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Causality Effects of Capital Accumulation and Employment on Turkey's Economic Growth: Findings from the Toda-Yamamoto Approach

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Abstract

A time-dependent change in the amount of goods and services produced in an economy refers to economic growth. Economic growth is considered an important factor in increasing the welfare of a society and in determining the level of development of countries. Therefore, all countries in the world endeavour to increase their economic growth performance. By increasing the economic growth performance of countries, opportunities to compete with other economies increase because of the increase in production activities in the economy. Therefore, economic growth is considered to be one of the most important issues in the economy in terms of its causes and consequences. This framework aims to test the effects of capital accumulation, employment level, and technological progress factors on economic growth in Turkey between 1990-2021. For this purpose, the relationships between the variables were analysed using the Toda-Yamamoto causality test. The analyses revealed that capital accumulation, employment level, and technological progress have a statistically significant relationship with economic growth. This result is consistent with the hypotheses regarding the determinant role of capital, labour, and technology factors in economic growth, which are put forward in Solow's neoclassical growth model and endogenous growth theories.

Keywords
Economic Growth, Capital Accumulation, Employment Level

JEL Classification
E13, E24, O47

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Türkiye'de Sermaye Birikimi ve İstihdam Düzeyinin Ekonomik Büyüme Üzerindeki Nedensellik Etkisi: Toda-Yamamoto Yaklaşımından Bulgular

Öz

Bir ekonomide üretilen mal ve hizmet miktarının zamana bağlı değişimi ekonomik büyümeyi ifade etmektedir. Ekonomik büyüme bir toplumda refah artışının sağlanmasında ve ülkelerin gelişmişlik düzeylerinin belirlenmesinde önemli bir etken olarak değerlendirilmektedir. Bu nedenle dünyada tüm ülkeler ekonomik büyüme performanslarının artırılabilmesi için çaba sarf etmektedirler. Ülkelerin ekonomik büyüme performansının artırılması ile ekonomide üretim faaliyetlerinin artışına bağlı olarak diğer ekonomilerle rekabet etme imkanları da artmaktadır. Dolayısıyla ekonomik büyüme nedenleri ve sonuçları itibariyle ekonomide en çok üzerinde durulan konulardan biri olarak değerlendirilmektedir. Bu çerçevede Türkiye'de 1990-2021 yılları arasında sermaye birikimi, istihdam düzeyi ve teknolojik ilerleme faktörlerinin ekonomik büyüme üzerindeki etkisinin test edilmesi amaçlanmaktadır. Bu amaca yönelik olarak değişkenler arasındaki ilişkiler Toda-Yamamoto nedensellik testi ile analiz edilmiştir. Yapılan analizlerde sermaye birikimi, istihdam düzeyi ve teknolojik ilerlemenin ekonomik büyüme ile istatistiksel olarak anlamlı bir ilişkiye sahip olduğu tespit edilmiştir. Bu sonuç, Solow 'un neoklasik büyüme modeli ve endojen büyüme teorilerinde öne sürülen sermaye, emek ve teknoloji faktörlerinin ekonomik büyüme üzerindeki belirleyici rolüne ilişkin hipotezlerle uyumlu olarak değerlendirilebilir.

Anahtar Kelimeler
Ekonomik Büyüme, Sermaye Birikimi, İstihdam Düzeyi

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1. Introduction

The settlement of people in the world and the increase in population brought about the necessity of production, and communities engaged in output production activities in order to survive. This output production activity is important in terms of showing the size and competitiveness of economies and expressing economic growth. In this context, economic growth is expressed by an increase in gross domestic product (GDP), which is defined as the monetary value of final goods and services produced in an economy in a certain period (Timur and Doğan, 2015). Therefore, a change in the amount of goods and services produced in an economy over time represents economic growth. Economic growth is considered an important factor in increasing the welfare of a society and in determining the development levels of countries. For this reason, all countries strive for economic growth (Alancıoğlu and Utlu, 2012). As a result of these efforts, it can be said that developed countries exhibit higher economic growth performance, while underdeveloped countries' growth performance remains at lower levels (Timur and Doğan, 2015).

Economic growth is one of the most important macroeconomic indicators and performance criteria of an economy. Economic growth is one of the most discussed topics in economics in terms of its results and sources of growth. When the literature on economic growth is examined, it is observed that there are many theories on the sources of economic growth. This shows that each theory has different perspectives on economic growth. These differences in growth also bring about the differentiation of policy recommendations (Erdem and Dumrul, 2014).

When evaluated chronologically, modern growth theories are based on the work of Ramsey (1928). Over time, Ramsey determined the optimal condition by integrating growth theory based on household optimisation. It is difficult to discuss consumption theory, the asset pricing model, and business cycle models without considering the optimality conditions proposed by Ramsey. However, Ramsey's studies were not accepted, and became widespread until the 1960s. Ramsey, together with Harrod and Domar, worked on integrating Keynesian analysis with economic growth in the late 1950s. In this context, production functions with low substitution rates between inputs are used. Although these initiatives carried out by Ramsey, Domar and Harrod constituted a reference to many studies at that time, these analyzes are not thought to be very effective today. However, Solow (1956) and Swan (1956) claimed the most important contributions to growth theories. The main feature of the Solow-Swan model is that it is based on conditions of constant returns to scale, each of which has diminishing returns, and uses a neoclassical production function based on the positive elasticity of substitution between inputs. This production function is based on fixed savings rates using simple general equilibrium modelling in the economy. Another assumption of the neoclassical growth model is that, if technological developments are ignored, the per capita growth rate will stop. This assumption is based on the assumption of diminishing returns on capital. Economists advocating neoclassical growth in the 1960s realised this deficiency of the model and assumed that technological progress was external (Barro and Sala-i Martin, 2004).

When the neoclassical production function is examined based on neoclassical growth theory, it is assumed that household rights have inputs and assets. These units consume part of their income and save the remaining part. Another actor in the economy is a company. Companies rent capital and labour inputs and use them in the production of goods that they want to sell to other companies and households. Therefore, companies are considered to have knowledge, equipment, and technology to transform inputs into outputs (Ateş, 1996). In this context, the production function is defined when considering a function that converts inputs into outputs and uses technology.

$$Y_t = F\,[\lambda K_t, \lambda L_t, T_t] = \lambda[K_t, L_t, T_t] \quad \text{for } \lambda > 0 \tag{1}$$

This can be expressed as follows. In the defined production function, is the amount of output produced at time t, is the capital accumulation at time t, is the employment level at time t, and is technological development at time t. For a function to be considered a neoclassical production function, certain conditions must be met. The first condition is the assumption of constant returns to scale. In other words, when we multiply the input amount by λ, the output amount increases by λ. However, the assumption of constant returns to scale covers only two inputs: labour and capital. Another condition in defining the neoclassical production function is that inputs exhibit positive but diminishing returns. Another condition is that the marginal product of capital approaches infinity as capital approaches zero and approaches zero as capital approaches infinity (inada conditions) (Barro and Sala-i Martin, 2004).

Based on these explanations, economic growth performance in an economy provides information about the increase in welfare and level of development of countries. However, there are different theoretical approaches and policies in the literature regarding the sources of economic growth and the factors affecting this growth. The motivation for this study is to empirically analyse the impact of capital accumulation, employment level, and technological progress on economic growth in Turkey based on neoclassical growth theory. In this framework, the main hypothesis of the study is that capital accumulation, employment level, and technological progress have significant causal effects on economic growth. This hypothesis is tested using the Toda-Yamamoto causality test, based on the assumptions of neoclassical growth theory. In this framework, a literature review, empirical applications, and application results are provided in the following sections of the study.

2. Literature

Although many domestic and foreign studies examine the relationships between capital accumulation, employment level, technological development, and economic growth, it is noteworthy that there is no consensus in the literature. The reason for this may be that the datasets, samples, or methods used in the analyses were different. In this context, there have been some studies in the literature with different results. Şiriner and Doğru (2005) analysed the factors affecting economic growth in the post-1980 period in their study. As a result of their study, they concluded that unemployment level, capital accumulation, level of investments, R&D investments, financial discipline and public financing deficits affect economic growth. Ay and Yardımcı (2008) analysed the effects of human and physical capital on economic growth in Turkey between 1950 and 2000. They conclude that human and physical capital affect economic growth. Bayraktutan and Arslan (2008) analysed the relationship between economic growth and fixed investments in Turkey between 1980 and 2006. The study concludes that fixed capital investments positively affect economic growth in the long term. Muratoğlu (2011) analysed the causality relationship between economic growth and employment levels in Turkey between 2000 and 2011. The study found no causal relationship between economic growth and employment level. Altuntepe and Güner (2013) analysed the relationship between employment level and economic growth in Turkey between 1988 and 2011. They concluded that developments in employment levels affected economic growth. Cinel (2014) analysed the impact of variables such as capital accumulation, employment level, and population on economic growth in Turkey in the post-1980 period. As a result of his study, it was concluded that investments and employment do not affect economic growth. Şahbaz (2014) analysed the relationship between economic growth, employment level, and fixed investments in European Union countries and Turkey between 1991 and 2011. He concluded that fixed capital investments and employment levels cause economic growth in the long term. Kaitila (2016) analysed the relationship between the terms of trade, fixed capital, and economic growth in Russia between 1995 and 2013. The study concluded that terms of trade positively affected fixed capital and economic growth. Koyuncu (2017) analysed the relationship between economic growth, employment level, and foreign direct investments in Turkey between 1990 and 2015. As a result of his study, he concluded that foreign direct investments cause economic growth and economic growth also causes employment. Afshar et al. (2017) analysed the relationship between economic growth, employment, and unemployment in Turkey between the 2000Q1 and 2016Q1 periods. They conclude that economic growth causes unemployment and positively affects employment. Teyyare (2018) analysed the relationship between fixed capital investments and economic growth in Turkey between 1963 and 2014. The study concludes that fixed capital investments positively affect economic growth. Salmanzadeh-Meydani and Ghomi (2019) analysed the relationship between economic growth, capital accumulation, and energy consumption in Iran between 1975 and 2011. They concluded that there is a bidirectional causal relationship between energy consumption and economic growth. Mahmoudinia et al. (2020) analysed the long- and short-term relationships between economic growth, population, and capital accumulation in member countries of the Organization of Islamic Cooperation between 1980 and

2018. The study concludes that capital stock and population have a positive effect on economic growth in the long run. Chishti (2022) analysed the relationship between economic growth, demographic factors, and capital accumulation in Pakistan between 1960 and 2018. The study concluded that demographic factors reduce capital accumulation, and therefore, economic growth is negatively affected. Oli (2024) analysed the effects of domestic and foreign capital flows on economic growth and employment in 43 low- and middle-income economies and concluded that both domestic and foreign capital have an impact on economic growth and employment in low- and middle-income countries. El Asli et al. (2024) analysed the effects of productivity (total factor productivity), capital investment, employment, human capital and energy intensity, which are the main determinants of Moroccan economic growth, and concluded that human capital, energy intensity and productivity factors significantly affect economic growth.

3. Dataset and Model

In this study, the effects of capital accumulation, employment level, and technological development level on economic growth in the Turkish economy between 1990 and 2021 were analysed using the Toda-Yamamoto causality test method. The data used in the analysis were obtained from the Total Economy Database (Total Economy Database [TED], 2024), and are included in the table below.

Table 1

Variables Description

Variables	Variables description
Y	Real GDP at constant 2017 national prices (in mil. 2017US$)
K	Capital stock at constant 2017 national prices (in mil. 2017US$)
L	Number of persons engaged (in millions)
A	TFP at constant national prices (2017=1)

Note. The data in the table were analysed linearly without any transformation.

Among the variables in the table, Y is defined as real GDP, K: capital accumulation, L: employment level and A: total factor productivity representing technological development. The linear model established based on the neoclassical production function used in the study is;

$$Y=\beta_1+\beta_2A+\beta_3K+\beta_4L+\varepsilon_t \quad (2)$$

It is defined as: Descriptive statistics for the variables included in the model are given in the table below.

Table 2

Descriptive Statistics

Variables	Mean	Median	Max	Min	Std. Dev.	Skewness	Kurtosis
Y	4.4141	5.8591	10.6161	-5.9214	4.3838	-1.0815	3.3267
A	-0.0302	0.5182	6.6309	-11.313	4.1145	-0.8322	3.4050
K	6.7068	7.0905	10.4446	1.6584	2.0983	-0.2268	2.7108
L	1.3100	1.8119	11.7610	-16.364	4.4066	-1.6810	9.9338

4. Methodology and Application Results

The Toda-Yamamoto causality test was developed by Hiro Y. Toda and Taku Yamamoto in 1995. The Toda-Yamamoto causality test is generally defined as an improved form of the Granger causality test. In this context, the Toda-Yamoto causality test ignores the condition that the variables in the Granger causality test are stationary at the same level (Doğan, 2017). In this way, the data loss that occurs when the differences of the non-stationary series are taken according to their stationarity level in the Granger causality test does not occur in the Toda-Yamamoto causality test (Meçik and Koyuncu, 2020). This situation shows the advantage of the Toda-Yamamoto causality test over the Granger causality test. Another problem of the Granger causality test is the extreme sensitivity of the test to lag length. For this reason, it is important for the accuracy of the results to find the correct lag length (Yenilmez and Erdem, 2018). At the same time, since the Granger causality test also takes into account the co-integration relationship between the variables, it may lose its effectiveness if the integration relationship between these variables is disturbed. In the Toda-Yamamoto causality test, analyzes are carried out on the basis of the level values of the variables and without taking the co-integration relationship into account. When performing the Toda-Yamamoto causality test, the unit root test is used at the maximum stationarity level of the variable (d_{max}). The Toda-Yamamoto causality test is performed using the VAR model. Therefore, the causality relationship between the variables is tested using the Wald test. To determine the appropriate lag length (k) between the variables, the variables must first be estimated using the VAR model. In addition, unit root tests are applied to the data to determine the maximum stationarity level of the variables. This is because in order to perform the Toda-Yamamoto causality test, the VAR model must be recreated with a lag length of k+d_{max}. After the VAR model is appropriately estimated, diagnostic tests must be performed to check the reliability of the model (Medetoğlu and Doğru, 2022). Accordingly, assuming that two variables such as X and Y are used in the analysis, the VAR model is estimated with k + d_{max} lag length for the Toda-Yamamoto causality test;

$$Y_t=\omega+\sum_{i=1}^{k} a_{1i}X_{t-i}+\sum_{i=1}^{k} \beta_{1i}Y_{t-i}+\sum_{J=k+1}^{d_{max}} \delta_i X_{t-i}+\sum_{J=k+1}^{d_{max}} \theta_{1i}Y_{t-i}+\varepsilon_{1t} \quad (3)$$

$$X_t=\varphi+\sum_{i=1}^{k} a_{2i}X_{t-i}+\sum_{i=1}^{k} \beta_{2i}Y_{t-i}+\sum_{J=k+1}^{d_{max}} \delta_{2i} X_{t-i}+\sum_{J=k+1}^{d_{max}} \theta_{2i}Y_{t-i}+\varepsilon_{2t} \quad (4)$$

It is expressed as (Medetoğlu and Doğru, 2022). In this context, the results of the VAR model created to determine the appropriate lag length for the variables are presented in the following table.

Table 3

Choosing The Appropriate Lag Length Criteria

Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-248.6823	---	243.2465	16.8454	17.0323	16.90525
1	-207.4416	68.7345*	45.7786*	15.1627*	16.0969*	15.4616*
2	-198.1667	12.9848	76.3829	15.6111	17.2925	16.1490

Based on the results of the selection criteria LogL, LR, FPE, AIC, SC and SC in the table, the suitable lag length was determined as k = 1. Once the appropriate lag length has been selected, the d_max value must be determined on the basis of unit root tests for the variables. The results of the unit root tests applied to the variables are therefore shown in the table below.

Table 4

ADF and PP Unit Root Test Results

Variables	**ADF**		**PP**	
	I(0)	**I(1)**	**I(0)**	**I(1)**
Y	-5.9514***	------	-6.7054***	------
A	-7.5468***	------	-8.4906***	------
K	-3.0583**	-5.8991***	-2.9668**	-7.8726***
L	-5.8708***	-------	-5.8669***	------

The results of the Augmented Dickey Fuller and Philips Perron unit root tests for the variables used in the analysis show that all variables are at the [I(0)] level. In this case, d_{max} = 0.

Therefore, the result k+d_{max} =1 is obtained. Based on this result, the VAR model was retested and the Toda-Yamamoto causality test was applied. The results of the Toda-Yamamoto causality test are shown in the table below.

Tablo 5

Toda-Yamamoto Causality Test Results

Variables	Wald test	Probability Value
A=>Y	5.3349	0.0209**
K=>Y	4.5819	0.0323**
L=>Y	3.1754	0.0747*
Y=>A	6.8714	0.0087***
Y=>K	5.3707	0.0204**
Y=>L	1.2755	0.2587

According to the results of the Toda-Yamamoto causality test, a causal relationship was established between total factor productivity, capital accumulation and the level of employment and economic growth. In addition, a causal relationship was found between economic growth, total factor productivity and capital accumulation. However, no causal relationship was found between economic growth and the level of employment.

5. Result and Discussion

In this study, in which the effects of capital accumulation, employment level and technological development level on economic growth in the Turkish economy between 1990 and 2021 were analysed, the relationship between the variables was examined by Toda-Yamamoto causality test. As a result of the analysis, a causal relationship was found between total factor productivity, capital accumulation and employment levels and economic growth. In addition, a causal relationship was established between economic growth, total factor productivity and capital accumulation. However, no causal relationship was found between economic growth and the level of employment.

From these results, it can be concluded that capital accumulation, employment levels and technological development contribute to economic growth in Turkey. This result is consistent with growth theories. Therefore, it is important for policy makers to make investments that increase capital accumulation and ensure technological progress. In this way, the development of capital accumulation and technological progress will promote employment and increase labour productivity by contributing to the degree of specialisation in the division of labour. On the other hand, the existence of a causal relationship between economic growth and capital accumulation can be evaluated as the contribution of economic growth to capital accumulation. It can be expressed that economic growth contributes to the growth of sectors. At the same time, the existence of a causal relationship between economic growth and total factor productivity can be interpreted to mean that technical progress also goes hand in hand with economic growth and contributes to technical development. However, the lack of a causal relationship between economic growth and employment levels points to an important problem. This situation can be interpreted to mean that growth does not create employment. The fact that economic growth does not contribute to reducing unemployment, which is one of the basic macroeconomic objectives, can be seen as an important structural problem. This is due to unregistered employment, etc. It can also be caused by other factors. For this reason, policy makers can take measures for employment by strengthening controls on employees and employers. If there is no shadow economy, then the question of why employment levels are not increasing while the production of goods and services is increasing can be the subject of in-depth research. In this context, it is important to increase incentives to increase employment. It may also be necessary to analyse the wage equilibrium in the labour market.

Therefore, the results of this study support the views of Barro (1991) and Mankiw, Romer, and Weil (1992) that capital accumulation is an important source of growth, especially in low- and middle-income economies. This also coincides with the view in endogenous growth theories that capital accumulation will create continuous effects on growth through technological innovations and productivity increases. However, the effect of capital and total factor productivity on growth in this study also contradicts the idea that growth in energy-intensive sectors in Aghion and Howitt's (1998) model may limit the effects on employment. In conclusion, this study is largely consistent with growth theories in the literature and makes an important contribution to the understanding of growth dynamics in developing countries, such as Turkey. However, more detailed studies to understand the reasons for this limited impact on employment may fill this gap.

Declaration of Research and Publication Ethics

This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher's Contribution Rate Statement

Since the author is the sole author of the article, the contribution rate is 100%.

Declaration of Researcher's Conflict of Interest

There are no potential conflicts of interest in this study.

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