1, 1, 1, 0, 0), since this structure provides the lowest AIC value among the alternative lag combinations. In lag selection procedures, the model associated with the smallest information criterion value is generally considered the most efficient representation of the data.

Figure (1) illustrates the process of selecting the optimal lag length based on the AIC criterion, which identifies the model specification that minimizes the information loss and ensures a better balance between model fit and complexity.

All figures and results in the practical aspect are based on the EViews 12 statistical software



3. The Bound Test Approach to Cointegration :

Table (2) indicates that the computed F-statistic (14.013) exceeds both the lower and upper critical bound values at the 5% significance level. This result leads to the rejection of the null hypothesis of no cointegration and supports the alternative hypothesis. Accordingly, the findings confirm the presence of a long-run equilibrium relationship among the variables included in the model. Based on this evidence, it becomes appropriate to proceed with estimating both the short-run and long-run dynamics within the ARDL framework.

Table (2): Co-integration test using bounds testing methodology

Bound Test Approach		
Test Statistic	**Value**	**K**
F-Statistic	14.0133	4
Critical Value Bounds		
Significance	**Lower Bound I(0)**	**Upper Bound I(1)**
10%	1.9	3.01
5%	2.26	3.48
2.50%	2.62	3.9

4. Estimation and interpretation of long and short term results and error correction parameter:

Table (3): Estimating the results of the ARDL model

Method: ARDL (1, 3, 3, 2, 3, 3, 3)				
Long Run Coefficients				
Variables	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LnX1	**-0.344133**	**0.245013**	**-1.404547**	**(0.1735)n.s**
LnX2	**0.515663**	**0.209847**	**2.457327**	**(0.0220)****
LnX3	**-0.303582**	**0.109067**	**-2.783444**	**(0.0106)****
LnX4	**0.334529**	**0.065320**	**5.121417**	**(0.0000)*****
Short Run Coefficients				
Variables	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
ECM (-1)*	**-0.974369**	**0.107436**	**-9.069297**	**(0.0000)*****
D(LnX1)	**-3.031099**	**0.858467**	**-3.530829**	**(0.0018)*****
D(LnX2)	**-0.822633**	**0.492628**	**-1.669889**	**(0.108)n.s**
R^2 = 6941.0		**Adjusted R^2 = 0.6143**		
Notes: a: (*) Significant at the 10%; (**) Significant at the 5%; (***) Significant at the 1% and (n.s) Not Significant.				

Discussion:

Table (3) shows the results of estimating the long- and short-term relationship and the error correction factor, as the following is noted:

1: Economic Interpretation of Long-Term Results

A- The results indicate a non-significant inverse relationship between industrial value added and economic growth, with a coefficient of (-0.344). This means that a 1% increase in industrial value added may lead to a decrease in the economic growth rate by approximately 0.34%, although this effect is not statistically significant. This result can be explained economically by the fact that the industrial sector in some economies may not be able to generate high added value or may rely heavily on low-technology industries, thus reducing its actual contribution to driving long-term economic growth.

B- The results showed a significant positive relationship between exports to high-income countries and economic growth, with a coefficient of (0.515). This means that a 1% increase in these exports contributes to raising the economic growth rate by approximately 0.51%. This result is consistent with the economic theory of international trade, which indicates that trade liberalization and export expansion contribute to increased productivity, improved resource allocation efficiency, and enhanced foreign exchange inflows.

C. The results indicate a significant inverse relationship between research and development (R&D) spending and economic growth, with a coefficient of (-0.303). Although economic theory often links R&D to increased innovation and economic growth, the emergence of this negative relationship may reflect that these expenditures are not being directed efficiently towards productive activities, or that their economic effects require a longer period to be reflected in economic growth.

D. The results showed a strong and significant positive relationship between foreign direct investment (FDI) and economic growth, with a coefficient of (0.334). This indicates that a 1% increase in FDI inflows leads to an increase in the economic growth rate of approximately 0.33%. This aligns with economic literature, which confirms that FDI contributes to the transfer of modern technology, the development of managerial skills, and increased productivity, thus boosting economic growth.

2: Economic Interpretation of Short-Term Results

A. The error correction coefficient was (-0.974), which is negative and significant at the 1% level, indicating a long-term equilibrium relationship between the model variables. This value also indicates a high rate of correction of short-term imbalances, with approximately 97% of deviations from equilibrium being corrected within a single timeframe. This reflects the economic system's ability to quickly return to equilibrium after economic shocks.

B- The results showed a significant inverse relationship between changes in industrial value added and short-term economic growth, with a coefficient of (-3.03). This means that a sudden increase in this variable could lead to a decline in short-term economic growth. This may be due to structural changes in the industrial sector, increased production costs, or reduced production efficiency in some industries.

C- The results indicate a non-significant inverse relationship between changes in exports to high-income countries and short-term economic growth. This means that the impact of exports on growth may not be immediate and direct, but rather requires a longer period to be reflected in economic activity.

D- The corrected coefficient of determination reached approximately 0.6143, which means that the independent variables included in the model explain about 61% of the changes in the economic growth rate, while the remaining percentage is due to other factors not included in the model or to the random variable.

Fourth: Diagnostic test results for model residuals

The diagnostic tests conducted on the model residuals, as reported in Table (4), indicate that the estimated model is statistically reliable. The results show that the model successfully satisfies the main assumptions required for regression analysis. Specifically, the Jarque–Bera test confirms that the residuals follow a normal distribution. In addition, the LM test indicates the absence of serial correlation among the residuals. The results also reveal no evidence of heteroskedasticity, as confirmed by both the Breusch–Godfrey test and the ARCH test. Furthermore, the model does not suffer from specification errors, which confirms the correctness of the functional form used in the estimation. Overall, these diagnostic results demonstrate that the estimated model is well specified and statistically valid for interpretation and inference.

Table (4) Diagnostic test results for model residuals

Statistics test	Estimated value	Prob	Statistics test
Normality (Jarque-Bera)	0.679425	0.711975	Normality (Jarque-Bera)
Breusch-God Frey Serial Correlation LM Test	1.734558	0.2014	Breusch-God Frey Serial Correlation LM Test
Heteroscedasticity test BY: (ARCH)	0.356521	0.5554	Heteroscedasticity test BY: (ARCH)

2.Structural stability test of model parameters:

After estimating the Error Correction Model (ECM) within the ARDL framework, it becomes important to examine the structural stability of the model parameters in both the short run and the long run. This step is necessary to verify that the dataset used in the analysis does not contain structural breaks that could affect the reliability of the estimated relationships. Moreover, testing parameter stability helps determine whether the long-term coefficients remain consistent with the short-term dynamics of the model. Conducting such stability tests ensures that the estimated relationships are stable over the study period and that the model provides dependable results for economic interpretation.

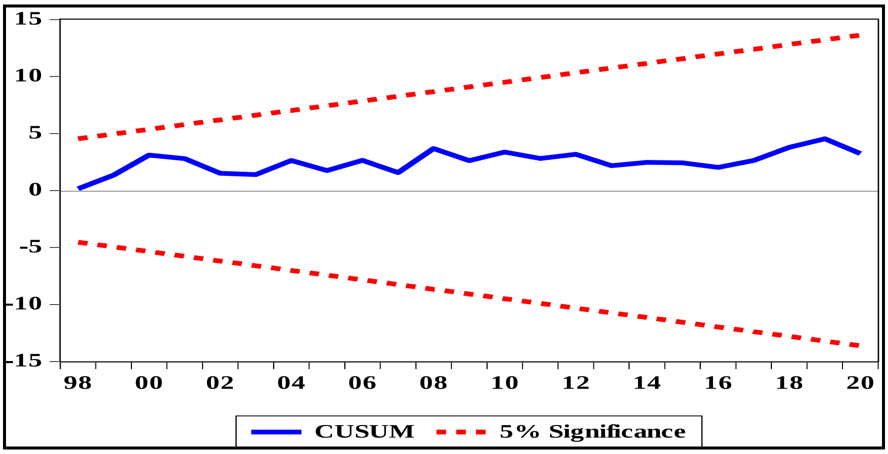


Figure (3): A typical model test.

It can be observed from Figure (3) that the plot of the Cumulative Sum (CUSUM) test of recursive residuals remains within the critical bounds throughout the study period. This indicates that the estimated coefficients of the model are stable over time. Consequently, the results confirm that the model does not suffer from structural instability, and the estimated parameters remain consistent during the period under investigation.

Conclusion :

1- The period between 2020 and 2025 has demonstrated that countries investing in technological infrastructure—such as Egypt—were more resilient and capable of maintaining positive growth rates during global crises.

2-Growth Correlation with Quality Exports: There is a strong positive correlation between increasing high-tech exports to advanced markets and the growth of the Gross Domestic Product (GDP), indicating that technological quality is the key to economic expansion.

3-Speed of Structural Correction: The Error Correction Mechanism (ECM) results showed a high speed of adjustment (approximately 92%), suggesting that the Egyptian economy possesses sufficient flexibility to absorb technological shocks and convert them into actual growth.

Reference :

1- Alanne, K., & Cao, S. (2019). An overview of the concept and technology of ubiquitous energy. Applied Energy, 238, 284-302.

2-Almeshref, Y., & Khwanda, H. (2022). Information Systems Effect on Enabling Knowledge Management. International Journal of Professional Business Review, 7(5), e0834.

3-Almunawar, M. N., & Anshari, M. (2012). Health information systems (HIS): Concept and technology. arXiv preprint arXiv:1203.3923.

4-Alqahtani, A. S., Daghestani, L. F., & Ibrahim, L. F. (2017). Environments and system types of virtual reality technology in STEM: A survey. International Journal of Advanced Computer Science and Applications, 8(6).

5-Aunger, R. (2010). Types of technology. Technological Forecasting and Social Change, 77(5), 762-782.

6-Bayarcelik, E. B., & Taşel, F. (2012). Research and development: source of economic growth. Procedia-Social and Behavioral Sciences, 58, 744-753.

7-Box, G. E., Jenkins, G. M., Reinsel, G. M., & Ljung, G. M. (2015). Time series analysis: Forecasting and control. John Wiley & Sons.

8-Carlaw, K. I., & Lipsey, R. G. (2003). Productivity, technology, and economic growth: what is the relationship? Journal of Economic Surveys, 17(3), 457-495.

9-Chaguaro Feijoo, A. D., & Briones Aguirre, K. L. (2022). The importance of technology as a teaching resource in oral expression (Bachelor's thesis). Universidad de Guayaquil.

10-Coccia, M. (2009). Measuring the impact of sustainable technological innovation. International Journal of Technology Intelligence and Planning, 5(3), 276-288.
11-Edwards-Stewart, A., Hoyt, T., & Reger, G. (2016). Classifying different types of augmented reality technology. Annual Review of CyberTherapy and Telemedicine, 14, 199-202.
12-Ferreira, J. J., Fernandes, C., & Ratten, V. (2019). The effects of technology transfers and institutional factors on economic growth: evidence from Europe and Oceania. The Journal of Technology Transfer, 44(5), 1505-1528.
13-Frieske, B., Kloetzke, M., & Mauser, F. (2013). Trends in vehicle concept and key technology development for hybrid and battery electric vehicles. 2013 World Electric Vehicle Symposium and Exhibition (EVS27).
14-Godfrey, A., Hetherington, V., Shum, H., Bonato, P., Lovell, N. H., & Stuart, S. (2018). From A to Z: Wearable technology explained. Maturitas, 113, 40-47.
15-Godin, B. (2016). Technological innovation: on the origins and development of an inclusive concept. Technology and Culture, 57(3), 527-556.
16-Guloglu, B., & Tekin, R. B. (2012). A panel causality analysis of the relationship between research and development, innovation, and economic growth in high-income OECD countries. Eurasian Economic Review, 2(1), 32-47.
17-Hill, R. C., Griffiths, W. E., & Lim, G. C. (2018). Principles of econometrics. John Wiley & Sons.
18-Hongyun, H., & Radwan, A. (2021). Economic and social structure and electricity consumption in Egypt. Energy, 231, 120962.
19-Lestari, C. D., & Rahmawati, F. (2021). Measuring the Impact of Technology, Politics, and Human Resources on Inclusive Economic Growth in Indonesia. EcceS (Economics, Social, and Development Studies), 8(1), 65-85.
20-Lopatukhina, T., Egorova, E., Bulankina, N., & Mishutina, O. (2020). Personalized Education: origins, characteristics, and technology of use. EDULEARN20 Proceedings, 899-904.
21-Mohamed, A. N., Abdulle, A. Y., & Abdullahi, A. O. (2023). Factors Influencing Foreign Direct Investment Inflow in Somalia. International Journal of Professional Business Review, 8(2), e0514.
22-Najarzadeh, R., & Rahimzadeh, F. (2013). Measuring the Impact of Internet on Economic Growth in Selected Countries: the Panel Cointegration Approach. Quarterly Journal of Economic Growth and Development Research, 3(9), 85-98.
23-Pesaran, M. H., & Shin, Y. (1999). An Autoregressive Distributed Lag Modeling Approach to Cointegration Analysis. In S. Strom (Ed.), Econometrics and Economic Theory in the 20th Century. Cambridge University Press.
24-Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics, 16(3), 289-326.
25-Pousttchi, K., Gleiss, A., Buzzi, B., & Kohlhagen, M. (2019). Technology impact types for digital transformation. 2019 IEEE 21st Conference on Business Informatics (CBI), 1, 487-494.
26-Schatzberg, E. (2018). Technology: Critical history of a concept. University of Chicago Press.
27-Shaaban, M., & Scheffran, J. (2017). Selection of sustainable development indicators for the assessment of electricity production in Egypt. Sustainable Energy Technologies and Assessments, 22, 65-73.
28-Waxman, H. C., Boriack, A. W., Lee, Y. H., & MacNeil, A. (2013). Principals' perceptions of the importance of technology in schools. Contemporary Educational Technology, 4(3), 187-196.
29-World Bank (2021). World Development Indicators.
30-Yüksel, S. (2017). The impacts of research and development expenses on export and economic growth. International Business and Accounting Research Journal, 1(1), 1-8.
31-Zhang, J. (2019). The dynamic linkage between information and communication technology, human development index, and economic growth: evidence from Asian economies. Environmental Science and Pollution Research, 26(26), 26982-26990.

Table (4) Data for explanatory variables and dependent variable
For the period 1990 - 2025 the logarithmic statements adopted in the research

the years	technological development	direct foreign investment/GDP	Spending on research and development / GDP	Industrial Value Added/GDP	GDP growth rate
1990	0	0.230449	-0.52288	1.437751	0.752816
1991	0.30103	-0.17393	-0.49485	1.506911	0.049218
1992	0.477121	0.037426	-0.46852	1.497068	0.650308
1993	0.60206	0.021189	-0.46852	1.493319	0.462398
1994	0.69897	0.383815	-0.31876	1.4843	0.598791
1995	0.778151	-0.00436	-0.25964	1.480582	0.666518
1996	0.845098	-0.02687	-0.20066	1.469969	0.697229
1997	0.90309	0.053078	-0.67778	1.462248	0.739572
1998	0.954243	0.100371	-0.72125	1.456973	0.745855
1999	1	0.068186	-0.72125	1.453318	0.782473
2000	1.041393	0.089905	-0.74473	1.487845	0.804139
2001	1.079181	-0.284	-0.72125	1.489818	0.547775
2002	1.113943	-0.12494	-0.22185	1.507586	0.378398
2003	1.146128	-0.5376	-0.72125	1.523356	0.503791
2004	1.176091	0.201397	-0.63827	1.528917	0.578639
2005	1.20412	0.777427	-0.58503	1.533264	0.650308
2006	1.230449	0.970347	-0.58503	1.558108	0.835056
2007	1.255273	0.947924	-0.60206	1.544812	0.850033
2008	1.278754	0.765669	-0.60206	1.558829	0.854306
2009	1.30103	0.549003	-0.56864	1.554004	0.669317
2010	1.322219	0.462398	-0.36653	1.55364	0.710963
2011	1.342423	-0.69897	-0.36653	1.555699	0.245513
2012	1.361728	0	-0.27572	1.59384	0.346353
2013	1.380211	0.161368	-0.30103	1.600755	0.338456
2014	1.39794	0.176091	-0.20066	1.600864	0.463893
2015	1.414973	0.322219	-0.20761	1.563837	0.640481
2016	1.431364	0.385606	-0.14874	1.511215	0.63749
2017	1.447158	0.49693	-0.14874	1.528274	0.621176
2018	1.462398	0.513218	-0.17393	1.543571	0.725095
2019	1.477121	0.472756	-0.14267	1.551694	0.744293
2020	1.491362	0.491362	-0.10791	1.50515	0.55145
2021	1.505153	.0.485389	-0.10267	1.51287	0.52245
2022	1.520332	0.510341	-0.09542	1.52512	0.82078
2023	1.535227	0.495431	-0.08831	1.54045	0.58043
2024	1.550347	0.520328	-0.08012	1.56086	0.47711
2025	1.565129	0.550390	-0.07533	1.58042	0.60232

Source: The table was made by the researcher depending on the source. World Development Indictors 2025