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Technological Endogeneity and Growth Trajectories: A Comparative Analysis of Türkiye and South Korea's Economic Journeys

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Abstract The sources of differences in the growth and welfare of countries in the globalising world have been a long-standing topic of debate. In the economic growth literature, numerous studies have explored these sources, yet there is still no clear consensus. One of the most prominent fields regarding the sources of growth and the welfare of nations is the endogenous growth theory introduced in the 1990s. The effects of technological development, a standout achievement of the modern era, on economic growth have led to the discovery of many substantial sources related to the growth and welfare of countries, integrated into popular culture via endogenous growth theories. This study aims to enhance the understanding of the endogenous growth theory by exploring the interplay between technology and economic development across various countries and variables. The primary motivation is to examine potential technology-driven disparities in nations' growth and welfare levels. The main research question is whether countries pursuing endogenous growth policies experience more sustainable and higher-quality growth compared to others. To answer this question, the study examines the effects of technology endogenization on Türkiye and South Korea, two countries that had similar economic conditions in the past but now show significant differences. Using ARDL Cointegration Analysis and covering the period from 1990 to 2020, the evidence demonstrates that South Korea achieved more stable and higher-quality growth due to its policy of endogenizing technology. In contrast, Türkiye has not succeeded in this area and needs improvements.

Keywords Endogenous growth · Technology · ARDL analysis

Jel Codes C32, O30

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Technological Endogeneity and Growth Trajectories: A Comparative Analysis of Türkiye and South Korea's Economic Journeys

The concept of economic growth has been one of the most extensively contemplated subjects in economic thought from its inception to this day. Historically, this concept, which has been attributed to various sources, is considered the fundamental determinant for nations to reach a certain level of prosperity. In this context, identifying the primary sources of economic growth and implementing policies to strengthen these sources is of great importance.

Even more crucial than achieving economic growth is, as Acemoğlu and Üçer (2015) state, the establishment of a stable, high-quality, and equitably shared growth infrastructure across the nation. It is predicted that only when such a growth structure is achieved can national welfare reach optimal levels. The key to attaining these desired conditions is, as one of the most significant problems in the field of economics, the efficient utilisation of all available resources. The effective use of economic resources, in other words, total factor productivity growth, is directly related to one of the most significant achievements of the age: technological advancements and innovations.

Although the importance of new production techniques in the economical growth area has been explored in economic literature since the era of classical economists, the direct relationship between growth and technology was not explicitly established until the Solow (1956) model. According to the Solow model, which laid the foundations for this relationship, technology was an external factor representing the segment of growth that could not be explained by variations in labour and capital. This significant relationship gained a substantial dimension in the early 1990s with Paul Romer's article. Romer (1990) argued that technology is as influential on growth as capital and labour and incorporated technology into the centre of the production function by endogenizing it. The process of endogenizing technology initiated by Romer has been expanded or differentiated through various studies with different perspectives.

Considering all this, the aspects of how technology and growth interact, as well as potential differences among countries, constitute the fundamental motivation of this study. In the process of investigating this relationship, two prominent examples emerge: South Korea, which has successfully integrated technology, and Türkiye, which has struggled to incorporate technological development into its growth policies. In the 1960s, Türkiye and South Korea emerged on the international stage as two countries with similar economic growth rates and socio-economic characteristics. However, the gap between these two nations, which had been growing at a comparable pace for nearly twenty years, began to widen in South Korea's favour during the 1980s. Since then, this gap has continued to expand rapidly. Under current conditions, South Korea has achieved the status of a developed country and ranks among the world's largest economies, whereas Türkiye remains a developing country struggling with unresolved structural problems. Although the two countries experienced similar economic conditions until the 1980s, the significant differences that have emerged since then, and the underlying reasons for these differences, have drawn considerable interest. This research attributes South Korea's success—often referred to as a "miracle" in the literature—to its robust economic structure, underpinned by production and exports.

The primary aim of this study is to provide policy recommendations for Türkiye by empirically demonstrating that South Korea's most critical strategy for achieving this economic structure lies in the export of high value-added technologies. It also explores how weaknesses in this area have affected Türkiye's growth trajectory.

In the context of all these explanations, the original contribution of this study lies in its comparative analysis of Türkiye and South Korea, nations that have adopted distinct approaches to technological endogeneity and economic growth policies, using multiple growth-based variables. The models in which the mentioned variables are structured are Romer (1990)-based endogenous growth models. The empirical analysis applied constitutes another pillar of this study's contribution by addressing the empirical gap in previous studies, which have primarily focused on R&D activities but have fallen short in examining high value-added technology production, their exports, and the structural dynamics of labour and comprehensive capital variables in relation to these factors.

With this perspective, the research question of the study revolves around whether countries that endogenize technological advancements and pursue growth policies in alignment with technology achieve a more stable and high-quality growth structure. Furthermore, potential outcomes that may arise when labour and capital variables, traditionally considered the main determinants of growth, are examined in conjunction with technology integration are also central to the research focus.

This research seeks to offer a deeper understanding of how varying strategies of integrating technology with economic policies can impact overall economic stability and growth quality. In addition, this research seeks to bridge existing knowledge gaps by highlighting the interplay between traditional growth determinants and modern technological integration, offering a nuanced understanding of how technology-driven growth can be optimised in varying national contexts.

In the course of investigating the aforementioned relationships, the study is structured into four sections. Following the introduction, which outlines the general framework of the study, the second section briefly touches upon a literature review that highlights the overall trends in similar studies. When we reach the third section, the methodology to be employed will be explained. In this step, data sets and variables are introduced, followed by an explanation of the derivation of the econometric model, which forms the basis of the analysis. The fourth section of the study will encompass the econometric analysis comparing Türkiye and South Korea. Within this section, unit root tests, serving as the foundational steps of the time series analysis, will be conducted initially, followed by the presentation of the empirical findings. Subsequently, the quantitative results obtained from the simultaneous analysis of the two selected countries will be qualitatively compared. Finally, the study will be concluded in the discussion and conclusion sections, providing an overall assessment.

Literature

The endogenization of technology is a prominent subject concerning nations' ability to achieve high-quality economic growth. The achievements of countries such as Germany, China, and South Korea, which have successfully endogenized technology within their growth policies, are economically enlightening examples. In the empirical analysis, different perspectives and approaches are used to demonstrate the positive impact of technology on total factor productivity and growth.

When reviewing the studies in the existing literature, the empirical comparison of the growth structures of Türkiye and South Korea, which began with significant similarities in their growth patterns, has largely been overlooked. Moreover, nearly all studies have focused on R&D activities as a measure of technological development. While R&D activities are undeniably one of the most important indicators for measuring technological progress, the emphasis on countries achieving strong growth through the volume of technology exports—especially South Korea—has not been sufficiently addressed, representing a notable gap in the literature.

Furthermore, the integration of the two models by combining Romer's (1990) theoretical framework, which underpins endogenous growth theories and highlights the importance of large-scale capital and technological development, with Okun's law, which examines the negative relationship between unemployment and growth, introduces a significant new dimension to this study.

Table 1 presents a summary of related studies within the field of economics that focus on the endogenization of technology, aligning with the approach taken in the current research. It provides an overview of the methodologies employed and the findings achieved in studies examining the effects of technology on total factor productivity and economic growth through various variables.

Table 1
Literature Review

Authors	Period	Countries	Method	Variables	Effect
Coe and Helpman (1995)	1971 1990	22 OECD Countries	Panel Cointegration Analysis	Domestic and Foreign R&D Investments	Positive
Jones (1995)	1880 1987	USA and 14 OECD Countries	Time Series	R&D Investments	Varies*
Nonneman and Vanhoudt (1996)	1960 1985	22 OECD Countries	Panel Data	R&D Investments, Physical Capital, Labour	Positive
Chiang, Kao & Chen (1997)	1971 1990	15 OECD Countries and G7 Countries	Panel Cointegration Analysis	Domestic and Foreign R&D Investments	Positive
Segerstrom (1998)	1965 1990	5 Developed Countries	Quantitative Data Analysis	R&D Investments and Patents	Negative
Eaton and Kortum (1999)	1980 1990	5 Developed Countries	Quantitative Data Analysis	Participants in R&D Activities and Patents	Positive
Howitt (2000)	1998	Selected Countries	Cross-Sectional Data	R&D Investments and Technology Transfers	Positive
Griffith, Redding & Reenen (2001)	1974 1990	12 OECD Countries	Panel Data	R&D Investments, Human Capital, Import	Positive
Cuaresma & Wörz (2005)	1981 1997	45 OECD Countries	Panel Data	Low-Tech and High-Tech Product Exports	Positive
Rodrik (2006)	1992 2003	China	Linear Regression Analysis	Tech Product Exports	Positive
Falk (2007)	1970 2004	22 OECD Countries	Panel GMM	R&D Investments and High-Tech Product Exports	Positive
Ha and Howitt (2007)	1950 2000	USA	Cointegration Analysis	R&D Investments	Varies*
Coe, Helpman & Hoffmaister (2009)	1971 2004	24 OECD Countries	Panel Cointegration Analysis	R&D and Human Capital Investments	Positive
Jarreau and Poncet (2011)	1997 2009	China	Time Series	Foreign Direct Investments (FDI), Human Capital, Foreign Trade, and High-Tech Product Exports	Positive

Authors	Period	Countries	Method	Variables	Effect
Göçer (2013)	1996 2012	11 Asian Countries	Panel Data	R&D, High-Tech Exports, ICT	Positive
Wu, Ma & Zhuo (2016)	1981 2010	Selected 80 Countries	Panel Data	FDI, High-Tech Product Exports, Scientific Articles, Human and Physical Capital	Positive
Ekananda and Parlinggoman (2017)	1992 2014	Selected 50 Countries	Panel Data	FDI, High-Tech and Other Technological Products Export	Positive
Kim (2020)	1996 2013	14 OECD Countries	Panel Data	R&D in the High-Tech Industry Sector	Positive
Daysi et al. (2021)	2000 2020	Colombia, Ecuador, and Peru	Panel Data	High-Technology Product Exports and Carbon Dioxide Emissions	Positive
Ahmad and Zheng (2022)	1990 2019	36 OECD Countries	Panel GMM	GDP, R&D Expenditure, Patents, Saving Rate, Household Consumption, Labour Force, Gross Fixed Capital, Real Interest Rate	Positive
Hamia (2022)	1990 2019	Developing 18 Countries-Developed 22 Countries	Panel Causality Analysis	Technology Transfers in Low, Medium, and High-Tech Industries	Positive
Lam et al. (2022)	1990 2015	Malaysia	ARDL	FDI, High-Tech Product Exports	Positive
Behera, Haldar & Sethi (2023)	2000 2020	Emerging 13 Countries	Panel Data	GDP Per Capita, ICT Usage (Mobile Cellular Subscription & Individual Using Internet), Spending on Technological Innovation, R&D Expenditures, FDI, Institutional Quality, Financial Development, Trade Openness	Positive
Nihal et al. (2023)	1996 2020	G8 Countries	Panel VAR and Causality Analyses	GDP, R&D Expenditures, Technological Human Capital, Scientific Articles, Patent Applications	Positive
Akcigit, Pearce & Prato (2024)	2001 2013	Denmark	Calibration-Simulated Method of Moments (SMM)	R&D Subsidies, Education Subsidies, Total Factor Productivity (GDP Growth), Patents, R&D Project Numbers, Individual Indicators	Positive
Islam, Rahaman & Chen (2024)	1996 2021	25 Middle-income countries	Panel ARDL Analysis	GDP, R&D Expenditure, Foreign Remittances, FDI, Labour Force, TFP, Capital Stock	Positive
Li et al. (2024)	2008 2021	30 Provinces of China	Spatial Panel Data	GDP, R&D Personnel Flow, R&D Capital Flow, and Regional Absorptive Capacity	Positive
Sojoodi and Baghbanpour (2024)	2007 2020	Developing 30 Countries–Developed 30 Countries	Panel Causality Analysis	GDP Growth and High-Tech Industry Exports	Varies*
Tung and Hoang (2024)	1996 2019	Emerging 29 Countries	Panel ARDL Analysis	Gross National Output, National Gross Capital, Labour, R&D Expenditure and Education Development, Corruption Index	Positive

Note: * Different effects have been observed in the short and long term.

Methodology

The impact of technology endogenization on economic growth is examined through a comparison of Türkiye and South Korea, following models such as Romer's (1990) endogenous growth model and R&D-based models like Grossman & Helpman's (1991). Based on preliminary tests, it has been determined that the most suitable method for the analysis is the method of Autoregressive Distributed Lag (ARDL). Here, the dataset and variables are introduced, followed by an explanation of the establishment and derivation of the econometric model.

Data and Variables

The common variables and data sets for the analyses to be conducted for Türkiye and South Korea are presented in Table 2.

Table 2
Variables

Variables	Indicators	Sources
GDP (Y)	Real GDP Per Capita (Base Year 2015, Million $)	World Bank
Unemployment (UNL)[1]	Number of Unemployed Individuals Aged 15 and Over	ILO
Human Capital (HC)	Number of Individuals Enrolled in Higher Education	UNESCO
Physical Capital (K)	Real Gross Fixed Capital Formation (Base Year 2015, Million $)	World Bank
High-Tech Product Exports (HTX)	Export of Computer, Electronic, Optical, Pharmaceutical, Aerospace, and Space Industry Products (Base Year 2015, Million $)	OECD

Due to the data limitations in the high-technology product export data, the analyses for both countries cover the period from 1990 to 2020. The data for all monetary variables used in the analyses are real data adjusted to the base year 2015 by data sources. This is because nominal data may not reflect real values as they are not adjusted for inflation effects. Additionally, the data are selected annually and included in the analysis after taking natural logarithms. Time series analyses were conducted using the EViews 13 software package, which is one of the most useful econometric programs.

Modelling

While establishing the main model for analysing the impact of technology on growth, starting from a Cobb-Douglas (1928) type production function will enhance the understanding of the model's endogenous growth foundations. In technology-based growth models, due to the productivity increase generated by technology, the marginal productivities of production factors do not decrease over time. In other words, the assumption of increasing returns to scale holds. Therefore, the basic model of the production function, the Cobb-Douglas type for endogenous growth models, where $\alpha+\beta > 1$, can be expressed as follows:

$$Y = A.K^{\alpha}.L^{\beta} \tag{1}$$

[1]The variable coded as UNL represents the population aged 15 and over who are not in the labour force. Consistent with the fundamental equation, Total Labour Force = Employment + Unemployment, as in various studies in the literature, the representative variable for labour is based on unemployment data. This enables the investigation of the relationship between unemployment and economic growth in the empirical section.

In the equation, Y denotes the growth indicator represented by per capita GDP, while A signifies the total factor productivity. Additionally, K stands for physical capital and L represents labour. In the fundamental Cobb-Douglas production function, capital encompasses both physical capital (K) and human capital (HC), similar to the AR&D-based growth literature. Human capital plays a crucial role in these models of technology-based growth. Accordingly, the production function used in the model is the Extended Cobb-Douglas production function, reflecting the comprehensive treatment of capital.

$$Y = A.UNL^{\alpha}.HC^{\beta}.K^{\theta}.HTX^{\delta} \tag{2}$$

In the common model established for the comparative analysis of Türkiye and South Korea, total factor productivity (A) is considered as an indicator that represents how much of the growth is attributable to technological advancement and the efficient utilisation of production factors (Acemoğlu & Üçer, 2019: 6). High-technology product exports, denoted as HTX, symbolise the technology variable that enhances total factor productivity and growth.

The econometric model will be developed from the Extended Cobb-Douglas production function by applying Log-Linearisation, owing to the characteristic exponential form of the Cobb-Douglas production functions. The Log-Linearisation method is defined as the process of linearising non-linear models by using the Taylor series. In this context, non-linear models go through a series of mathematical steps until they reach stationary conditions. Within this scope, the principles of the First-Order Taylor Series Approximation, based on the theorem of the famous mathematician Brook Taylor, are followed through the following steps (Zietz, 2006). According to the Taylor Series Approximation (First Order), for any function f(x), at the initial spot to represent the stationary value of the x variable, it is expressed as follows:

$$x = x^* \tag{3}$$

$$f(x) = f(x^*) + f'(x^*).(x - x^*) \tag{4}$$

In the equation, where f'(x*) represents the derivative of the stationary value of the function f(x), and (x-x*) represents the change in x, the logarithmic representation of any exponential function is as follows:

$$y = a.x^{b} \tag{5}$$

$$\log(y) = b.\log(x) + \log(a) \tag{6}$$

In adapting this fundamental approach to the model, the natural logarithm of the variables is taken first:

$$Y = A.UNL^{\alpha}.HC^{\beta}.K^{\theta}.HTX^{\delta} \tag{7}$$

$$lnY = lnA + \alpha.lnUNL + \beta.lnHC + \theta.lnK + \delta.lnHTX \tag{8}$$

Taking into account the necessity of linearising variables in the stationary equilibrium and using the initial condition x = x*:

$$lnY^* = lnA^* + \alpha.lnUNL^* + \beta.lnHC^* + \theta.lnK^* + \delta.lnHTX^* \tag{9}$$

Then, the stationary values of each variable are substituted into equation (4), with f(x) = lnY:

$$\begin{aligned} lnY^* + \frac{1}{Y^{*.}}(Y - Y^*) = lnA^* + \frac{1}{A^{*.}}(A - A^*) + \alpha.lnUNL^* + \frac{a}{UNL^{*.}}(UNL - UNL^*) + \\ \beta.lnHC^* + \frac{\beta}{HC^{*.}}(HC - HC^*) + \theta.lnK^* + \frac{\theta}{K^{*.}}(K - K^*) + \delta.lnHTX^* + \frac{\delta}{HTX^{*.}}(HTX\text{-}HTX^*) \end{aligned} \tag{10}$$

Given that the equality in equation (9) is known, when the variables are substituted in their place:

$$lnY* = lnA* + \alpha.lnUNL* + \beta.lnHC* + \theta.lnK* + \delta.lnHTX* + \frac{1}{Y*.}(Y - Y*) = lnA* + \frac{1}{A*.}(A\text{-}A*) + \alpha.lnL* + \frac{\alpha}{UNL*.}(UNL\text{-}UNL*) + \beta.lnHC* + \frac{\beta}{HC*.}(HC\text{-}HC*) + \theta.lnK* + \frac{\theta}{K*.}(K\text{-}K*) + \delta.lnHTX* + \frac{\delta}{HTX*.}(HTX\text{-}HTX*) \tag{11}$$

When the necessary simplifications are performed, the equation transforms into the following form:

$$\frac{1}{Y*.}(Y - Y*) = \frac{1}{A*.}(A - A*) + \frac{\alpha}{UNL*.}(UNL\text{-}UNL*) + \frac{\beta}{HC*.}(HC\text{-}HC*) + \frac{\theta}{K*.}(K\text{-}K*) + \frac{\delta}{HTX*.}(HTX\text{-}HTX*) \tag{12}$$

$$\frac{(Y - Y*)}{Y*} = \frac{(A - A*)}{A*} + \alpha.\frac{(UNL\text{-}UNL*)}{UNL*} + \beta.\frac{(HC\text{-}HC*)}{HC*} + \theta.\frac{(KK\text{-}KK*)}{K*} + \delta.\frac{(HTX\text{-}HTX*)}{HTX*} \tag{13}$$

and:

$$\frac{(Y - Y*)}{Y*} = \tilde{Y} \tag{14}$$

$$\frac{(A - A*)}{A*} = \tilde{A} \tag{15}$$

$$\frac{(UNL\text{-}UNL*)}{UNL*} = \widetilde{UNL} \tag{16}$$

$$\frac{(HC\text{-}HC*)}{HC*} = \widetilde{HC} \tag{17}$$

$$\frac{(KK\text{-}KK*)}{K*} = \tilde{K} \tag{18}$$

$$\frac{(HTX\text{-}HTX*)}{HTX*} = \widetilde{HTX} \tag{19}$$

Thus, when the deterministic format, showing the estimated values of the main population for the variables and including the residuals (ũ), is transformed into a stochastic format, it appears as follows:

$$\tilde{Y} = \tilde{A} + \alpha.\widetilde{UNL} + \beta.\widetilde{HC} + \theta.\tilde{K} + \delta.\widetilde{HTX} + \tilde{u} \tag{20}$$

Analysis

In this subsection of the study, a roadmap is aimed to be created for the stages of the applied analyses, and a theoretical framework regarding the tests used will be outlined. Then, the results of the application for Türkiye and South Korea will be presented sequentially. In the final stage, the obtained analysis results will be interpreted comparatively. Within the scope of the ARDL analysis to be applied in the study, the basic equation for Türkiye and South Korea is as follows:

$$Y_{\mathrm{t}} = A_0 + \sum_{\mathrm{i=1}}^{\mathrm{p}} \psi_{\mathrm{i}}.Y_{\mathrm{t\text{-}i}} + \sum_{\mathrm{j=0}}^{\mathrm{q_1}} .\alpha_{\mathrm{j}}.UNL_{\mathrm{t\text{-}j}} + \sum_{\mathrm{j=0}}^{\mathrm{q_2}} .\beta_{\mathrm{j}}.HC_{\mathrm{t\text{-}j}} + \sum_{\mathrm{j=0}}^{\mathrm{q_3}} .\theta_{\mathrm{j}}.K_{\mathrm{t\text{-}j}} + \sum_{\mathrm{j=0}}^{\mathrm{q_4}} .\delta_{\mathrm{j}}.HTX_{\mathrm{t\text{-}j}} + u_{\mathrm{t}} \tag{21}$$

In addition to the basic ARDL model, the most suitable ECM model as described in the Pesaran, Shin, & Smith (2001) article has been selected and adapted to the variables of the main model. The representation of the common, unrestricted intercept, and trendless equation for the ECM model is as follows:

$$\Delta Y_t = A_0 + \gamma.Y_{t\text{-}1} + \alpha.UNL_{t\text{-}1} + \beta.HC_{t\text{-}1} + \theta.K_{t\text{-}1} + \delta.HTX_{t\text{-}1} + \sum_{i=1}^{p\text{-}1} C_{0,i}.\Delta Y_{t\text{-}1} + \sum_{j=1}^{qj\text{-}1} C_j.\Delta UNL_{t\text{-}j}$$
$$+ \sum_{j=1}^{qj\text{-}1} C_j.\Delta HC_{t\text{-}j} + \sum_{j=1}^{qj\text{-}1} C_j.\Delta K_{t\text{-}j} + \sum_{j=1}^{qj\text{-}1} C_j.\Delta HTX_{t\text{-}j} + d_1.\Delta UNL_t + d_2.\Delta HC_t + d_3.\Delta K_t + d_4.\Delta HTX_t + u_t \quad (22)$$

Unit Root Tests

In the first stage of the ARDL analysis, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests were sequentially applied for Türkiye and South Korea, and stationarity checks of the series were performed. On the basis of the preliminary tests conducted before this stage, no structural breaks were detected for both countries, and these tests were deemed sufficient.

Table 3

Unit Root Tests for Variables Related to Türkiye

	ADF H_0 : The series has unit roots.			PP H_0 : The series has unit roots.		
Variables	**Test Statistics**	**%5 Critical Value**	**Probabilities***	**Test Statistics**	**%5 Critical Value**	**Probabilities***
Y	-2.56		0.30	-2.60		0.28
UNL	-2.63		0.27	-2.10		0.52
HC	-3.04	-3.57	0.14	-1.84	-3.57	0.66
K	-2.62		0.28	-2.69		0.25
HTX	-0.50		0.98	-0.76		0.96

Note: *MacKinnon (1996) one-sided p-values

According to the findings, it can be said that the null hypothesis H_0 cannot be rejected for any variable related to Türkiye, and all variables contain unit roots.

Table 4

Unit Root Tests for the First Differences of Variables Related to Türkiye

	ADF H_0 : The series has unit roots.			PP H_0 : The series has unit roots.		
Variables	**Test Statistics**	**%5 Critical Value**	**Probabilities***	**Test Statistics**	**%5 Critical Value**	**Probabilities***
ΔY	-5.38		0.00	-5.95		0.00
ΔUNL	-5.07		0.00	-9.41		0.00
ΔHC	-3.99	-3.57	0.02	-4.14	-3.57	0.01
ΔK	-5.75		0.00	-5.77		0.00
ΔHTX	-3.86		0.03	-3.70		0.04

Note: *MacKinnon (1996) one-sided p-values

Table 4 demonstrates that all series are stationary in their first differences for both unit root tests. In this case, none of the variables is integrated of order 2. Thus, the condition of no variable being I(2) is satisfied for the ARDL analysis.

Table 5

Unit Root Tests for Variables Related to South Korea

	ADF			PP		
	H_0 : The series has unit roots.			H_0 : The series has unit roots.		
Variables	**Test Statistics**	**%5 Critical Value**	**Variables**	**Test Statistics**	**%5 Critical Value**	**Variables**
Y	−0.84		0.95	−0.90		0.94
UNL	-3.61		0.04	-2.01		0.57
HC	−1.17	-3.57	0.90	−0.94	-3.57	0.94
K	-3.53		0.05	-5.40		0.00
HTX	-4.65		0.00	-4.60		0.01

As a result of the unit root tests applied, it is concluded that the Y, HC, and K variables related to South Korea contain unit roots, while the UNL and HTX variables are non-stationary and exhibit stationary properties in levels. At this stage, for the applicability of the ARDL analysis, it is necessary for the non-stationary Y, HC, and K variables to become stationary in their first differences. Thus, the ADF and PP tests were applied to the first differences in the non-stationary series:

Table 6

Unit Root Tests for the First Differences of Variables Related to South Korea

	ADF			PP		
	H_0 : The series has unit roots.			H_0 : The series has unit roots.		
Variables	**Test Statistics**	**%5 Critical Value**	**Variables**	**Test Statistics**	**%5 Critical Value**	**Variables**
ΔY	-4.75		0.00	−16.80		0.00
ΔUNL	-		-	-6.18		0.00
ΔHC	-6.81	-3.57	0.00	-6.85	-3.57	0.00
ΔK	-4.65		0.00	-		-
ΔHTX	-		-	-		-

Note: *MacKinnon (1996) one-sided p-values

According to the ADF test, the non-stationary Y, HC, and K variables become stationary in their first differences. According to the PP test, the non-stationary Y, UNL, and HC variables also become stationary in their first differences. In this case, the null hypothesis H_0 is rejected for all series containing unit roots based on both the probability and test statistic values. Thus, it is concluded that the ARDL analysis can be applied to South Korea as well, as none of the series exceeds the I(2) level.

Empirical Findings

As a result of the preliminary tests applied, the most suitable models were determined as ARDL(3, 4, 4, 3, 3) for Türkiye and ARDL(4, 3, 4, 2, 4) for South Korea. In the next stage, the applicability of ARDL analysis was confirmed for both countries based on the results of all diagnostic tests.

Table 7

F Bound Test Results

H_0 : No cointegration		n = 30*	
Test Statistics	**α**	**I(0)***	**I(1)***
F_{TR} = 21.04	10%	2.752	3.994
F_{KR} = 7.47	5%	3.354	4.774
k = 4	1%	4.768	6.67

Source: *Narayan (2005)

When examining the F bound test results, the critical values from the table published in Narayan's (2005) article are used, considering the sample size is 30. According to the boundary test results, in order to speak of the presence of a cointegration relationship, it is necessary to consider I(0) and I(1) critical values proposed by Peseran, Shin, & Smith (2001):

- If the F-stat is less than I(0), there is no cointegration relationship.
- If I(0) < F-stat < I(1), no conclusion can be made about the presence of a cointegration relationship.
- If the F-statistic is greater than I(1), the series are cointegrated.

In this context, the findings of the F bound test provide proof of a cointegration relationship for both countries. However, the validity of the cointegration relationship may not always be accurately determined based on the F-test values. In some cases, the cointegration relationship that emerges may be spurious or insignificant. Therefore, for the most reliable results, it is necessary to also examine the t-statistic value and make the final decision (Mert & Çağlar, 2019).

Table 8

t Bound Test Results

H_0 : No cointegration			
Test Statistics	**α**	**I(0)**	**I(1)**
t_{TR}= −8.27	10%	-2.57	-3.66
t_{KR}= −3.85	5%	-2.86	-3.99
	2.5%	-3.13	-4.26
	1%	-3.43	-4.6

For Türkiye, the test statistic value t_{TR} = |-8.27| was calculated, which is greater than the critical value |-4.6|, leading to the rejection of the null hypothesis (H_0). Thus, it is observed that the series has a valid cointegration relationship at a 99% confidence level. In the case of South Korea, at a 90% confidence level, t_{KR} = |-3.85|, which is greater than the critical value |-3.66|, indicating that a cointegration relationship is valid.

Concluding that the cointegration relationship is valid, the models must pass the diagnostic tests for the analysis to work. The diagnostic tests of the analyses for both models are shown in Tables 9 and 10:

Table 9
Diagnostics for Türkiye

Tests	Test Statistics	Probabilities
Normality (Jarque-Bera)	JB= 1.87	0.39
Serial Correlation (Breusch-Godfrey LM)	F = 1.45	0.36
Heteroskedasticity (Breusch-Pagan-Godfrey)	F = 0.36	0.96
Specification (Ramsey-RESET)	t = 0.08	0.94
R^2 = 0.99, Adj. R^2 = 0.99, F = 5598.66, Prob. = 0.00		

Table 10
Diagnostics for South Korea

Tests	Test Statistics	Probabilities
Normality (Jarque-Bera)	JB = 0.02	0.99
Serial Correlation (Breusch-Godfrey LM)	F = 8.93	0.05
Heteroskedasticity (Breusch-Pagan-Godfrey)	F = 0.25	0.99
Specification (Ramsey-RESET)	t = 0.65	0.55
R^2 = 0.99, Adj. R^2 = 0.99, F = 2376.93, Prob. = 0.00		

The probability value of the Jarque-Bera test, which examines whether the error terms are distributed around the mean value of 0, is 0.39 > 0.01 for Türkiye and 0.99 > 0.01 for South Korea. This indicates that the error terms are normally distributed in both cases. Similarly, the probability value of the Breusch-Godfrey LM test was calculated as 0.36 > 0.01 for Türkiye and 0.05 > 0.01 for South Korea. From these results, it can be concluded that there is no serial correlation in the models up to 2 lags. According to the Breusch-Pagan-Godfrey test results, which assess heteroscedasticity, the probability values are 0.96 > 0.01 for Türkiye and 0.99 > 0.01 for South Korea. This suggests that the variance of the error terms remains constant in both models. Finally, Ramsey's RESET test, which checks for measurement and specification errors in the models, yields probability values of 0.94 > 0.01 for Türkiye and 0.55 > 0.01 for South Korea. This confirms that there are no measurement or specification errors in either model. At this stage, conducting the CUSUM and CUSUM2 tests to assess the stability of the parameters is crucial for ensuring accurate analysis results. The diagrams for Türkiye and South Korea are presented below:

Figure 1
CUSUM and CUSUM of Squares Tests for Türkiye

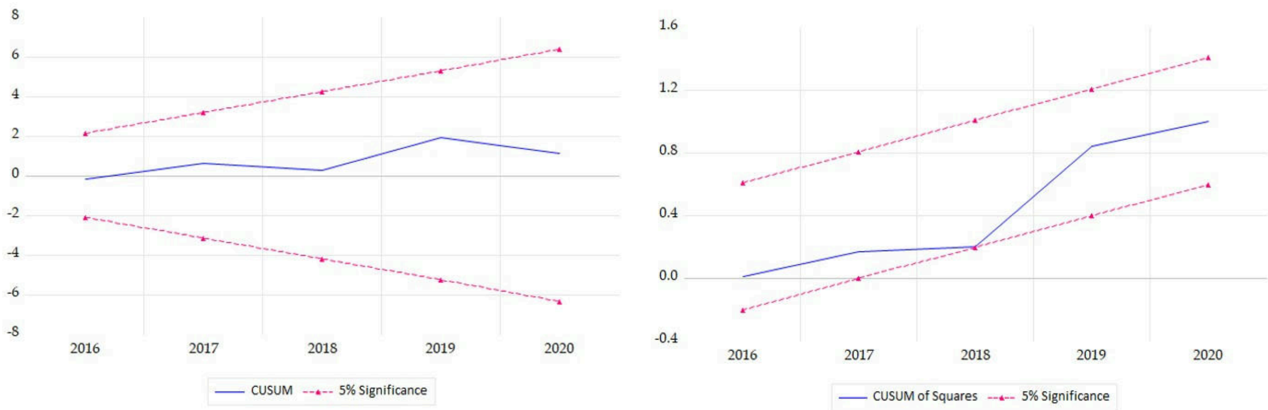
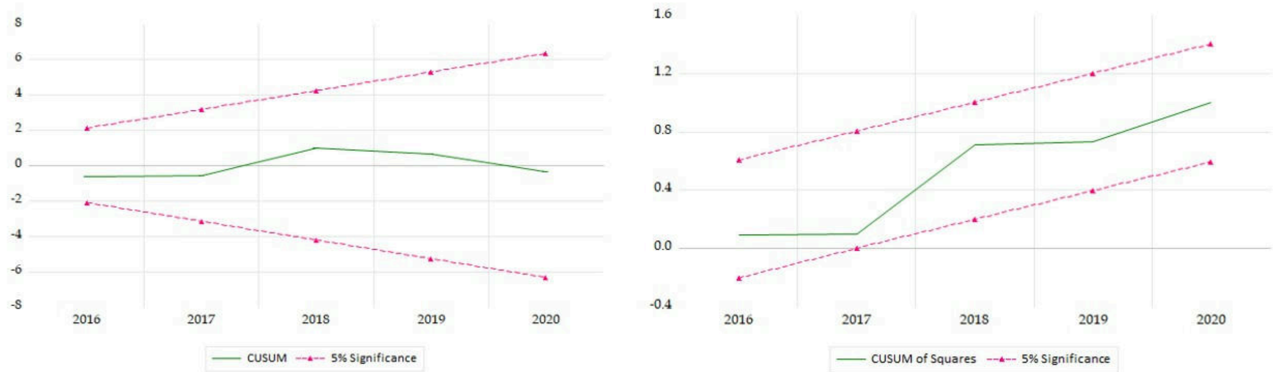


Figure 2

CUSUM and CUSUM of Squares Tests for South Korea



The CUSUM and the CUSUM of squares tests indicate whether the model parameters are stable in the long run. Analysis of the figures shows that none of the parameters for the two countries exceed the critical limits of the 95% confidence level. Therefore, the assumption that the parameters are stable is met and the results are robust. Thus, the last assumption of the ARDL analysis is also met and the conclusions of the long- and short-term results can be analysed.

Table 11

Long-Term Results and Error Correction Coefficient of ARDL(3, 4, 4, 3, 3) Model:

Y	Coefficients	Standart Error	Test Statistics	Prob.
UNL	0.027935	0.010710	2.608421	0.0478
HC	0.180998	0.008693	20.82059	0.0000
K	0.271056	0.017367	15.60743	0.0000
HTX	-0.009818	0.002155	-4.555130	0.0061
ECM_{t-1}*	-1.414397	0.102779	-13.76160	0.0000

Note: *The probability value does not conform to a standard distribution.

The findings of the long-term tests for Türkiye show that all parameters are economically and statistically significant, and their standard errors are reasonable. The coefficient of the UNL variable being 0.028 implies that a 1% change in unemployment increases growth by 0.028%. This result suggests that in Türkiye, the Okun's Law, which typically shows a negative correlation between unemployment and growth, is not applicable. The main reason for this is that growth in Türkiye does not create employment opportunities, indicating Schumpeterian creative destruction. In other words, the effects of Schumpeterian creative destruction lead to increased growth in the long term, accompanied by rising unemployment.

In a developing country like Türkiye, the coexistence of qualitative endogeneous growth and imperfect labour market matching implies that the effects of Schumpeterian creative destruction lead to increased growth in the long term, along with rising unemployment (Cerisier, & Postel-Vinay, 1998). Additionally, the low flexibility of Türkiye's labour market and the absence of effective wages result in technology-driven economic growth moving in tandem with increased unemployment (Nagel, 2015). Such unemployment, where technology-driven economic growth and increased unemployment coexist, points to the presence of a dual economy with a labour market that features a high-wage primary sector and a secondary sector characterised by lower wages. When viewed from the perspective of human capital, a 1% change in the enrolment rate in higher education yields 0.18% expand in growth, indicating a positive relationship between an increase in educated workforce skills and growth. The impact of changes in physical capital accumulation on growth is also confirmed, with a coefficient of 0.27 for the K variable. As expected, a 1% rise in physical capital accumulation expands growth by 0.27%.

In this context, the findings demonstrate that the only variable with a negligible impact on growth is HTX, with a coefficient of −0.098. This suggests that Türkiye lacks the necessary conditions for the manufacturing and export of value-added technologies and that the effectiveness of high-technology production is insufficient.

Table 12

Long-Term Results and Error Correction Coefficient of ARDL (4, 3, 4, 2, 4) Model:

Y	Coefficients	Standart Error	Test Statistics	Prob.
UNL	−0.218771	0.039429	−5.548524	0.0026
HC	0.349047	0.029549	11.81240	0.0001
K	0.458207	0.087696	5.224954	0.0034
HTX	0.104066	0.025372	4.101589	0.0093
ECM_{t-1}*	−0.778944	0.095013	−8.198312	0.0004

Note: *The probability value does not conform to a standard distribution.

For South Korea, the long-term results of the model show that all parameters are statistically significant at a 99% confidence level and their standard errors are acceptable. In addition, all parameter coefficients are consistent with economic theory.

As an indicator of unemployment in the economy, the coefficient of the UNL variable is calculated as −0.22. This result suggests that a 1% change in unemployment decreases growth by 0.22%. This finding validates Okun's Law in South Korea, indicating that changes in unemployment have a significant negative impact on economic growth. This outcome also underscores the quality of growth in South Korea, where an increase in economic growth corresponds to a rise in employment.

When considering the human capital denoted by the HC variable, the coefficient is 0.35. This coefficient's interpretation indicates that a 1% change in human capital results in a 0.35% increase in economic growth, underscoring the substantial role of human capital in fostering economic growth in South Korea. The coefficient for physical capital stands at 0.46, signifying that a 1% alteration in physical capital accumulation leads to a 0.46% boost in economic growth. This highlights the essentiality of accumulating physical capital as a crucial component of South Korea's economic growth.

Focusing on the main objective of this study to explore the connection between technology and economic growth—the coefficient of the HTX variable included in the model holds critical significance.The HTX variable represents data on high-technology exports. The coefficient for this variable is computed as 0.10, indicating that a 1% shift in high-tech product exports results in a 0.10% uptick in economic growth. This discovery holds particular significance for countries like South Korea, which prioritise growth policies centred on exports. It highlights the crucial role of generating and exporting advanced technologies in fuelling the country's economic growth. Furthermore, it introduces an additional dimension to the well-established positive nexus between R&D and high-technology export within the context of the endogenous growth literature.

To determine whether the error correction models (ECM) are working, the most crucial factor is the significance of the error correction coefficient, as presented in Table 12 and Table 13 In both countries, this coefficient is significant. However, its deviation from a standard t-distribution indicates that this result may not be reliable. Therefore, the t-statistic values for the ECM model should be examined for the conclusions.

Table 13

t-Test Results for Error Correction Models

H_0 : No cointegration			
Test Statistics	**α**	**I(0)**	**I(1)**
t_{TR} = −13.76	10%	-2.57	-3.66
t_{KR} = −8.20	5%	-2.86	-3.99
	2.5%	-3.13	-4.26
	1%	-3.43	-4.6

The t-statistic value for the ECM coefficient is −13.76 for Türkiye and −8.20 for South Korea. These values are significant at the 99% confidence level as they are greater than |-4.6|. This indicates that the coefficients are both statistically and economically significant, confirming the validity and robustness of the ECM models. Furthermore, these results provide strong evidence for the presence of cointegration relationships between the series at the highest level of significance, 99%.

The error correction coefficients also reveal how rapidly adjustments are made to return to the long-term equilibrium. For Türkiye, the error correction coefficient is 0.71, meaning that any short-term fluctuations will be corrected within 0.71 years. For South Korea, the coefficient is 1.28, indicating that deviations from the long-term equilibrium will be corrected within 1.28 years. This implies that both countries' economic variables are Granger-causing long-term economic growth.

Upon examining the outcomes of the ARDL analysis between Türkiye and South Korea, it is observed that high technology exports have different effects on growth. In Türkiye, the coefficient for high-tech exports is −0.01, whereas in South Korea, it stands at 0.10. This discrepancy suggests that Türkiye has not attained a significant concentration of high-value technology, a fact reinforced by research and development (R&D) activity indicators.

When we examine the capital accumulation coefficients, South Korea scores 0.45, whereas Türkiye lags behind with a coefficient of 0.27, indicating an investment and savings gap. On another note, the coefficients for human capital were 0.18 in Türkiye and 0.35 in South Korea, emphasising the need for productivity improvements in both physical and human capital accumulation.

To conclude, this comparative econometric analysis underscores the inadequacies in the efficient utilisation of economic resources in Türkiye, spanning physical and human capital. This deficiency adversely affects the country's capacity to achieve a high-quality growth model. In contrast, South Korea has successfully harnessed its limited natural resources by prioritising technological innovations. These findings elucidate the substantial disparities in income levels, income distribution, and overall well-being between the two countries, despite their initially similar economic structures.

Conclusion

The technological revolutions, from the Industrial Revolution in 18th-century England to the approaching Industry 5.0 era, have been among the most remarkable periods the world has faced. The swift progress in information technologies, AI and robotics, integrated swiftly into daily life, necessitated adaptation from all countries worldwide.

From an economic growth perspective, the rapid innovations in this technological age made the potential impacts of these changes on growth and prosperity a significant area of research. Particularly in the 1990s, the effects of technological activities that accelerated worldwide on growth became the subject of various studies. In this context, studies that constructed endogenous growth theories, such as Romer (1986; 1990), Grossman and Helpman (1991; 1997), and Aghion and Howitt (1992), generally suggested that the primary source of technological development was the R&D activities carried out by profit-seeking firms and governments.

In line with this common view, knowledge obtained through R&D activities enabled the implementation of new production techniques in sectors such as agriculture and industry, allowing for the creation of a more efficient production chain in a shorter period. Furthermore, with the continuous development of machinery, equipment, and devices, the productivity of both capital and labour increased, resulting in an increase in production volume. On the other hand, the demand for products, especially those of countries that exported high-tech products, increased rapidly due to product differentiations and innovations. As understood from this general framework, innovations were expected to lead to an increase in the total output produced within the country, the level of total factor productivity, and the income to be obtained, or, in other words, the economy was expected to grow further.

Alongside R&D activities, various significant variables can be examined for their impact on growth within the context of technological effects. The variables included patents, scientific research and publications, and the manufacturing or export of high technology. Given the current conditions, one of the leading areas of the technological age was the assembly and trade of high technology such as computers, robots, electronic devices, advanced medical equipment, aerospace, and space industry vehicles. Especially for countries with booming industrial and technology sectors such as Germany, China, and South Korea, high-tech products were among the areas where innovative activities were concentrated the most.

When reviewing the previous studies on the nexus between technology and growth in the context of endogenous growth, most studies evaluated technology solely through R&D activities. However, very few studies have focused on the export of high technology within the context of this innovation. In particular, there were almost negligible studies that simultaneously analysed high-tech product exports, labour, and extensive capital. Therefore, this study aimed to contribute to this limited field in the literature by selecting high-tech product exports as the main technology variable and shedding light on this subject with current data.

In line with this goal, a comparative econometric analysis framework was drawn for the selected countries, Türkiye and South Korea, by following Romer's model. The most crucial step in this process was determining the variables. In this study, to align with economic theory, high-tech product exports, representing the main technology indicator, were included in the model along with a comprehensive set of capital, both human and physical. Additionally, unemployment data were chosen to represent labour to examine the relevance of Okun’s Law, allowing for the challenge of deficiencies in the employment-intensive quality of growth in Türkiye and South Korea.

The findings of the ARDL analysis revealed that while the findings for South Korea aligned directly with R&D-based endogenous growth theories, there were some inconsistencies on the Turkish side. The results for South Korea indicated that the effect of both physical and human capital, as well as high-tech product exports on growth, were positive and significant. Furthermore, the results for the unemployment variable were consistent with Okun’s Law, showing a negative relationship between growth and unemployment.

These findings suggested that the endogenization of technology had been a policy success for South Korea. Thanks to the technology-intensive growth policies implemented since the 1980s, South Korea has followed a path of high-quality growth as an advanced country today. Furthermore, areas such as income distribution and the increase in welfare were improving every day. South Korea's results also supported Lucas' theory, which highlighted the positive effect of educated human capital on growth. In terms of human capital, Türkiye's results also supported the same theory, providing positive and statistically significant results. As expected, physical capital was positively related to growth in both countries.

The results of the analysis revealed a fundamental disparity in the findings of the two countries concerning technology and labour representative variables. For Türkiye, the effect of high technolgy exports on economic growth was calculated to be very low and negative. As seen from this effect, Türkiye did not seem to prioritise R&D activities and the manufacturing and export of high technologies. Based on Türkiye's findings regarding the labour variable, the positive coefficient of unemployment indicated that although the country's growth path was positive, it did not create employment.

The research conducted throughout this study highlighted that the necessity for Türkiye to emphasise technology-related activities was an important economic policy recommendation. In this regard, it was anticipated that growth policies should be made more technology-intensive, enabling the country to greatly enhance the productivity of its abundant natural resources, workforce, human and physical capital. Thus, the currently positive accumulation of human and physical capital could reach even higher levels, and the structure of growth could shift towards job creation. Specifically, this transformation would depend on the increase in R&D and the workforce's skills in these areas, the establishment or enhancement of new and quality R&D centres and technology zones, and the provision of more comprehensive tax incentives and support in technology-related areas. With these policies, it was expected that the production and export of information technology could be increased, and economic growth could take a much more structurally sound path. In the current circumstances, it seemed that the increase in national prosperity was largely contingent on such radical changes and developments.

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References

Acemoğlu, D., & Üçer, M. (2015). The Ups and Downs of Turkish Growth, 2002-2015: Political Dynamics, the European Union and the Institutional Slide. *NBER Working Paper Series*, No. w21608, *1*(32). (Online), SSRN: https://ssrn.com/abstact=2669797.

Acemoğlu, D., & Üçer, M. (2019). High-Quality versus Low-Quality Growth in Türkiye: Causes and Consequences. *CEPR Discussion Paper Series*, No. DP14070. (Online), SSRN: https://ssrn.com/abstract=3474442.

Aghion, P., & Howitt, P. (1992). A Model of Growth Through Creative Destruction. *Econometrica, 60*(2), 323- 351. https://doi.org/10.2307/2951599.

Ahmad, M., & Zheng, J. (2022). The Cyclical and Nonlinear Impact of R&D and Innovation Activities on Economic Growth in OECD Economies: a New Perspective. *Journal of the Knowledge Economy, 12*(2023), 544-593. https://doi.org/10.1007/s13132-021-00887-7

Akcigit, U., Pearce, J., & Prato, M. (2024). Tapping into Talent: Coupling Education and Innovation Policies for Economic Growth. *Review of Economic Studies*, *2024*(00), 1-41. https://doi.org/10.1093/restud/rdae047

Behera, B., Haldar, A., & Sethi, N. (2023). Investigating the direct and indirect effects of Information and Communication Technology on economic growth in the emerging economies: role of financial development, foreign direct investment, innovation, and institutional quality. *Information Technology for Development, 30*(1), 33-56. https://doi.org/10.1080/02681102.2023.2233463

Cerisier, F., & Postel-Vinay, F. (1998). Endogenous Growth and the Labour Market. *Annales D'economie Et De Statistique, 49*(50), 105-126. https://doi.org/10.2307/20076112

Chiang, M.H., Kao, C., & Chen, B. (1997). International R&D Spillovers: an Application of Estimation and Inference in Panel. *Oxford Bulletin of Economics and Statistics, 61*(S1), 691-709. https://doi.org/10.1111/1468-0084.0610s1691

Cobb, C.W., & Douglas, P.H. (1928). A Theory of Production, *The American Economic Review, 18*(1), 139-165.

Coe, D.T., & Helpman, E. (1995). International R&D Spillovers. *European Economic Review, 39*(1995), 859-887. https://doi.org/10.1016/0014-2921(94)00100-E.

Coe, D.T., Helpman, E., & Hoffmaister, A.W. (2009). International R&D Spillovers and Institutions. *European Economic Review, 53*(7), 723-741. https://doi.org/10.1016/j.euroecorev.2009.02.005.

Cuaresma, J.C., & Wörz, J. (2005). On Export Composition and Growth. *Review of World Economics, 141*(1), 33- 49. https://doi.org/10.1007/s10290-005-0014-z.

Daysi, G., Karla, M., Paco, A., & Santiago, O. (2021). Co2 Emissions, High-Tech Exports and GDP Per Capita, *16th Iberian Conference on Information Systems and Technologies*, Conference Paper, ISBN: 978-989- 54659-1-0. https://doi.org/10.23919/CISTI52073.2021.9476289.

Eaton, J., & Kortum,S. (1999). International Technology Diffusion: Theory and Measurement. *International Economic Review, 40*(3), 537-570.

Ekananda, M., & Parlinggoman, D.J. (2017). The Role of High-Tech Exports and of Foreign Direct Investments (FDI) on Economic Growth. *European Research Studies Journal, 20*(4A), 194-212. https://doi.org/10.35808/ersj/828

Falk, M. (2007). R&D Spending in The High-Tech Sector and Economic Growth. *Research in Economics, 61*(2007), 140-147. https://doi.org/10.1016/j.rie.2007.05.002

Göçer, İ. (2013). Ar-Ge Harcamalarının Yüksek Teknolojili Ürün İhracatı, Dış Ticaret Dengesi ve Ekonomik Büyüme Üzerindeki Etkileri. *Maliye Dergisi*, *165*, 215-240.

Griffith, R., Redding, S., & Reenen J.V. (2001). Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries. *Review of Economics and Statistics*, *86*/(4), 883-895. https://doi.org/10.1162/0034653043125194

Grossman, G.M., & Helpman, E. (1991). Quality Ladders in the Theory of Growth. *The Review of Economic Studies, 58*(1), 43-61. https://doi.org/10.3386/w3099

Grossman, G.M., & Helpman, E. (1997). Innovation and Growth in the Global Economy, MIT Press.

Ha, J., & Howitt, P. (2007). Accounting for Trends in Productivity and R&D: A Schumpeterian Critique of the Semi-Endogenous Growth Theory. *Journal of Money, Credit and Banking*, *39*(4), 733-774. https://doi.org/10.1111/j.1538-4616.2007.00045.x

Hamia, M.A. (2022). What Level of International Technology Should Developing Countries Transfer to Sustain Their Economic Growth?. *Quality & Quantity*, *56*. https://doi.org/10.1007/s11135-0 21-01259-8

Howitt, P. (2000). Endogenous Growth and Cross-Country Income Differences, *The American Economic Review*, *90*(4), 829-846. https://doi.org/10.1257/aer.90.4.829

ILO. (2021). Unemployment by Sex and Age - ILO Modelled Estimates, Nov. 2021 (Thousands) - Annual, *ILO STAT*, (Online), https://www.ilo.org

Islam, Z., Rahaman, H., & Chen, F. (2024). How do R&D and remittances affect economic growth? Evidence from middle-income countries. *Heliyon*, *10*(2024), 2-14. https://doi.org/10.1016/j.heliyon.2024.e30160

Jarreau, J., & Poncet, S. (2011). Export Sophistication and Economic Growth: Evidence from China. *Journal of Development Economics, 97*(2), 281-292. https://doi.org/10.1016/j.jdeveco.2011.04.001

Jones, C.I. (1995). Time Series Tests of Endogenous Growth Models. *The Quarterly Journal of Economics, 110*(2), 495-525. https://doi.org/10.2307/2118448.

Kim, M. (2020). Cross-Industry Distribution of R&D Investments and Economic Growth. *Applied Economics Letters, 27*(8), 679-684. https://doi.org/10.1080/13504851.2019.1644426

Lam, L.F., Law, S.H., Azman-Saini, W.N.W., & Ismail, N.W. (2022). High Technology Trade and the Roles of Absorptive Capabilities in Malaysia. *Millennial Asia,* 1-26. https://doi.org/10.1177/0976399 6211065565

Li, X., Liang, F., Pi, Y., & Chen, D. (2024). The impact of R&D factors flow and regional absorptive capacity on China's economic growth: Theory and evidence. *Plos One*, *19*(11), 1-23. https://doi.org/10.1371/journal.pone.0310476

Lucas, R.E. (1988). On The Mechanics of Economic Development. *Journal of Monetary Economics*, *22*(88), 3-42. https://doi.org/10.1016/0304-3932(88)90168-7

Mackinnon, J.G. (1996). Numerical Distribution Functions for Unit Root and Cointegration Tests, *Journal of Applied Econometrics, 11*(6), 601-618 https://doi.org/10.1002/(SICI)1099-1255(199611)11:6<601::AID-JAE417>3.0.CO;2-T

Mert, M., & Çağlar, A.E. (2019). Eviews ve Gauss Uygulamalı Time Series Analizi, Detay Yayıncılık.

Nagel, K. (2015). Relationships Between Unemployment and Economic Growth - The Review (Results) of the Theoretical and Empirical Research. *Journal of Economics and Management*, *20*(2), 64-79.

Narayan, P.K. (2005). The Saving and Investment Nexus for China: Evidence from Cointegration Tests. *Applied Economics*, *37*(17), 1979-1990. https://doi.org/10.1080/00036840500278103

Nihal, G., Mounia, C., Hussain, M., Humayun, S., Perveen, N., Yousaf, N.R., & Akthar, S. (2023). Impact of Innovation on Economic Growth of G8 Countries- Analysis Over 1996-2020. *Intern. Journal of Profess. Bus. Review.*, *8*(5), 01-18. https://doi.org/10.26668/businessreview/2023.v8i5.1403

Nonneman, W., & Vanhoudt, P. (1996). A Further Augmentation of the Solow Model and the Empirics of Economic Growth for OECD Countries. *The Quarterly Journal of Economics, 111*(3), 943-953. https://doi.org/10.1080/00036840500278103

OECD. (2020). Total Exports: Computer, Electronic and Optical, Pharmaceutical and Aerospace Industry, *OECD MSTI*, (Online), https://stats.oecd.org/Index.aspx?DataSet Code=MSTI_PUB.

Peseran, 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. https://doi.org/10.1002/jae.616

Rodrik, D. (2006). What's So Special about China's Exports?. *China and World Economy, 14*(5), 1-19. https://doi.org/10.1111/j.1749-124X.2006.00038.x

Romer, P. (1986). Increasing Returns and Long-Run Growth. *Journal of Political Economy*, *94*(5), 1002-1037.

Romer, P. (1990). Endogenous Technological Change. *Journal of Political Economy*, *98*(5), S71-S102.

Segerstrom, P.S. (1998). Endogenous Growth without Scale Effects. *The American Economic Review*, *88*(5), 1290-1310.

Sojoodi, S., & Baghbanpour, J. (2024). The Relationship Between High-Tech Industries Exports and GDP Growth in the Selected Developing and Developed Countries. *Journal of the Knowledge Economy*, *2024*(15), 2073-2095. https://doi.org/10.1007/s13132-023-01174-3

Solow, R.M. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, *70*(1), 65-94. https://doi.org/10.2307/1884513

Tung, L.T., & Hoang, L.N. (2024). Impact of R&D expenditure on economic growth: evidence from emerging Economies. *Journal of Science and Technology Policy Management*, *15*(3), 636-654. https://doi.org/10.1108/JSTPM-08-2022-0129

UNESCO. (2022). Enrolment in Tertiary Education, All Programmes, Both Sexes (Number), *UIS Stat*, (Online), http://data.uis.unesco.org/.

World Bank. (2020). GDP (Constant 2015 US$) - Türkiye, Korea Rep., 1990-2020, *WDI*, (Online), https:// databank.worldbank.org/reports.aspx?source=2&series=NE.GDI.FTOT.KD&country=KOR,TUR#.

World Bank. (2020). Gross Fixed Capital Formation (Constant 2015 US$) - Türkiye, Korea Rep., 1990-2020, *WDI*, (Online), https://databank.worldbank.org/reports.aspx?source=2&series=NE.GDI.FTOT.KD& country=KOR,TUR#.

Wu, J., Ma, Z., & Zhuo, S. (2016). Enhancing National Innovative Capacity: the Impact of High-Tech International Trade and Inward Foreign Direct Investment, *International Business Review*, *26*(3), 502-514. https://doi.org/10.1016/j.ibusrev.2016.11.001

Zietz, J. (2006). Log-Linearizing Around the Steady State: A Guide with Examples, *SSRN Electronic Journal*, *2006*, 1-16. https://doi.org/10.2139/ssrn.951753