Scientific Papers of the University of Pardubice, Series D: Faculty of Economics and Administration
2023, 31(1), 1663.

DOI: 10.46585/sp31011663
editorial.upce.cz/SciPap

# Impacts of Technology on Economic Growth: With Difference Between Tourism Countries and Industry Countries Aspect Based on Extended Solow Growth Model

**Ebru Gül Yılmaz**

İstanbul Gelişim University, International Trade and Finance, Turkey

**Süreyya İmre Bıyıklı**

İstanbul Gelişim University, Management Information Systems, Turkey

**Ceren Demir**

İstanbul Gelişim University, International Trade and Finance, Turkey

**Abstract**

The effects of technology on economic growth and development have been an area that many economists have focused on, especially since the post-World War II period. Technology itself has been taken as an external factor by Solow (1957) for economic growth whereby later is accepted as an internal factor by Romer (1986) and Lucas (1988). This study aims to analyze the differing technological impact on economic growth between countries with a high share of tourism in their gross domestic product and countries with a high share of the industry by setting a model based on Solow Growth Model. Another aim of the study is to determine the direction of the net effect of technology for the determined country groups. In such a way that, by increasing productivity, technology is the most important factor in solving the world's scarce resources problem. However, it also causes social and economic problems by creating negative externalities such as environmental pollution and global warming. The primary motivation of this paper is to fulfill the area that can not be met in the literature about the specific difference in technology's effect on economic growth between industry and tourism countries. In addition, to set the impact differences and clarify the net effect of technology, two different country groups have been defined consisting of 30 tourism countries and 30 industrialized countries. The same growth model was imposed in which capital, labor, tourism income, trade openness, and middle and high-technology export level as independent variables for both groups. GMM-Generalized Method of Moment estimator was applied, and it is surprisingly concluded that technology has a negative impact on both country groups' economic growth. This paper fulfills the area that can not be met in the literature about the specific difference in technology's effect on economic growth between industry and tourism countries.

**Keywords**
Technology, Tourism, Industry, Economic growth

**JEL Classification**
O11, O14, F10

## Introduction

Economic growth may be accepted as the initial stage of economic development which is the main aim of almost all countries. On the other hand, by increasing productivity, technology is the most important factor in solving the world's scarce resources problem. When technology is considered as the organization of the production functions necessary for the production of goods and services, its connection with economic development can be stated as an increase in the amount of production and employment opportunities and optimization in costs At the point of determining its effect on economic growth, technology has become a subject of study that attracts the attention of

**Corresponding author:**
Ebru Gül Yılmaz, İstanbul Gelişim University
Email: egyilmaz@gelisim.edu.tr

researchers with its effects that provide efficiency, cost optimization, and profit maximization. Technology has been handled in two different ways as an endogenous and an exogenous factor in economic growth. Solow's (1957) economic growth model takes technology as an exogenous factor likewise Harrod's (1956) and Hicks (1963) models. The neo-classical approach defined technological development as achieving more output with the same amount of input and excluded factors such as the quality of the product and the need for skilled labor (Anlar, 2004).

Schumpeter (1975) is the first researcher to emphasize the contribution of competition created by technology to economic growth as an endogenous factor. According to Schumpeter, technology is a factor that impacts economic development and causes economic fluctuations. Schumpeter's perspective on technology offers a broader content than neo-classical school. This perspective also reveals the invention of different product groups depending on innovation, the discovery of a new market or the discovery of a different raw material. According to Romer (1986) and Lucas's (1998) exogenous growth model, sustainable economic growth can be achieved with physical and human accumulation since physical and human capital accumulation brings technological development automatically.

Whether technology is considered an endogenous or exogenous factor, its effects on economic growth are undeniable. Besides the positive effects of technology on economic growth and development, it has also negative economic impacts likewise air and water pollution, and labor force losses due to illnesses arising from pollution. One of the most important studies dealing with the impact of technology on the environment is Grossman and Krueger's (1991) Environmental Kuznets Curve. Environmental Kuznet Curve states that countries consume more natural resources at the beginning of their development processes. And this causes an increase in total greenhouse gas consumption. Parallel to the increase in total greenhouse gas consumption, as the level of income, they will experience the negative effects of environmental pollution. While developing countries focus only on economic growth in the first stages of industrialization, countries that have reached a certain level of industrialization, aim at economic development (Seyidoğlu, 2006, s.829).

Reduction in environmental pollution with the effect of both living and environmental issues gaining importance is experienced when a country reaches a certain level of industrialization. Technological development is in the funds allocated to research and development funds. As a result of the increase in productivity and thus the increase in efficiency, less resource usage is in question. It is considered a factor that leads to a decrease in environmental pollution (Grossman et al. Krueger, 1991:7). The main purpose of technology investments is to increase production efficiency and productivity with certain physical inputs.

On the other hand, tourism is a labor-intensive sector. And it is assumed that the technology level is less when compared to countries that grow mostly by capital-intensive sectors. When it comes to the roles of technology in tourism Stipanuk (1993), listed them as creator, protector, enhancer, focal point, tool, and destroyer. And the use of technology in the tourism sector, it can be said that unlike the medium and high technology structure used in the production sector, it focuses more on the structures that will create different experiences for tourists such as simulators such as Disney World, architectural design, three-dimensional cinema, jet boat technology, the technology used for health tourism etc. As it can be foreseen that all the mentioned types of technology are expected to create less contribution to economic growth because of their indirect effect and at the same time, it is expected that this type of technology creates less pollution sort of negative externalities on economic growth.

With these ideas behind, the main two questions of this paper ate: Is technology a bloom or a curse for humanity and is this fact differs according to the country groups such as tourism-based countries and industry-based countries Solow growth model is shown as follows Q= AF (K, L) whereby 'K' denotes capital and 'L' denotes labor, was enlarged by adding, tourism income, middle and high-technology export levels, and trade openness to the model. And it is aimed to reveal the net effects of technology by comparing tourism countries and industrialized countries.

This paper has aimed to fulfill the area that can not be met in the literature about the specific difference in technology's effect on economic growth between industry and tourism countries. The motivation behind this, is finding the answer to the question; what is the net effect of technology on the economies? Is the positive effect higher than the negative effect or vice versa? And does the effect of technology differ between industrialized countries and tourism countries? The model was set based on Solow's growth model and technology and trade openness tourism income is also added to the model for robust checking. It is assumed that especially differing effects between two country groups will be very important for policy-makers. So that they can change their growth and development strategy accordingly. Our hypothesis was set as the impact of technology on GDP growth for industrial countries is higher than the impact on tourism countries and the negative impact of technology is higher for industry countries compared to tourism countries. With this expectation, it is predicted that if the mentioned hypothesis is proved then policymakers may have the opportunity to change their direction to tourism instead of industrial growth. While doing the research the most important limitation of the paper was because of the lack of separate data on the negative impacts and positive impacts of technology. That is why just medium-high technology export level is used as the indicator of technology and assessing the sign and the magnitude of the coefficient have taken into consideration.

## Literature Review

The issue of growth is one of the most frequently discussed topics in the economics literature. The subject of growth has been analyzed over many different variables in economics. These studies, which try to determine the dynamics and sustainability of growth, also facilitated the categorization of countries. The factors contributing to the growth of countries have become more evident through various headings. In the studies, it is seen that technology and industry are frequently used because of their high impact on growth. Success in technology and industrial production is highly related to the development of countries. Although, there are countries also grow agriculture and tourism. Therefore, the growth sources of countries vary with each other. This study aims to deal with technological effects on economic growth for two different country groups through the determined variables with a different perspective. In our model, the primary focus is on the differing relationship between technology and economic growth for tourism-based and industrial-based countries. Besides, the effects of labor, capital, and trade openness on economic growth have been tested. At the initial stage, it is discovered that there is not any research specifically related to searching the differing technology effect on economic growth between tourism and industrial countries. After this achievement, the literature has been reviewed by dividing it into four separate focuses. First, research that is based on the impact of technology on economic growth was investigated. And then, technology and pollution-based papers were studied, and in the third step pollution and growth-based papers were investigated for the last step, the papers which focus on, trade openness, labour, capital, and economic growth relationships were studied.

### *Literature on technology's impact on economic growth*

Technology itself has been taken as an external factor by Solow (1957) for economic growth whereby later is accepted as an internal factor by Romer (1986) and Lucas (1988).

Many different points have been emphasized in studies carried out on concepts such as technology, industry, tourism, growth, and economy in the literature. Different relationships have been established with different variables and many results have been obtained. An article which was written by (Aghion et al., 2007) focused on technology, democracy, and growth and they inferred growth concerning democracy demand. They see related countries that have more technological progress, are economically richer, and demand democracy more. Another article pointed out an important comparison (Basu and Weil, 1998-Volume 113, Issue 4). According to comparatives between Japan and the United States, they found a deduction in 1998. Imagine a world with two countries which include a poorer, faster-growing country with a higher savings rate like Japan and a rich country and a relatively low savings rate like the United States. According to the Solow model, Japan will grow faster than the United States as it is well below the steady-state output level. Their model predicts that Japan will overtake the United States and they pointed out that Japanese growth will slow as it reaches its steady state. (Jorgenson and Stiroh, 1999) examine Solow's productivity paradox -fast information technology investments and low productivity- and they tried to get proof for the substitution of IT for inputs. Research shows that in the 1990s, the European Union lagged significantly behind the USA in adopting and utilizing information technologies. Expenditure and investment rates for information technologies and their contribution to growth have long remained much lower in Europe than in the United States. (Daveri, 2001)

Another study shows that TFP -total factor productivity- growth declines as soon as there is an increase in information, which is a technological change, and that growth remains low relative to information growth. The productivity slowdown that began in the mid-1970s and followed the "New Economy" perception in productivity linked to information and communication technology in the late 1990s can be explained by this result. (Carlaw and Lipsey, 2003). Specific research about the German industry made by (Webb, 2010) focused on the Wilhelminian German steel industry. This is particularly known for its tariff protection, anti-competitive behaviour and the huge growth of its output. Limiting competition with the tariffs and cartels created productivity in the German steel industry by reducing the risk of capital-intensive technologies. Increasing productivity has made a significant contribution to the growth of the sector. Research carried out by (Ruttan, 2000) explains the direction of technical change. It appears to have been triggered by changes in institutional innovations such as the modern research universities and this research analyzed the economic and institutional sources of technical change in the electrical, chemical, computer, agriculture, and biotechnology industries. A book related to technology and growth by (Von Tunzelmann, 1995) wanted to show the nature of industrialization and examined industrialization within the framework of historical events by considering many countries and talked about R&D studies, technology information, and growth processes. One of the studies examining growth through tourism, which is another factor related to our subject, Kahouli (2018) has studied the effects of technology on the economic growth of Mediterranean countries for the years between 1990-2016 and has concluded that capital, electrical energy consumption, and CO2 emissions have a positive effect on GDP growth, while labor and research and development expenses have a negative effect.

Desmet and Rossi-Hansbergb (2009) examined general purpose technology (GPT) and their findings focused on the service & manufacturing sectors about the distinct evolution and the age of an industry as evaluated by the time since the last GPT innovation had a huge impact on the sector and research internalizes technological growth from inside regions by making this a function of employment levels. One of the oldest articles about growth and technology related to the industry was written by (Nef, 1934) and this research explained the hockey stick growth of technology and industrial capital in Great Britain between the middle of the sixteenth and the eighteenth centuries. They succeed to a considerable extent through the progress of technology, and they changed the world, and still going on. (Timmer et al., 2011) carried out research for European economies which referred productivity growth to increase living standards with it. They see a negative factor is the projected slowdown in labor growth for 2010–2020 seen as rapid aging and limited attraction for skilled immigration.

***Literature on technology's impact on pollution***

Byrne (1997) showed in the model that while parallelism is observed in the increase of resources such as capital, labor, and emissions in the model; The finding that technology accumulation creates pollution is not emphasized.

Liu and Xu (2021) explained to failing of the Kuznets curve (EKC) about the ''pollution halo'' or ''pollution haven'' effect. They suggest that enterprises should show attention to the potential to extenuate domestic agricultural non-point pollution. They also implied that government could constitute a software environment for the spatial diffusion of disembodied technology for agricultural trade.

The study, which examines the relations between electricity consumption, economic growth, urbanization, Information, and Communication Technologies (ICT) penetration, and environmental pollution in OECD countries, used panel data analysis and machine learning methods. According to these analyzes, it is explained that the use of ICT increases economic growth, and this finding has a significant effect on electricity consumption. It has been emphasized that these uses turn into polluting emissions as a result (Magazzino et al., 2021).

In another study examining the relationship between income per capita and mismanaged plastic waste for 151 countries, empirical evidence was found for the environmental Kuznets curve using plastic pollution data. The study stated that investment in scientific and technological research is supportive to reduce plastic pollution. (Barnes, 2019) In the study, which examines the relationship between carbon emissions and energy growth based on EKC, annual time series data from the world development indicator (WDI) from 1990 to 2019 were used. The results found bidirectional causality between economic growth and energy use (Mughal et al., 2022).

The results of another study, which uses the STIRPAT equation to predict the relationships between population, industrialization, welfare, technology, and sustainability in MENA and OECD countries, show that the relevant countries positively affected by international agreements on technology and environment in 1975-2015 period, and negatively affected by population and industrialization (Nasrollahi et al., 2020).

Using annual data from 30 provinces and cities in China for the period 2003-2016, the results of the study examining the impact of heterogeneous technological progress on haze pollution show that neutral technological progress and labor-saving technological progress help haze reduction. Second, energy-saving technological progress cannot effectively reduce haze pollution. Third, the haze reduction effects of different types of technological progress are regionally heterogeneous in China. In terms of control variables, strengthening environmental regulation is seen as the only factor that could help in haze reduction (Yi et al., 2020).

***Literature on pollution's effect on economic growth***

A study carries out by Jones and Manuelli (1995) and emphasizes on positive growth model and pollution controls with mathematical background. Research that was done in 1995 said the paradox of today and said that capital stocks in producing consumption are creating pollution at the same time. They suggest that new tax arrangements can be useful to reduce pollution that is created by capital. Another study in the 90s focused endogenous growth model with AK production function Chung-Huang Huang and Cai (1994) and they explained that if a household's preference parameter against pollution is small; a lower growth rate will happen with a greater intertemporal elasticity of substitution. The research carries out computationally and researchers tried to calculate timing. (Kelly and Kolstad, 1999) Seeing Bayesian learning as uncertainty about the relationship between greenhouse gas levels and global average temperature changes, the researchers found the expected learning time related to the variance of the shock and emissions policy. The dynamic model they solved based on this method was realized through the climate sector placed in an optimal growth model, and as a result of the calculations, it was determined that learning took around 90 years, much longer than believed.

Ali and Puppim de Oliveira (2018) pointed out the negative impact of pollution on human development and economic growth through death rates and they stressed that healthy life years are lost in developing countries due to pollution and this rate is 15 times higher than in developed countries. This is explaining to the dying result of pollution; around nine million people die from pollution each year, mostly young children, and the elderly to World Bank's report.

Zheng et al., (2015) focused on the pollution and GDP relationship between the cities in China. They observed that pollution was negatively related to GDP per capita. Accordingly, cities with high GDP can take action to reduce pollution.

Research in G-3 countries with the data from 1970 to 2020 using “Pooled Mean Group-Autoregressive Distributed Lag” (PMG-ARDL) showed that renewable energy is critical for reducing environmental degradation. However, bidirectional causality (BC) was observed in the relationship between pollution and energy consumption. Large-volume energy consumption, which is emphasized in economic growth, increases pollution. At this point, policies with sustainability have an important function in this area (Nahrin et al., 2023). Similarly, another study emphasizing that energy consumption significantly increases environmental degradation in Turkiye explained similar periods with the Fourier Toda and Yamamoto causality test. FDIS needs to use new and clean technology to invest in the country to reduce environmental pollution (Cil, 2022)

### *Literature on variables other than technology*

Brida et al., (2013) focused on the crucial notion of TLGH (tourism-led growth hypothesis) as combining both growth and tourism. They see that even if TLGH research expands, the number of countries is limited. They emphasized this in 2013, 10 countries in MENA, and for European countries, nine papers Turkiye has worked on this subject. In the research, a long-run bidirectional Granger causality between tourism and GDP is seen for those countries whose aim to TLGH and this notion is useful to governments that are willing to wide tourism to make their economic growth better. Another study that focused on the tourism-led growth hypothesis for Turkiye showed that TLGH is supported empirically. Turkiye has been emphasized as closer to Spain than Korea related to the share of tourism revenues in GDP, exports, and trade balance deficit. Turkiye is more similar to country as Spain from the point of tourism revenues in the economy (Gunduz and Hatemi-J, 2006).

Lin et al., (2018) worked on tourism and economics in China and their empirical results with Bayesian probit models showed that from 1978 to 2013, 10 of 29 regions were tourism-led growth (TLG), and nine regions were seen as economy-driven tourism growth (EDTG). Their analysis unveiled that regions with less-developed economies can experience EDTG, yet regions with larger economic sizes, covering larger geographic areas, and less-developed economies can be closer to TLG. Brida and Pulina (2010) as a result of the long-term bidirectional Granger causality between tourism and GDP through a panel data analysis between countries such as Turkiye, Malta, Taiwan, Spain, and Malaysia, it is important for countries that want to grow by promoting tourism. Zhang and Zhang (2020) used the vector error correction model (VECM) Granger causality to show the long and short-run causal relationships among economic, tourism, growth, $CO_2$ emissions, and energy consumption between 2000–2017 for 30 Chinese provinces. Results proved the bidirectional short-term causalities statistically between tourism and gross domestic product (GDP).

Jacobsson and Bergek (2003) researched the wind turbine industry in Germany, Sweden, and the Netherlands and they focused on some factors like creation, the establishment of legitimacy, the employment of advanced market creation policies, and the use of industrial policy to show the success of the German industry.

According to Solow’s growth model, capital and labor are the variables which affect economic growth (Solow, 1957).

Some researchers reveal that gross capital formation has a positive impact on economic growth (Solow, 1962), Vukenkeng and Ongo, (2014), whereby some papers conclude a negative relationship between the gross capital formation of growth (Topcu et al., 2020).

Lee (2000) focused on 16 OECD countries in the study and determined the existence of a cointegration relationship between unemployment and growth variables. According to classical economists like Smith and Ricardo free trade increases effectiveness by the creation of specialization and competition and this leads to an increase in the level of wealth.

Many papers have concluded that trade openness has a positive impact on economic growth, whereby many papers concluded trade openness has a negative impact on economic growth. Dollar (1992), Sachs and Warner (1995), Frankel and Romer (1999), Hye (2012), and Raghutla (2020) are examples of concluding the positive impact of technology.

Ulaşan (2014), concluded that a lower level of barriers does not create any positive impact on economic growth.

Dura and Yılmaz (2022) have studied on economic growth model by imposing Huber Eicker and White & Driscol lKraay test for the 28 developed countries for the period 2007-2019. They revealed that trade openness has a negative effect on economic growth.

When it comes to this research, our study aims to examine all the factors mentioned above and their compatibility and incompatibility. The most important contribution of this paper to the literature is revealing the differing impact levels of technology between industrial and tourism countries. This is the first research that imposed the same growth model on two different country groups to differentiate the impact levels of technology on economic growth by using dynamic panel data analysis.

## Data and Methodology

### *Dynamic Panel Data Models*

In this study, autoregressive panel data models with the lagged value of the dependent variable as the independent variable are discussed and shown as follows.

$$Y_{it} = \delta Y_{it-1} + \beta X'_{it} + v_{it}$$

Here it is expressed as $v_{it} = \mu_i + u_{it}$ and $|\delta|$<1.

When estimating dynamic panel data models, two different features should be considered for the selection of the appropriate method. The first is whether the error terms are autocorrelated and the other is whether the dependent variables are fully exogenous (Akay, 2018).

Due to the violation of important assumptions in dynamic panel data models, Fixed Effects and First Difference Estimators are used, which consider more unit effects and allow unit effects and independent variables to be related. However, in the case of using a fixed effects estimator at small values of time dimension $T$, the estimations of slope parameters will be biased, and it has been investigated by Nickell (1981) as "Nickell deviation" (Bekar et. Al.,2022).

With the first difference transformation, the $(Y_{it} = \delta Y_{it-1} + \beta X'_{it} + v_{it})$ unit effect in the above model drops from the $\mu_i$ model. However, the lagged dependent variable is internal, so biased estimates are obtained.

As mentioned earlier, the lagged value of the dependent variable and the error term are associated with the internality problem. Therefore, the correlation between $Y_{it-1}$epsilon-1 should be controlled using instrument variables (Tatoğlu, 2013). Several instrumental variable estimation methods are used to estimate dynamic panel data models. In Anderson and Hsiao's estimator, the first difference error terms are often negatively autocorrelated, and in this case, the Arellano and Bond (1991) Generalized Moments estimator is more appropriate. Arellano and Bond is an instrumental variable method suitable for panel data models that show the presence of rigid non-extrinsic explanatory variables and a linear relationship between these variables (Arellano & Bond, 1991).

In the case of an unbalanced panel or when the T dimension is relatively small, the first difference transform is still weak. In cases where T is small (N>T), the System GMM estimator of Arellano and Bover/Blundell and Bond is used to obtain efficient estimators from the dynamic panel data model. Further, the panel GMM technique can control the individual and temporal-specific effects (Arellano &Bover, 1995; Blundell & Bond, 1998). It gives more reliable and consistent results in controlling internality (Dagar et. Al.,2022). With the first difference transformation, the data of some units can be completely lost. Therefore, the method of orthogonal deviations instead of the first difference transformation was proposed by Arellano and Bover (1995). In this method, the difference of the mean of a variable for all possible future values is taken. Thus, possible data loss is minimized. Considering the panel data model below,

$$Y_{it} = X'_{it}\beta + Z'_i\gamma + v_{it} \tag{1}$$

Here, $Z_i$ is the time constant variable and $X_{it}$ is the variables that change according to time and unit. In vector form it is expressed as:

$$Y_i = \mu_i\eta + v_i \tag{2}$$

$n' = (\beta', \gamma')$, $W_i = [X_i, l_t Z'_i]$ and $l_t T$ is the unit vector of dimension T. In the one-way error components model, the residuals are obtained as follows:

$$v_i = \mu_i l_t + u_i \tag{3}$$

Using the system transformation of the equation in Model 1, Arellano and Bover obtained the following equation (Arellano & Bover, 1995; Blundell & Bond, 1998):

$$H = \begin{bmatrix} C \\ l'_T/T \end{bmatrix} \tag{4}$$

Here, it is any (T-1)×T matrix of row (T-1) that satisfies the condition $C\iota_T = 0$. The converted residue is as follows:

$$v_i^+ = Hv_i = \begin{bmatrix} C_{vi} \\ \bar{v}_i \end{bmatrix} \tag{5}$$

All explanatory variables, this is the first (T-1). Are valid tools for equality. It is assumed that $m_i$ is a subset of $\mu_i$ uncorrelated with $\mu_i$, and the size of $m_i$ is equal to or greater than the size of η.

In the study of Hausman and Taylor (1981), $X = [X_1, X_2]$ and $Z = [Z_1, Z_2]$. Here, $X_1$ ve $Z_1$, $NT \times k_1$ an 1-dimensional $N \times g_1$ dimensional exogenous variables, $X_2$ and $Z_2$ are correlated variables with $NT \times k_2$ and $N \times g_2$dimensional unit effects (Tatoğlu, 2013). In this case, $m_i$ contains the variables $X_1$ and $Z_1$.

The valid instrumental variable matrix for the fully transformed system is expressed as:

$$M_i = \begin{bmatrix} w_i' & 0 \\ 0 & m_i' \end{bmatrix} \quad (6)$$

The moment condition is as follows:

$$E(M_i' H v_i) = 0$$

Here, $\overline{H} = I_N \otimes H$ and $\hat{\Omega} = I_N \otimes \Omega$.

The following equation is obtained by multiplying equation 1 by $M'\overline{H}$ from the front:

$$M'\overline{H}Y = M'\overline{H}W_\eta + M'\overline{H}v$$

The estimation of this model with the Generalized Least Squares Method gives the Arellano and Bover Estimator. In this case, η is obtained as follows:

$$\eta = [M'\overline{H}M\left(M'\overline{H}\hat{\Omega}^+\overline{H}'M\right)^{-1}M'\overline{H}W]^{-1}W'\overline{H}M\left(M'\overline{H}\hat{\Omega}^+\overline{H}'M\right)^{-1}M'\overline{H}Y$$

In practice, the following consistent estimator is used instead of the variance covariance matrix $\hat{\Omega}^+ = H\Omega H'$ of the transformed system:

$$\hat{\Omega}^+ = \frac{\sum_{i=1}^N \hat{u}_i^+ \hat{u}_i^{+\prime}}{N}$$

Here $\hat{u}_i^+$ are the residues from the consistent initial estimate.

Some problems may arise in estimators when making dynamic panel data models with known estimation methods. In general, in dynamic models, it is known that Yit-1 is correlated with uit-1 due to past shocks. Since Yit is also a function of μi in panel data models, Yit-1 is also a function of $\mu$i. Therefore, Yit-1 is correlated with the error term including $\mu$i. In this case, the assumption of strict externality is broken. Therefore, biased and inconsistent estimates are obtained with the Pooled Least Squares Method of dynamic panel data models (Tatoğlu, 2013). Likewise, random effects Generalized Least Squares Estimators should also be biased.

Because the unit effect $\mu$i in the error term is correlated with the independent variable Yit-1, the assumption of E(Xit$\mu$i) = 0 of the random effects model is broken (Tatoğlu, 2013). In this context, the prediction of the dynamic model with the assumption of random effects is inconsistent.

In summary, a two-system equation named original equation and transformed equation is established and estimated together as a system. For this reason, the estimator is known as "System GMM". This estimator allows the use of multiple tools and increases efficiency.

## Econometric Analysis

### *Data set*

In this study, 30 countries were determined among the countries with high tourism income with high industrial income countries years 2000-2020 and included in the analysis. Some countries were not included in the analysis due to gaps in the data set. While the dependent variable is determined as the amount of gross domestic product in the tourism countries and industrial countries model, the explanatory variables differ based on the model. While international tourism revenues, medium and high technology exports, gross capital formation, carbon dioxide emissions, and total unemployment rates are used as explanatory variables in the tourism countries model, international tourism revenues, medium and high technology exports, gross capital formation, trade, and total unemployment rates are used in the industrial countries model is used. Detailed information about these variables is given in Table 1.

**Table 1.** Information about variables.

| Tourism Countries Model | | | | |
|---|---|---|---|---|
| Variable Names | Variable Codes | Data Source | Country | Rates |
| Gross domestic product growth | GDP | World Bank Data | 30 | annual % |

| | | | | |
|---|---|---|---|---|
| International tourism, revenues | ITR | World Bank Data | 30 | % of total exports |
| Medium and high-technology exports | TECH | World Bank Data | 30 | % product exports |
| Gross capital formation | CAPITAL | World Bank Data | 30 | % of GDP |
| Trade | TRADE | World Bank Data | 30 | % of GDP |
| Unemployment, total | UNM | World Bank Data | 30 | % of the total workforce |
| Industrial Countries Model | | | | |
| Variable Names | Variable Codes | Data Source | Country | Rates |
| Gross domestic product growth | GDP | World Bank Data | 30 | annual % |
| International tourism, revenues | ITR | World Bank Data | 30 | % of total exports |
| Medium and high-technology exports | TECH | World Bank Data | 30 | % product exports |
| Trade | TRADE | World Bank Data | 30 | % of GDP |
| Unemployment, total | UNM | World Bank Data | 30 | % of the total workforce |
| Gross capital formation | CAPITAL | World Bank Data | 30 | % of GDP |

In this context, while the models of tourism and industrial countries were created, the countries included in the study are presented in Table 2.

**Table 2.** Countries Included in the Analysis.

| Tourism Countries Model | | |
|---|---|---|
| Argentina | Greece | Norway |
| Australia | Hungary | Peru |
| Bosnia and Herzegovina | India | Philippines |
| Bulgaria | Japan | Poland |
| Colombia | Korea, Rep. | Portugal |
| Ecuador | Kyrgyz Republic | Romania |
| Egypt, Arab Rep. | Malaysia | Switzerland |
| Finland | Mexico | Thailand |
| France | Moldova | Tunisia |
| Germany | North Macedonia | Turkiye |
| Industrial Countries Model | | |
| Australia | Hungary | Peru |
| Azerbaijan | Indonesia | Philippines |
| Bangladesh | Japan | Poland |
| Belarus | Kazakhstan | Romania |
| Bosnia and Herzegovina | Korea, Rep. | Russian Federation |
| Chile | Kyrgyz Republic | Slovak Republic |
| Czech Republic | Malaysia | Sri Lanka |
| Ecuador | Mexico | Switzerland |
| Egypt, Arab Rep. | Morocco | Thailand |
| Germany | Norway | Turkiye |

Descriptive statistics were obtained dependent and independent variables of the models and the results are shown in Table 3.

The number of observations used in the study is 330. Minimum, maximum, mean, median, primary quartile, and tertiary quartile values appear for all variables. These statistics are very important as they provide information about both the centrality and spread of the data. When we sort a data set from largest to smallest or smallest to largest, the values that divide it into four equal parts are called quartiles. The first quartile (25%) is defined as the number between the smallest number of the data set and the median. The second quartile (50%) is the median of a dataset and the third quartile (75%) is the middle value between the median and the highest value of the data set. Knowing the first and third quartiles provide information about how large the spread is and whether the dataset is skewed to one side. We can determine whether a series is symmetrical by looking at the sequence of values taken by the arithmetic mean and median. Therefore, the closeness of the mean value and the median value indicates that the variables are symmetrically distributed. When the table is examined, the distribution of these series may exhibit a right-skewed feature, except for GDP, since the average values are generally calculated larger than the median values. The standard deviation gives information about the closeness of the data to the mean. If the standard deviation is small, the data are scattered close to the mean. Accordingly, TECH and TRADE variables showed distribution in places farther from the mean than other variables.

**Table 3.** Descriptive Statistics.

| Tourism Countries Model | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Variables | Obs | Min | 1st. Qu | Median | Mean | 3rd.Qu | Max | Std.Dev. |
| GDP | 330 | -10.9527 | 0.9969 | 2.5823 | 2.1739 | 4.2096 | 11.2001 | 3.621 |
| ITR | 330 | 1.347 | 4.531 | 7.490 | 9.094 | 12.309 | 28.334 | 6.044 |
| TECH | 330 | 4.632 | 31.913 | 46.705 | 48.233 | 65.851 | 81.727 | 20.936 |
| CAPITAL | 330 | 11.89 | 21.06 | 23.77 | 23.80 | 26.46 | 39.79 | 5.036 |
| TRADE | 330 | 22.48 | 52.55 | 77.12 | 79.72 | 100.10 | 168.34 | 34.15 |
| UNM | 330 | 0.250 | 3.810 | 6.135 | 8.208 | 10.027 | 32.020 | 6.326 |
| Industrial Countries Model | | | | | | | | |
| Variables | Obs | Min | 1st. Qu | Median | Mean | 3rd.Qu | Max | Std.Dev. |
| GDP | 330 | -10.953 | 1.362 | 2.967 | 2.783 | 4.797 | 11.200 | 3.224 |
| ITR | 330 | 0.355 | 3.228 | 4.885 | 7.787 | 10.557 | 30.230 | 6.470 |
| TECH | 330 | 1.801 | 22.785 | 44.400 | 44.710 | 69.934 | 81.727 | 24.991 |
| TRADE | 330 | 26.27 | 49.67 | 73.93 | 83.05 | 107.07 | 190.70 | 39.634 |
| UNM | 330 | 0.250 | 3.717 | 4.910 | 6.170 | 6.968 | 28.010 | 4.346 |
| CAPITAL | 330 | 13.64 | 22.67 | 25.37 | 25.78 | 28.10 | 40.66 | 4.696 |

The economic expectations of the explanatory variables in the tourism and industrial countries model are presented in Table 4.

**Table 4.** Signal Expectations and References for Explanatory Variables.

| Variables | Sign Expectation | References |
|---|---|---|
| ITR | + | (Brida, Cortes-Jimenez, & Pulina, 2013), (Gunduz & Hatemi-J, 2006), (Lin, Yang, & Li, 2018) |
| TECH | + | (Aghion, Alesina, & Trebbi, 2007), (Jorgenson & Stiroh, 1999), (Daveri, 2001) |
| CAPITAL | + | Solow (1962), Kahouli (2018), Nef (1934), Vukenkeng and Ongo, (2014) |
| TRADE | + | Frankel and Romer (1999), Hye (2012), Raghutla (2020), Dura ve Yılmaz (2022) |
| UNM* | - | Solow (1957) |

The variable is used as an indicator of labor. Expectation negative for unemployment represents labor effect expectation as positive

The hypothesis of the model are as follows:

Hypothesis I: There is a positive and long-run relationship between GDP growth and technology.

Hypothesis II: The impact of technology on GDP growth for industrial countries is higher than the impact on tourism countries

Hypothesis III: There is a positive and long-run relationship between GDP growth and trade openness

Hypothesis IV: There is a positive and long-run relationship between GDP growth and capital

Hypothesis V: There is a positive and long-run relationship between high-technology export levels and labor

Hypothesis VI: Negative impact of technology is higher for industry countries compared to tourism countries

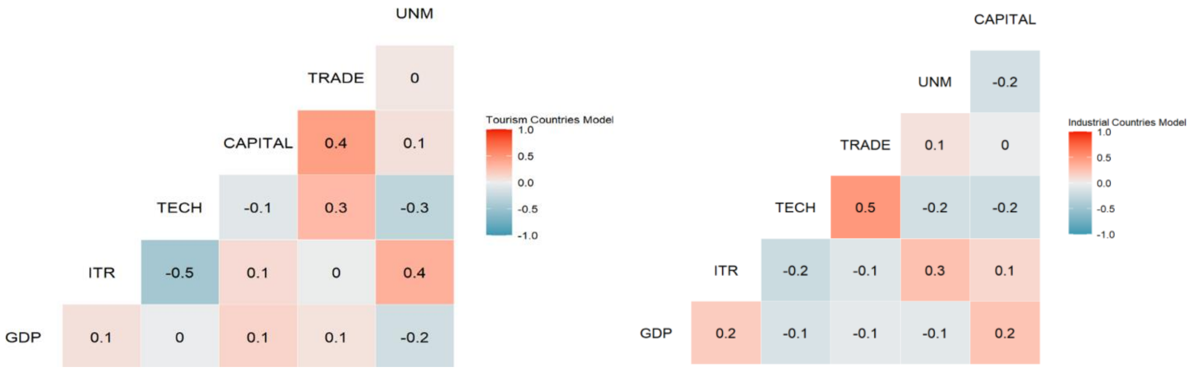


**Fig. 1.** Correlation Matrix.

According to the correlation matrix obtained from 10 tourism countries model, the highest correlation value is between C02 and CAPITAL with a ratio of 0.4, while the lowest correlation coefficient is between ITR and TECH with a ratio of -0.5.

**Table 5.** Arellano-Bover/ Blundell-Bond Test Results.

| | | | | | |
|---|---|---|---|---|---|
| Tourism Countries Model | | | | | |
| GDP | Coef. | Std. Error | Z | P>\|Z\| | [95% Conf. Interval] |
| L1.GDP | 0.06044 | 0.628147 | 1.00 | 0.316 | -0.0600706 0.1861586 |
| ITR | 0.6708327 | 0.0549856 | 12.20 | 0.000 | 0.5630628 0.7786025 |
| TECH | -0.1599989 | 0.0269753 | -5.93 | 0.000 | -0.2128696 -0.1071282 |
| CAPITAL | 0.0176941 | 0.0679829 | 0.26 | 0.795 | -0.1155499 0.1509381 |
| TRADE | 0.0409738 | 0.0171496 | 2.39 | 0.017 | 0.0073612 0.0745864 |
| UNM | -0.0890692 | 0.0455777 | -1.95 | 0.051 | -0.1783998 0.0745864 |
| Diagnostic Tests | | | | | |
| Wald-Chi2 (6) | Prob > Chi2 | Arellano Bond Test (AR(1)) | Arellano Bond Test (AR(2)) | Sargan Test Chi2 (17) | Number of instrumental Variables |
| 483.42 | 0.0000 | -2.0405 (0.0413) | 1.0998 (0.2714) | 25.26208 (0.0890) | 23 |
| Industrial Countries Model | | | | | |
| GDP | Coef. | Std.Error | Z | P>\|Z\| | [95% Conf. Interval] |
| L1.GDP | 0.3850521 | 0.1040829 | 3.70 | 0.0000* | 0.1810534 0.5890508 |
| ITR | 0.5314624 | 0.053433 | 9.95 | 0.0000* | 0.4267356 0.6361892 |
| TECH | -0.101298 | 0.0247639 | -4.09 | 0.0000* | -0.1498344 -0.0527617 |
| TRADE | 0.0809453 | 0.014175 | 5.71 | 0.0000* | 0.0531627 0.1087279 |
| UNM | -0.4441567 | 0.1108765 | -4.01 | 0.0000* | -0.6614707 -0.2268427 |
| CAPITAL | -0.155523 | 0.0402128 | -3.87 | 0.0000* | -0.2343387 -0.0767073 |
| Diagnostic Tests | | | | | |
| Wald-Chi2 (6) | Prob > Chi2 | Arellano Bond Test (AR(1)) | Arellano Bond Test (AR(2)) | Sargan Test Chi2 (17) | Number of instrumental Variables |
| 403.76 | 0.0000 | -2.2402 (0.0251) | 0.98418 (0.3250) | 24.79954 (0.0893) | 23 |

Note: *,**,*** indicate that it is significant at 1%, 5%, 10% significance level. The “probability” values of AR(1), AR(2), and Sargan test statistics are in parentheses.

In the industrial countries model, the highest correlation value is between TECH and TRADE with a ratio of 0.5. The lowest correlation coefficient is between ITR and TECH, CAPITAL and UNM, UNM and TECH, and CAPITAL and TECH with a ratio of -0.2.

Due to its superiority over other dynamic models, Arellano Bover / Blundell-Bond (1998) (System GMM) test was performed. Parameter estimations were made with two-step robust standard errors in the model and the results are given in Table 5.

According to the results obtained from the table, $\Delta GDP_{it-1}$(LD.GDP) in the level equation subscript 2/2).GDP) in the GMM equation was used as instrumental variables. The dynamic panel data model of the tourism countries model is shown below:

$\Delta GDP_{i,t} = \Delta GDP_{i,t-1} + \Delta ITR_{i,t} - \Delta TECH_{i,t} + \Delta CAPITAL_{i,t} - \Delta TRADE_{i,t} + \Delta UNincrement_{t}$

When the system GMM parameter estimation results are examined, it is seen that the dependent variable, the gross domestic product, is positively affected by its own delay, international tourism revenues, gross capital formation, and total unemployment rates. At the same time, all variables except unemployment rates were statistically significant at the 1% significance level. As a result, the independent variables in the model are significant in explaining the dependent variable. When the gross domestic product of the previous period increases by 1%, the amount of gross domestic product in the current period will increase by 0.12%. When international tourism revenues, gross capital formation and total unemployment rates increase by 1%, gross domestic product will increase by 73%, 39% and 14%, respectively. Medium and high technology exports and carbon dioxide emissions will decrease by 0.22% and 0.13%, respectively.

At the bottom of the table, important inferences can be made about whether the assumptions of the dynamic panel data model are met. The first of these assumptions was the condition that the number of instrument variables should be smaller than the number of unit sizes, and it was provided for both models.

Sargan test is the first difference and system test of Arellano and Bond(1991) that tests the validity of all instrumental variables used in the first difference model and system generalized moments estimation (Tatoğlu, 2013).

The hypotheses used in the Sargan test are as follows:

$H_0$: Instrumental variables are external.

$H_1$: Instrument variables are internal.

Sargan's test statistic is as follows:

$$S = \Delta\hat{u}Z\left(\sum_{i=1}^{N} Z_i' \, \Delta\hat{u}_i\hat{u}_i' z_i\right)^{-1} Z'\Delta\hat{u} \ \sim \chi^2_{p-k-1}$$

Here $Z_i = diag(Y_{i1}, \ldots Y_{is}), (s = 1, .., T-2)$ and $\Delta\hat{u}$ are the residues obtained from the two-stage estimation. If the null hypothesis is rejected, at least one of the instrumental variables used is associated with the error term, and therefore the instrumental variable estimation based on the selected means is invalid(Gujarati, 2004).

According to the results obtained, it is seen that the over-identification restrictions are valid according to the 5% significance level, that is, the tools are valid. As it is known in the generalized moments method, there should be no second-order autocorrelation for parameter estimators to be effective. For this purpose, in the Arellano and Bond tests, which will be used to test the existence of autocorrelation, the presence of both first and second-order autocorrelation is tested. The test statistics of Arellano and Bond are expressed as follows:

$$m_2 = \frac{\hat{u}_{-2}\hat{u}}{\hat{u}^{1/2}} \sim N(0,1)$$

The hypotheses used in the autocorrelation test of Arellano and Bond are established as follows;

$H_0$: There is no second-order autocorrelation between the error terms.

$H_1$: There is second-order autocorrelation between the error terms.

Here, it was seen that the test statistic used to test the existence of second-order autocorrelation was meaningless. In the first order, there is negative autocorrelation as expected. The Wald test results show that the independent variables are significant on the gross domestic product at the 1% level of significance.

If we look at the results obtained for the industrial countries model $\Delta GDP_{it-1}$(LD.GDP) in the level equation subscript 2/2).GDP) variables in the GMM equation are used as instrumental variables. The dynamic panel data model of the industrial countries model was obtained as follows:

$\Delta GDP_{i,t} = \Delta GDP_{i,t-1} + \Delta ITR_{i,t} - \Delta TECH_{i,t} + \Delta TRADE_{i,t} + \Delta UNM_{i,t} - \Delta CAPITAL_{i,t} + \Delta v_{i,t}$

It is seen that the dependent variable, the gross domestic product, is positively affected by its own delay, international tourism revenues, and trade rates in the previous period. In addition, all variables used in the model were found to be statistically significant at the 1% significance level. According to the system GMM parameter estimation results, when the gross domestic product of the previous period increases by 1%, the amount of gross domestic product in the current period will increase by 0.38%. When international tourism revenues and trade rates increase by 1%, the gross domestic product will increase by 0.53% and 0.08%, respectively. Medium and high technology exports, unemployment rates, and gross capital formation variables will decrease by 0.10%, 0.44%, and 0.15%, respectively.

When the diagnostic tests of the industrial model are examined, it is seen that the validity of the tools used is valid according to the Sargan test, according to the 5% significance level.

According to the Arellano and Bond autocorrelation test, there is negative autocorrelation as expected from the first order. There is no second-order autocorrelation. The Wald test results show that the independent variables are significant on the gross domestic product at the 1% level of significance.

In summary, within the scope of the economic growth model, international tourism revenues make the most important contribution to economic growth for both country groups. While the coefficient is 0.67 for tourism countries, it is determined as 0.53 for industrial countries. While capital affects growth negatively in industrial countries, it creates a positive effect in tourism countries. The reason for this may be that the investment process in industrial countries is still ongoing. While openness had a positive effect in both country groups, the coefficient (0.08) is higher in industrial countries than in tourism countries (0.04). Unemployment data is used to measure the labor force included in the model. From this point of view, although the labor force positively affects both country groups, the contribution of the labor force to growth is higher in industrial countries than in tourism countries. Finally, it is concluded that technology has a negative effect on the economic growth of both country groups, and this effect is observed more strongly in industrial countries.

## Conclusion and Discussion

The fact of duality should be taken as a default reality in every aspect of any event. This is also valid for technology. Although it is accepted as one of the most important prime movers for the growth and development of an economy, it is also part of negative externalities. Is technology a curse or a bloom for humanity? And does the technological effect between industry-based and tourism-based countries differ? To answer the question, two different country groups which are tourism-based, and industry-based countries have been defined. And an extended growth model of Solow has been applied. In the model of the paper, tourism income, trade openness, and middle and high-technology export level are added to Solow's model as independent variables. This paper has aimed to fulfill the area that cannot be met in the literature about the specific difference in technology's effect on economic growth between industry and tourism countries. The motivation behind this, is finding the answer to the question; what is the net effect of technology on the economies? Is the positive effect higher than the negative effect or vice versa? And does the effect of technology differ between industrialized countries and tourism countries? It is assumed that especially differing effects between two country groups will be very important for policymakers. So that they can change their growth and development strategy accordingly the model was set based on Solow's growth model and technology and trade openness tourism income is also added to the model for robust checking. It is assumed that especially differing effects between two country groups will be very important for policymakers. So that they can change their growth and development strategy accordingly. While doing the research the most important limitation of the paper was because of the lack of separate data on the negative impacts and positive impacts of technology. That is why just medium-high technology export level is used as the indicator of technology and assessing the sign and the magnitude of the coefficient have taken into consideration. At the beginning of the study, it was predicted that the effect of technology on economic growth would be positive for both country groups and the positive effect would be higher for industrialized countries compared to tourism countries. It was assumed that countries that have an economy mostly based on tourism incomes would have minor effects on both positive and negative sides because the infrastructure of technology is not established on high-technology products. Instead, it focuses more on the structures that will create different experiences for tourists such as simulators such as Disney World, architectural design, three-dimensional cinema, jet boat technology, the technology used for health tourism, etc. However, according to the results of the analysis, the effect of technology on growth was determined as negative for both country groups. For tourism-based countries, 1% increase in middle and high-tech export levels leads to a decrease by 0,16% in economic growth and for industry-based countries, 1% increase in middle and high-tech export levels leads to a decrease by 0,10% in economic growth. Another very important result of the paper is for both country groups tourism income has the highest effect on economic growth among all independent variables. For tourism-based countries, 1% increase in international tourism income leads to an increase of 0,67% in economic growth and for industry-based countries, 1% increase in international tourism income leads to an increase of 0,53% in economic growth. These results indicate that another further research should be done for the same countries as if these countries have an export infrastructure that is dependent upon imports. If this is the case, it can be a proper explanation for the negative impact of technology on economic growth. In the literature, mostly the economic growth effect of information and communication technologies has been emphasized especially in the tourism sector and the positive effects at various levels have been revealed. And in the literature, many types of research concluded increase in technology leads to an increase in $CO_2$ emissions. In our study, the export rate of medium and high-technology products is considered as a technology indicator. At this point, it is thought that the negative effect obtained may arise from an import-dependent export structure. Another scenario may be the answer to the question is technology a curse or an abloom? Negative effects such as labor force loss arising from air pollution may be greater than the positive effects of it on economic growth. Of course, to confirm these assumptions further necessary empirical studies should be carried out in the next study.

## References


Aghion, P., Alesina, A., & Trebbi, F. (2007). Democracy, Technology, And Growth. Natıonal Bureau Of Economıc Research.

Akay, E. Ç. (2018). Dinamik Panel Veri Modelleri. S. Güriş içinde, *Uygulamalı Panel Veri Ekonometrisi* (s. 105-129). İstanbul: DER Yayınları.

Ali, S. H., & Puppim de Oliveira, J. (2018). Pollution and economic development: an empirical research review. *Environmental Research Letters*, 13(12), 123003.

Arellano, M., & Bond, S. (1991). Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *The Review of Economic Studies*, 277–297.

Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics*, 29-51.

Barnes, S. J. (2019). Understanding plastics pollution: The role of economic development and technological research. *Environmental pollution*, 249, 812-821.

Basu, S., & Weil, D. N. (1998). Appropriate Technology And Growth. *Oxford Academic-The Quarterly Journal of Economics*, 113(4), 1052.

Bekar, M., Tüfekçi, A., Yalçın, Y., & Emirmahmutoğlu, F. (2022). Teleomünikasyon Ve Ekonomik Büyüme İlişkisinin Panel Veri Analizi. *Ekonomi, Politika & Finans Araştırmaları Dergisi*, 366-385.

Brida, J. G., & Pulina, M. (2010). A Literature Review On The Tourısm-Ledgrowth Hypothesis. Centro Ricerche Economiche Nord Sud (Crenos), 12.

Brida, J. G., Cortes-Jimenez, I., & Pulina, M. (2013). Has the tourism-led growth hypothesis been validated? A literature review. *Current Issues in Tourism*, 19(5), 394-430.

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, 115-143.

Byrne, M. M. (1997). Is growth a dirty word? Pollution, abatement, and endogenous growth. *Journal of Development Economics*, 261-284.

Cil, N. (2022). Re-examination of pollution haven hypothesis for Turkey with Fourier approach. *Environmental Science and Pollution Research,* 30(4), 10024-10036.

Carlaw, K. I., & Lipsey, R. G. (2003). Productivity, Technology, and Economic Growth: What is the Relationship? *Journal of Economic Surveys*, 17(3), 457-495.

Chung-Huang Huang, & Cai, D. (1994). Constant-returns endogenous growth with pollution control. SpringerLink.

Dagar, V., Khan, M. K., Alvarado, R., Rehman, A., & Irfan, M. (2022). Impact of renewable energy consumption, financial development, and natural resources on environmental degradation in OECD countries with dynamic panel data. *Environmental Science and Pollution Research* , 18202–18212.

Daveri, F. (2001). Information Technology and Growth in Europe. University of Parma and IGIER, May (http://digilander.iol. it/crenos/cnr67701/Daveri. pdf).

Desmet, K., & Rossi-Hansbergb, E. (2009). Spatial growth and industry age. *Journal of Economic Theory*, 144(6), 2477-2502.

Dura, Y., Yılmaz E.G. (2022). Does Export of High-TechProducts Provide Advantage for Economic Growth? Empirical Evidence from Developed Countries. *Journal of Science-Technology-Innovation Ecosystem*, 3(1), 82-94.

Dollar, D. (1992). Outward-Oriented Economies Really Do Grow More Rapidly: Evidence from 95 LDCs. *Economic Development and Cultural Change*, 40(3), 523-544. http://dx.doi.org/10.1086/451959

Frankel, A. J., & Romer, D. (1999). Does Trade Cause Growth? The American Economic Review, 89(3), 379-399. http://dx.doi.org/10.1257/aer.89.3.379

Grossman, G. M., & Krueger, A. B. (1991) Environmental Impacts of a North American Free Trade Agreement, National Bureau of Economic Research Working Paper 3914 NBER, Cambridge, MA.

Gujarati, D. (2004). *Basic Econometrics.* Newyork: The McGraw-Hill Companies.

Gunduz, L., & Hatemi-J, A. (2006). Is the tourism-led growth hypothesis valid for Turkiye? *Applied Economics Letters*, 12(8), 499-504.

Harrod R.F (1948). Towards a Dynamic Economics. London. MacMillan Co Ltd.

Hausman, Jerry A. and William E. Taylor, 1981, Panel Data and Unobservable Individual Effect. *Econometrica*, 49(6), 1377-1398.

Hicks J.R. (1963). The Theory of Wages. London.

Hye, Q. M. A. (2012). Long term effect of trade openness on economic growth in case of Pakistan. *Quality and Quantity*, 46, 1137–1149.

Jacobsson , S., & Bergek, A. (2003). The emergence of a growth industry: a comparative analysis of the German, Dutch and Swedish wind türbine industries. *In Change, transformation and development (pp. 197-227).* Physica-Verlag HD.

Jones, L. E., & Manuelli, R. E. (1995). A Positive Model of Growth and Pollution Controls. National Bureau of Economic Research.

Jorgenson, D. W., & Stiroh, K. J. (1999). Productivity Growth: Current Recovery and Longer-Term Trends. *American Economic Association*, 109-115.

Kahouli, B. (2018). The causality link between energy electricity consumption, CO2 emissions, R&D stocks and economic growth in Mediterranean countries (MCs). *Energy*, 145, 388-399.

Kelly, D. L., & Kolstad, C. D. (1999). Bayesian learning, growth, and pollution. *Journal of Economic Dynamics and Control*, 491-518.

Lee, J. (2000). The Robustness of Okun's Law: Evidence from OECD Countries. *Journal of Macroeconomics*, 22(2), 331–356.
Lin, V. S., Yang, Y., & Li, G. (2018). Where can tourism-led growth and economy-driven tourism growth occur?. *Journal of Travel Research*, 58(5), 760-773.
Liu, S. J., & Xu, X. L. (2021). The pollution halo effect of technology spillover and pollution haven effect of economic growth in agricultural foreign trade: two sides of the same coin? *Environmental Science and Pollution Research*, 28, 20157-20173.
Lucas, R.E. (1988). On The Mechanics of Economic Development. *Journal of Monetary Economics*, 22, 25-50.
Magazzino , C., Mele, M., Morelli , G., & Schneider , N. (2021). The nexus between information technology and environmental pollution: Application of a new machine learning algorithm to OECD countries. *Utilities Policy*, 72, 101256.
Mughal, N., Arif, A., Jain, V., Chupradit, S., Shabbir, M. S., Ramos-Meza, C. S., & Zhanbayev, R. (2022). The role of technological innovation in environmental pollution, energy consumption and sustainable economic growth: Evidence from South Asian economies. *Energy Strategy Reviews*, 39, 100745.
Nahrin, R., Rahman, H., Majumder, S. C., & Esquivias , M. A. (2023). Economic Growth and Pollution Nexus in Mexico, Colombia, and Venezuela (G-3 Countries): The Role of Renewable Energy in Carbon Dioxide Emissions. *Energies,* 16(3), 1076.
Nasrollahi, Z., Hashemi, M.-s., Bameri, S., & Taghvaee, M. (2020). Environmental pollution, economic growth, population, industrialization, and technology in weak and strong sustainability: using STIRPAT model. *Environment, Development and Sustainability*, 22, 1105-1122.
Nef, J. (1934). The Progress of Technology and the Growth of Large-Scale Industry in Great Britain, 1540-1640. *The Economic History Review*, 5(1), 3-24.
Raghulta, C. (2020). The effect of trade openness on economic growth: Some empirical evidence from emerging market economies. *Journal of Public Affairs*, 20(3), e2081. https://doi.org/10.1002/pa.2081
Romer, P.M. (1986). Increasing Returns and Long-Run Growth. *Journal of Political Economy*, 94(5), 1002-1037.
Ricardo D. (1817). On the Principles of Political Economy and Taxation, Ed. R. M. Hartwell (1971), Pelican Classics.
Ruttan, V. W. (2000). Technology, Growth, and Development: An Induced Innovation Perspective. Oxford University Press.
Sach, D. J., & Warner, A. (1995). Economic Reforms and The Process of Global Integration. *Brookings papers on economic activity*, 1995(1), 1-118. http://dx.doi.org/10.2307/2534573
Schumacher, E. F. (1975). Small is Beautiful, Harper and Row, N.Y.
Seyidoğlu, H. (2006), İktisat Biliminin Temelleri, İstanbul, Güzem Can Yayınları No:21.
Smith A. (1776-1937), The Wealth of Nations. New York: The Modern Library.
Solow, R. M. (1957). Technical Change and Aggregate Production Function. *The Review of Economics and Statistics*, 39(3), 312–320.
Solow, R.M. (1962). Technical progress, capital formation and economic growth. *The American Economic Review,* 52(2), 76-86.
Stipanuk, D.M. (1993). Tourism and technology: Interactions and implications. *Tourism Management,* 14(4), 267-278.
Tatoğlu, F. Y. (2013). *İleri Panel Veri Analizi.* İstanbul: Beta.
Timmer, M. P., Inklaar, R., O'Mahony, M., & van Ark, B. (2011). Productivity and Economic Growth in Europe: A Comparative Industry Perspective. *International Productivity Monitor*, (21), 3.
Topcu, Altinoz, Aslan (2020). Global evidence from the link between economic growth, natural resources, energy consumption, and gross capital formation. *Resources Policy,* 66, 1-10.
Ulaşan, B. (2014). Trade openness and economic growth: panel evidence. *Applied Economic Letters,* 22(2), 163-167. https://doi.org/10.1080/13504851.2014.931914
Von Tunzelmann, G. N. (1995). Technology and Industrial Progress: The Foundations of Economic Growth. Great Britain: Edward Elgar Publishing.
Vukenkeng, A.W, Ongo, E.N. (2014). Does gross capital formation matter for economic growth in the CEMAC sub-region?. *EuroEconomica*, 33(2).
Yi, M., Wang, Y., Sheng, M., Sharp, B., & Zhang, Y. (2020). Effects of heterogeneous technological progress on haze pollution: Evidence from China. *Ecological Economics*, 169, 106533.
Webb, S. B. (2010). Tariffs, Cartels, Technology, and Growth in the German Steel Industry, 1879 to 1914. *The Journal of Economic History*, 40(2), 309-330.
Zhang, J., & Zhang, Y. (2020). Tourism, economic growth, energy consumption, and CO2 emissions in China. *Tourism Economics*, 27(5), 1060-1080.
Zheng, H., Huai, W., & Huang, L. (2015). Relationship between pollution and economic growth in China. *China Population, Resources and Development*, 16(1), 25-29.