Akademik Araştırmalar ve Çalışmalar Dergisi 2023, 15(29), 437-454
Journal of Academic Researches and Studies 2023, 15(29), 437-454
https://doi.org/10.20990/kilisiibfakademik.1376072

Makale Türü: Araştırma Makalesi
Paper Type: Research Paper

Geliş Tarihi/Received Date: 14.10.2023
Kabul Tarihi/Accepted Date: 21.11.2023

The Nexus of Structural Change, Trade Openness, Renewable Energy and Economic Growth in Türkiye, 1970-2020

Türkiye'de Yapısal Değişim, Ticari Açıklık, Yenilenebilir Enerji ve Ekonomik Büyüme Bağlantısı, 1970-2020

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Abstract

Purpose: This paper aims to investigate the effects of structural change, trade openness, and renewable energy on economic growth in Türkiye.

Design/Methodology: Structural change is defined as the shift of resources from the agricultural sector to the industrial sector and then to the services sector. In the structural change process, it is accepted that the manufacturing industry is the engine of growth. However, since the mid-1970s, especially in the post-1980 period, the manufacturing industry has lost its importance. In addition, trade liberalisation and energy policies came to the fore in this process. In this context, this paper analyses the determinants of economic growth within the framework of the structuralist approach. For this, we apply the ARDL bounds test approach and apply FMOLS, DOLS, and CCR for robustness check.

Findings: According to the ARDL bounds test results, the manufacturing industry, renewable energy, and trade openness affect economic growth positively; however, the coefficient of renewable energy is statistically insignificant. The results of the robustness check (FMOLS, DOLS, and CCR) also confirm these findings. The effect of the manufacturing industry on economic growth is greater than that of other variables.

Limitations: To analyse the impact of structural change on economic growth in the Türkiye, the study is limited to the period 1970-2020.

Originality/Value: The originality of our paper is that it analyses the impact of structural transformation (such as the manufacturing industry, trade openness, and renewable energy) on long-run economic growth in Türkiye.

Keywords: Structural Change, Trade Openness, Renewable Energy, Economic Growth, ARDL Bounds Test.

Öz

Amaç: Bu çalışma, Türkiye'de yapısal değişim, ticari açıklık ve yenilenebilir enerjinin ekonomik büyüme üzerindeki etkilerini araştırmayı amaçlamaktadır.

Tasarım/Yöntem: Yapısal değişim, kaynakların tarım sektöründen sanayi sektörüne ve ardından hizmetler sektörüne kayması olarak tanımlanmaktadır. Yapısal değişim sürecinde imalat sanayi büyümenin motoru olduğu kabul edilmektedir. Ancak 1970'lerin ortalarından itibaren, özellikle 1980 sonrası dönemde imalat sanayi önemini kaybetmiştir. Ayrıca bu süreçte ticaretin serbestleştirilmesi ve enerji politikaları da ön plana çıkmıştır. Bu bağlamda, bu çalışma ekonomik büyümenin belirleyicilerini yapısalcı yaklaşım çerçevesinde analiz etmektedir. Bunun için ARDL sınır testi uygulanmış ve sağlamlık kontrolü için ise FMOLS, DOLS ve CCR uygulanmıştır.

Bulgular: ARDL sınır testi sonuçlarına göre imalat sanayi, yenilenebilir enerji ve ticari açıklık ekonomik büyümeyi pozitif yönde etkilemektedir; ancak yenilenebilir enerjinin katsayısı istatistiksel olarak anlamsızdır. Sağlamlık kontrolünün (FMOLS, DOLS ve CCR) sonuçları da bu bulguları doğrulamaktadır. İmalat sanayinin ekonomik büyüme üzerindeki etkisi diğer değişkenlere göre daha fazladır.

Sınırlılıklar: Yapısal değişimin Türkiye'de ekonomik büyüme üzerindeki etkisini analiz etmek amacıyla, çalışma 1970-2020 dönemiyle sınırlandırılmıştır.

Özgünlük/Değer: Çalışmamızın özgünlüğü, Türkiye'de yapısal dönüşümün (imalat sanayi, ticari açıklık ve yenilenebilir enerji gibi dinamiklerin etkisi) uzun dönem ekonomik büyüme üzerindeki etkisini analiz etmesidir.

Anahtar Kelimeler: Yapısal Değişim, Ticari Açıklık, Yenilenebilir Enerji, Ekonomik Büyüme, ARDL Sınır Testi

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1. INTRODUCTION

After World War II, a significant industrialisation trend began in the world economy. For many developing countries, especially those that have just gained independence, development and growth meant the same as industrialisation. In this period, distinguished development economists such as Rosenstein-Rodan (1943) and Nurkse (1952) suggested that the development problems of developing countries would be solved by industrialisation and that policies should be produced in this direction. Because it is generally accepted that developing countries can only close the development gap with developed countries through industrialisation (Schmitz, 2015). This view actually forms the basis of structuralist economics.

Neo-classical economics, the dominant view in economics, ignores the relationship between structural change and economic growth. Unlike this view, structuralist economics emphasises that the manufacturing sector plays a central role in disseminating technological advancement and structural change. This paper aims to scrutinise the link between structural change, renewable energy, trade openness, and growth in Türkiye for the 1970-2020 period. Hence, the contribution of the paper to the literature by analysing the long-run effects of structural change on the economic growth in the Türkiye from 1970 to 2020. In this context, this paper concentrates on the long-run effects of the structural transformation process of the Türkiye. Our paper consists of seven sections. After the introduction, the second section presents the sectoral composition of the Gross Domestic Product (GDP) in Türkiye and the World economy. The third section presents the literature background. The fourth section presents the data and methodology. The fifth section presents empirical estimation and findings. The sixth section presents a discussion of the empirical findings. The seventh section presents conclusions and policy recommendations.

2. THE HISTORICAL OVERVIEW OF THE WORLD AND TÜRKİYE'S GDP and SECTORAL COMPOSITIONS

Structural transformation refers to a process occurring in the economy, and it is possible to reveal the background of this process with the change in GDP growth rates in different countries and regions. In this context, Table 1 presents the growth rates of GDP and GDP per capita in the world and some regions. The world economic growth rate is 4.91% in 1950-73. However, this growth rate in the world economy decreased to 3.01% in the 1973-98 period. For the period 1950-1973, the economic growth rates in other regions are respectively 4.81% in Western Europe, 4.03% in Western Offshoots, 9.29% in Japan, 5.18% in Asia, 5.33% in Latin America, 4.84% in Eastern Europe & former USSR, and 4.45% in Africa. It is seen that the same trend also occurs in GDP per capita. Over the period 1950-73, the GDP per capita growth rate is respectively 2.52% in the world, 4.01% in Western Europe, 2.44% in Western Offshoots, 8.05% in Japan, 2.92% in Asia, 2.52% in Latin America, 3.49% in Eastern Europe & former USSR, and 2.07% in Africa. Another finding that stands out in Table 1 is that only Asia (excluding Japan) has increased its growth rate in the 1973-98 period. This may be due to the continuation of industrialisation in Asia (McMillan et al., 2014). In brief, the world and the regions had the highest growth rates in 1953-1973 compared to the other periods.

Table 1: Growth of GDP and Per Capita GDP in the World and Regions, 1000-1998 (%)

Region/Period	1000–1500	1500–1820	1820–70	1870–1913	1913–50	1950–73	1973–98
GDP							
Western Europe	0.3	0.41	1.65	2.1	1.19	***4.81***	2.11
Western Offshoots	0.07	0.78	4.33	3.92	2.81	***4.03***	2.98
Japan	0.18	0.31	0.41	2.44	2.21	***9.29***	2.97
Asia (excluding Japan)	0.13	0.29	0.03	0.94	0.9	***5.18***	***5.46***
Latin America	0.09	0.21	1.37	3.48	3.43	***5.33***	3.02
Eastern Europe & former USSR	0.2	0.44	1.52	2.37	1.84	***4.84***	–0.56
Africa	0.06	0.16	0.52	1.4	2.69	***4.45***	2.74
World	0.15	0.32	0.93	2.11	1.85	***4.91***	3.01
GDP per capita							
Western Europe	0.13	0.15	0.95	1.32	0.76	***4.08***	1.78
Western Offshoots	0.00	0.34	1.42	1.81	1.55	***2.44***	1.94
Japan	0.03	0.09	0.19	1.48	0.89	***8.05***	2.34
Asia (excluding Japan)	0.05	0	–0.11	0.38	–0.02	***2.92***	***3.54***

Latin America	0.01	0.15	0.1	1.81	1.42	***2.52***	0.99
Eastern Europe & former USSR	0.04	0.1	0.64	1.15	1.5	***3.49***	–1.10
Africa	–0.01	0.01	0.12	0.64	1.02	***2.07***	0.01
World	0.05	0.05	0.53	1.3	0.91	***2.93***	1.33

Source: Maddison, 2017.

Therefore, the literature argues that growth resulting from industrial investments and production occurred in this period. Consequently, industrialisation policies gained importance in this period and increased industrial production and inward-oriented and import substitution-based industrialisation policies have been implemented to accelerate industrialisation and to protect and develop domestic industry (Soydan, 2018). Moreover, developing countries experienced significant economic growth, and therefore 1950-1973 period is called as the golden age of growth (Rodrik et al., 2016).

However, with the Oil Shock (1973), these policies (import-substitution industrialisation and inward-oriented growth policies) began to be questioned and lost popularity for several decades (since the 1980s). In addition, developed and developing economies have undergone a structural transformation with globalisation. With this transformation, export-led and outward-oriented growth policies gained importance in the world economy. In this framework, the contribution of the services sector to growth has also been questioned (Yeldan, 2016). However, re-industrialisation policies gained importance after the 2008-2009 global financial crisis (Stiglitz, 2017; Tregenna, 2013). Table 2 shows the growth rates of GDP and per capita GDP in the world and region from 1992-2020. When Table 1 and Table 2 are compared, it can be seen that the growth rates achieved in the post-1990 period were lower than the economic growth rates achieved in the 1975-1973 period.

Similarly, except for the Asian region, the GDP per capita growth rate in the period 1950-1973 is higher than in the period after 1990. At the same time, it is seen that the growth rate of GDP and GDP per capita in developing countries is higher than that of developed countries. Diao et al. (2017) argues that the reason for this is that structural changes have occurred in developing countries (particularly in Asia). However, the authors suggest that the growth rate in Latin America has decreased significantly since 2000 due to a lack of dynamic structural changes. Figure 1 is drawn for this purpose. Figure 1 illustrates the shares of sectors in the GDP of developed and developing countries between 1970 and 2020.

Table 2: Growth of GDP and Per Capita GDP in the World and Regions, 1992-2020 (%)

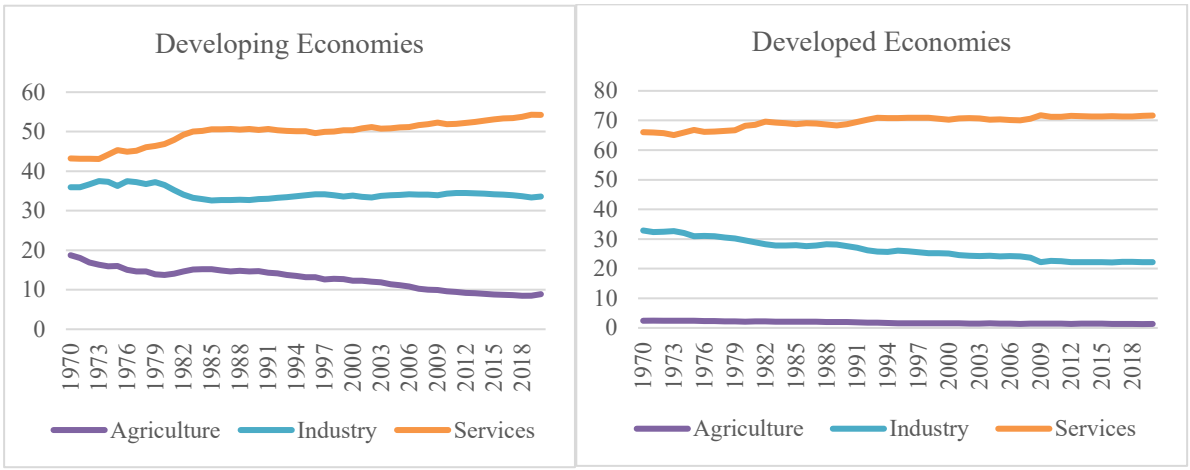
Region/Period	1992- 1995	1995- 2000	2000- 2005	2005- 2010	2010- 2015	2015- 2020
			GDP			
World	1.25	2.16	1.89	1.23	1.71	0.96
Africa	-0.97	0.99	2.85	2.63	1.37	-0.53
Americas	1.68	2.59	1.39	0.15	1.13	0.20
Latin America and the Caribbean	1.63	1.22	1.26	2.29	1.17	-1.81
Asia	2.97	2.26	3.85	4.32	4.08	2.82
Europe	0.85	2.86	2.03	0.61	0.92	0.79
Oceania	2.56	2.27	1.87	0.59	1.00	0.26
Developing economies	*3.27*	*2.74*	*4.15*	*5.03*	*3.89*	*2.14*
Developed economies	*1.63*	*2.91*	*1.96*	*0.33*	*1.26*	*0.89*
			GDP Per Capita			
World	1.25	2.16	1.89	1.23	1.71	0.96
Africa	-0.97	0.99	2.85	2.63	1.37	-0.53
Americas	1.68	2.59	1.39	0.15	1.13	0.20
Latin America and the Caribbean	1.63	1.22	1.26	2.29	1.17	-1.81
Asia	2.97	2.26	3.85	4.32	4.08	2.82
Europe	0.85	2.86	2.03	0.61	0.92	0.79
Oceania	2.56	2.27	1.87	0.59	1.00	0.26
Developing economies	*3.27*	*2.74*	*4.15*	*5.03*	*3.89*	*2.14*
Developed economies	*1.63*	*2.91*	*1.96*	*0.33*	*1.26*	*0.89*

Source: https://unctadstat.unctad.org/datacentre/

In developed countries, it is observed that the share of industry in GDP has shown a severe decline. The industrial sector's contribution to the GDP is an average of 26%. The percentage of the services sector is almost stable and around 70% throughout the period. The share of the agricultural

sector is relatively small, constituting only 2% of GDP. In developing countries, the industry share in GDP is almost stable, averaging 34%. There has been an increase in the services sector, and the share of the services sector is 50% on average. The percentage of the agricultural sector has declined, and the share of the agriculture sector (including forestry, fishing, and hunting) accounts for 13% of the GDP. As illustrated in Figure 1, the proportion of the industrial sector in the GDP of developing countries is higher than that of developed countries.

Figure 1: Economic Activities in Developing and Development Countries, 1970-2020 (%)



Source: https://unctadstat.unctad.org/datacentre/

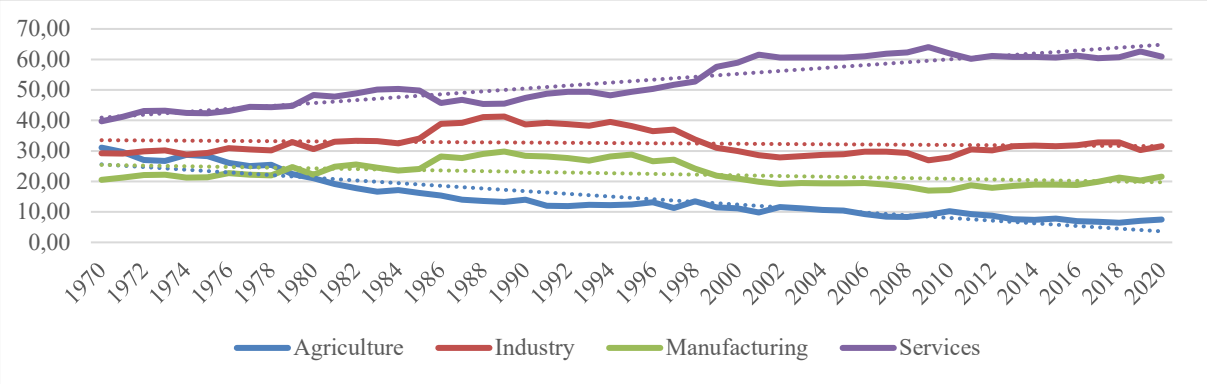
Türkiye's economy has also been seriously affected by these global developments and has experienced a significant structural transformation. In this context, the Türkiye's economy abandoned import-substitution and inward-oriented policies after 1980 and implemented outward-oriented and export-led growth policies. Since 1980, Türkiye implemented an outward-oriented economic growth strategy with the 24th January Decisions, and after these decisions, a trade liberalisation process began. The Türkiye's economy completed this with the liberalisation of financial and capital accounts in 1989. As a result, Türkiye has become more integrated into the world economy since the early 1980s, and this process accelerated after the 1990s (Kazgan, 2021; Yeldan, 2016). Figure 2 and Figure 3 are drawn to see how the growth moved along with the policies implemented in the post-1980 period. Figure 2 shows the growth rates of GDP and GDP per capita in Türkiye for the period 1970-2020. Upon analysing Figure 2, it can be suggested that the economic growth in Türkiye is unstable and fragile. Türkiye's lowest growth rates are observed during the crisis periods of 1994, 2001, and 2008. In 1976 and 2011, growth is above 10%. It can be argued that economic growth is more fragile in the post-1990 period. Throughout 1970-2020 period, GDP and per capita GDP growth rates are 4% and 2.72%, respectively.

Figure 2: Economic Growth in Türkiye, 1970-2020 (%)

Source: https://unctadstat.unctad.org/datacentre/

Figure 3 indicates the sectoral composition of GDP (%) in Türkiye for the period 1970-2020. Based on Figure 3, it can be observed that Türkiye's economy has shifted towards a more service-oriented structure since the 1970s. The agricultural sector has been on a constant downward trend since 1980, with its share in GDP lower than other sectors. It is clear from the slope lines that the agricultural and services sectors move in opposite directions. It is observed that the share of the industrial and manufacturing sectors in GDP move in a similar trend. Except for the 1985-2000 period, it can be said that the industrial and manufacturing industry sectors remained almost stable. In the 1970-2020 period, the shares of agriculture, industry, manufacturing, and services in GDP are 15%, %33, %23, and 53%, respectively.

Figure 3: The Sectoral Composition of GDP in Türkiye, 1970-2020 (%)



Source: https://unctadstat.unctad.org/datacentre/

3. LITERATURE BACKGROUND

There is extensive literature about the impacts of structural change, and the fact remains that our paper analyses the impacts of structural change, trade openness, and renewable energy on growth in Türkiye. In this context, the literature review is focused on these topics and divided into three sub-sections: i-) the link between structural change and economic growth, ii-) the link between trade openness and economic growth, iii) the link between renewable energy and economic growth.

3.1. Economic Growth and Structural Change

It is generally accepted that neo-classical economics does not consider the relationship between structural change and growth. In neo-classical economics, economic growth depends on dynamics such as savings, production, capital accumulation, and technological advances (McMillan et al., 2014). In the economic literature, there is a consensus that dynamics such as innovation and technological diffusion are the main drivers of productivity growth. Accordingly, the structuralist approach suggests that the manufacturing industry is the main source of technological progress and distribution, dynamically increasing returns to scale (Nassif et al., 2014). According to the structural approach, economic/productivity growth occurs when economic activities and resources shift from agricultural to industry/manufacturing and to the services sector (Tregenna, 2015). Stiglitz (2017) also states that economic growth can occur without structural change, particularly in economies reliant on natural resources, but this is not sustainable economic growth. In addition to economic growth, structural change increases savings and investment rates, goods and services' quality and diversity, accelerates urbanisation, reduces income inequality, and improves institutions (Kuznets, 1973; Szirmai & Verspagen, 2015). Since the Industrial Revolution, it has been accepted that manufacturing is the driving force of growth. Therefore, structural change has become identical to manufacturing production, and structural change has been one of the characteristics of economic growth (Kaldor 1967; Kuznets, 1973). There are several reasons why manufacturing is accepted as the engine of growth or/and structural change. The manufacturing industry is crucial for capital accumulation, innovation, technological advancement, and productivity growth (Szirmai & Verspagen, 2015). The development of the manufacturing sector can stimulate growth through various mechanisms, such as backward and forward linkages and diffusion of technology and knowledge (Cantore et al., 2017).

In addition to theoretical studies in the literature, empirical studies examine the various effects of structural change. For example, Kaldor (1967) provides findings that the manufacturing industry is the main driving force of economic growth. In his seminal paper, Kuznets (1973) emphasised that one of the characteristics of modern economic growth is rapid structural change driven by the manufacturing industry. In their study, Szirmai and Verspagen (2015) examined the hypothesis that the manufacturing industry served as the driving force for growth in 88 countries between 1950 and 2005. They highlighted the positive impact of the manufacturing industry on economic growth and underscored its favourable influence on the workforce with higher education. Cantore et al. (2017) employed the GMM model to examine how manufacturing affects growth in 80 countries from 1980 to 2020. According to their results, the manufacturing industry is the engine of growth. Examining data from 1968 to 2016 using the ARDL model, Rauf et al. (2018) explored how industry, agriculture, services, trade openness, and energy influence carbon emissions within China's economy. Their findings highlighted a significant positive correlation between the industry and carbon emissions. Villanthenkodath et al. (2022) applied the ARDL model to examine the impacts of tourism activities and structural change on environmental quality in India for the 1995Q1-2016Q1 period. According to findings, structural change improved environmental quality. Between 1997 and 2017, Ravindran and Manalaya (2023) examined the links between structural transformation, foreign direct investment (FDI), trade openness and growth in sub-Saharan Africa. The results from the ARDL model showed that structural change negatively impacts economic growth, while FDI and trade openness positively impact growth.

Arısoy (2013) scrutinised the impact of industrial production on growth in Türkiye for the period 1963-2005 and found that industrial production positively affects economic growth. Güçlü (2013) affirmed that the manufacturing industry positively affected economic growth in Türkiye from 1990 to 2012. Mercan and Kızılkaya (2014) examined the link between the industrial sector and growth in Türkiye over the period 1988Q1-2013Q3. The findings showed a positive linkage between the industrial sector and growth. Canbay and Kırca (2020) emphasised that the manufacturing industry positively affected growth in Türkiye from 1961 to 2017. Kopuk (2021) also provided empirical findings that the manufacturing industry positively affected growth in Türkiye from 1997 to 2018. Sarıdoğan (2020) suggested that the manufacturing industry positively affected Türkiye's economic growth between 1986 and 2018. Pata and Zengin (2020) analysed the symmetrical and asymmetrical effects of the manufacturing industry on growth. Their findings showed that the manufacturing industry positively affected growth in Türkiye for the 1980-2014 period. Finally, Doğaner (2022) examined the nonlinear co-integration linkage between industrial production and growth in Türkiye from 1960 to 2020. According to the findings, it is claimed that the industrial sector does not sufficiently support economic growth.

3.2. Economic Growth and Trade Globalisation

Globalisation is a broad concept that includes multidimensional. These dimensions include cultural, social, economic, and political dynamics. Therefore, globalisation can affect various socio-economic dynamics, such as poverty, investment, inequality, employment, and economic growth (Kumeka et al., 2023). In this context, trade globalisation is also an important component of globalisation. The exchange of goods and services between countries characterises the globalisation of trade, measured by the ratio of exports and imports of goods and services to GDP (Adjei & Grega, 2023). Due to its influence on various economic processes, the connection between trade openness and growth has been scrutinised by several researchers in the existing literature. Documenting findings from 1993 to 2016, Raghutla (2019) reported a positive effect of trade openness on growth in emerging market economies. Covering the data period from 1993 to 2016, Kong et al. (2021) investigated the relationship between trade openness and growth in China, concluding that trade openness fosters growth. In analysing the non-linear linkage between trade openness and growth in the ASEAN-6 countries, Nguyen and Bui (2021) found that the fixed-random-effects results indicate a positive impact of trade openness on growth. Beri, Mhonyera and Nubong (2022) evaluated the effect of globalisation on growth in 47 selected African countries covering the period 2001-2008. They stated that the effect of globalisation is insignificant on growth. Yu and Meng (2023) found that trade openness contributes to output growth in their study of 123 countries from 1963 to 2011. Similarly,

Abubakar (2023) suggested that trade globalisation positively affected growth in SSA countries between 1990 and 2019. Finally, Kumeka et al. (2023) examined the impacts of various dimensions of globalisation on growth in 45 African countries between 1996 and 2018. According to the study's results, all components of globalisation positively impact growth.

Several studies investigate trade globalisation and economic growth nexus in Türkiye. For the period from 1989 to 2014, Ümit (2016) analysed the impact of trade openness and credit volume on growth and revealed that trade openness leads to a decrease in economic growth. Çeştepe et al. (2018) stated that trade openness did not support growth in 1998q1-2016q2. Also, Ersungur and Demirci (2018) suggested no causality relationship between growth and trade openness in 1998-2017. Applying the Konya (2016) causality test to 18 emerging market economies from 1992 to 2015, Özcan et al. (2018) discovered evidence of causality from trade openness to growth in Türkiye. Pata (2020) applied the ARDL method to examine how trade openness, capital stock, and financial development impacted growth in Türkiye from 1965 to 2017, uncovering a positive effect of trade openness on growth. Şahin and Temelli (2022) analysed the connection between trade openness, financial development, tourism revenues, and growth in Türkiye during the 1995-2019 period, ultimately concluding that trade openness positively impacts growth. Çetin et al. (2023) employed the FMOLS estimator to examine the connection between trade openness and growth in Türkiye from 1970 to 2018. The empirical results confirm a positive impact of trade openness on growth. Conducting research using the ARDL model, Ülker (2023) investigated the correlation between the tourism sector, trade openness, and growth in Türkiye over the period 1995-2020, with the findings demonstrating the positive effect of trade openness on economic growth.

3.3. Economic Growth and Renewable Energy

Recently, energy has become one of the critical drivers of growth, affecting different economic activities such as industries and households. Renewable energy is considered to be particularly important both for the promotion of economic growth and development and for environmental sustainability. Countries move towards renewable energy because it reduces environmental damage (Kilci, 2023; Xie et al., 2023). As a result, the role of renewable energy in promoting growth and development has been the focus of research. Examining the interconnection between renewable and non-renewable energy consumption, trade openness, and economic growth in Iran from 1979 to 2014, Yazdi and Shakouri (2017) found, based on the ARDL model, that renewable energy adversely impacts economic growth. The Granger causality test also revealed a unidirectional causality from renewable energy to economic growth. Employing the Konya (2016) causality test, Ozcan and Ozturk (2019) scrutinised the link between renewable energy and economic growth in 17 emerging countries during the period from 1990 to 2016. They assert that, except for Poland, there is no causality association between renewable energy and growth. During 2010-2019, Török (2023) ascertained that renewable energy consumption fosters economic growth in the European Union.

Alper (2018), using the Bayer-Hanck and Toda-Yamamoto tests in Türkiye from 1990 to 2017, concludes that renewable energy contributes to economic growth and observes a causality from growth to renewable energy. From 1965 to 2017, Apaydın et al. (2019) proposed that the using renewable energy has a positive impact on economic growth in Türkiye. Çandarlı and Unakıtan (2021) examined the impact of renewable energy use on Türkiye's sustainable economic growth from 1990 to 2019 and found that renewable energy use increases economic growth, further revealing the existence of unidirectional causality from renewable energy to growth. Ateş and Yağcı (2022) also found a positive contribution of renewable energy to Türkiye's economic growth between 1990 and 2020. Çetinbakış and Kutlu (2022) investigated the connection between renewable energy consumption, environmental sustainability, and economic growth in Türkiye from 1988 to 2019, using the ARDL model, and found a positive impact of renewable energy on growth. Employing the Toda-Yamamoto test, Demir (2023) investigated the link between renewable energy and economic growth in Türkiye from 1990 to 2019, concluding a unidirectional causality from renewable energy to growth. Analysing the causal link between renewable and non-renewable energy and growth in Türkiye from 1993 to 2020, Çınar (2023) revealed the presence of causality from renewable energy to economic growth based on the study results.

Based on our review of existing literature, empirical findings suggest a favourable impact of structural change on growth. However, the impact of renewable energy and trade openness on growth appears to be inconsistent. Notably, our study differs from others in the field in that it examines Türkiye's comprehensive structural transformation by analysing manufacturing, renewable energy, and foreign trade processes together. Moreover, the examination of a longer period (1970-2020) specific to Türkiye is the uniqueness of this paper. Therefore, this research is expected to contribute to the existing literature significantly.

4. DATA AND METHODOLOGY

Our paper aims to examine the connection between renewable energy, trade openness, structural change, and growth in Türkiye from 1970 to 2020. As a proxy for growth, the study uses gross domestic product. The index of trade globalisation is used as a proxy for trade openness. With control variables such as renewable energy and trade openness, our paper focuses on the long-run effects of structural change on growth. A summary of the data used in this research, together with the sources of the data, is presented in Table 3.

Table 3: The Variables Definition

Variables	The Definition of Variable	Data Source
lngdp	GDP is taken in constant (2015) prices and US dollars.	https://databank.worldbank.org/
lnman	Manufacturing industry production index (2015 = 100)	https://stats.oecd.org/
lntropn	Trade globalisation index	https://ethz.ch/en.html
lnrnw	Renewable energy consumption per capita.	https://ourworldindata.org/energy

In light of the related studies in the literature, the empirical model for analysing the effects of the manufacturing industry, trade openness, renewable energy consumption, and growth can be represented (Szirmai & Verspagen, 2015; Rauf et al., 2018):

$$lngdp_t = \beta_0 + \beta_1 lnman_t + \beta_2 lntropn_t + \beta_3 lnrnw_t + \varepsilon_t \quad (1)$$

where β_0 represents for the constant term, β_1, β_2, and β_3 represents coefficients of the parameters, i.e. lnman, lnrnw, and lntropn, respectively, and ε_t denotes error term. In the model, all variables are normalised using natural logarithms. Equation (1) represents the dynamic relationship between structural change, trade openness, renewable energy, and growth. In an economy, in the growth/development process, production activities shift from the agriculture to the industry sector and from the industry sector to the services sector. In this structural change (Kuznets, 1973), the main driving force of economic growth is the manufacturing industry sector (Kaldor, 1967). For this reason, the manufacturing industry production index is included in the model. However, with the acceleration of globalisation trends in the post-1980 period, the Türkiye's economy underwent a significant transformation and followed a policy of integrating with world markets (Kazgan, 2021; Yeldan, 2016). Therefore, the model incorporates the variable of trade openness. The decision to include renewable energy in the model also reflects the current surge of interest in this area and the belief that it significantly impacts growth and structural change (Rauf et al., 2018; Szirmai & Verspagen, 2015).

The Autoregressive Distributed Lag (ARDL) bounds testing approach is employed to examine the impact of the manufacturing industry, renewable energy, and trade globalisation on economic growth. The ARDL model was first developed by Peseran, Shin & Smith (2001), which has some advantages. First, the ARDL model can be applied even with a small sample size. Another advantage of the ARDL model is its ability to produce unbiased estimates of the long-term model and valid t-statistics, even when some of the regressors are endogenous. Finally, the ARDL model can also be applied if independent variables are I(0), I(1), or both I(0) and I(1), provided that the dependent variable is I(1) (Pesaran et al., 2001; Villanthenkodat et al., 2022).

In this study, the ARDL model is two-stage. A co-integration test is conducted in the first stage to assess the long-term linkage between the variables. The ARDL bounds testing is based on an F-statistic for co-integration analysis. For the co-integration relationship, the following model is established (Kong et al., 2021):

$$\Delta lngdp_t = \beta_0 + \sum_{t=1}^{n} \beta_{1i} \Delta lngdp_{t-i} + \sum_{t=0}^{n} \beta_{2i} \Delta lnman_{t-i} + \sum_{t=0}^{n} \beta_{3i} \Delta lntropn_{t-i} + \sum_{t=0}^{n} \beta_{4i} \Delta lnrnw_{t-i} + \theta_1 lngdp_{t-1} + \theta_2 lnman_{t-1} + \theta_3 lntropn_{t-1} + \theta_4 lnrnw_{t-1} + + \varepsilon_t \quad (2)$$

In equation (2), Δ is the first-order difference of the series, n is the lags of the series, and ε_t is the error term. The coefficients of $\theta_1, \theta_2, \theta_3, \theta_4$ show the co-integration relationship between the series. The co-integration relationship is tested in equation (2) through the below assumptions (Eshetu & Eshetu, 2021):

$$H_0 = \theta_1 = \theta_2 = \theta_3 = \theta_4 = 0 \quad \text{there is no co-integration} \quad (3)$$

$$H_1 \neq \theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4 \neq 0 \quad \text{there is co-integration} \quad (4)$$

Suppose the co-integration relationship is determined according to the F-bound test results. In that case, the short-run and long-run coefficients are estimated in the second stage. In the ARDL ($\rho_1, \rho_2, \rho_3, \rho_4$) model, the long-run coefficients are estimated as follows (Kong et al., 2021):

$$lngdp_t = \beta_0 + \sum_{i=1}^{\rho_1} \beta_{1i} lngdp_{t-i} + \sum_{t=0}^{\rho_2} \beta_{2i} lnman_{t-i} + \sum_{t=0}^{\rho_3} \beta_{3i} lntropn_{t-i} + \sum_{t=0}^{\rho_4} \beta_{4i} lnrnw_{t-i} + \varepsilon_t \quad (5)$$

The estimation of short-run coefficients is accomplished through the utilisation of the error correction model (ECM) in the following (Rauf et al., 2018; Kong et al., 202):

$$\Delta lngdp_t = \beta_0 + \sum_{i=1}^{\rho_1} \beta_{1i} \Delta lngdp_{t-i} + \sum_{i=0}^{\rho_2} \beta_{2i} \Delta lnman_{t-i} + \sum_{i=0}^{\rho_3} \beta_{3i} \Delta lntropn_{t-i} + \sum_{t=0}^{\rho_4} \beta_{4i} \Delta lnrnw_{t-i} + \delta ECM_{t-1} + \varepsilon_t \quad (6)$$

Equation (6) is the lagged value of the residuals of long-term, and the term ECM_{t-1} shows the error correction part of the ARDL. The symbol δ in Equation (6) shows how much of an imbalance that occurs in the short term will be corrected in the long-run. For the model to work, this coefficient must be negative and statistically significant (Demir & Uzan, 2023).

5. EMPIRICAL ESTIMATION AND FINDINGS

5.1. Preliminary Test (Unit Root Tests and Optimal Lag Length)

Before applying the ARDL model, the implementation of stationarity tests of the variables is necessary. Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) unit root tests are used for this purpose. The results of the unit root tests are presented in Table 4. The results of ADF and PP indicate that all variables are stationary at the first difference I(1). If the dependent variable is stationary at first differences I(1) and the independent variables are stationary at the level I(0) or stationary at first differences I(1), or a mix of both I(0)/I(1), the ARDL can be applied (Mohamed et al., 2021; Pesaran et al., 2001).

Table 4: Unit Root Test Results

Variables		ADF		PP	
		I (0)	I (1)	I (0)	I (1)
lngdp	c	-0.2811 (0.9202)	-6.7247 (0.0000)***	-0.2826 (0.9199)	-6.7189 (0.0000)***
	c & t	-2.7668 (0.2159)	-6.6523 (0.0000)***	-2.9028 (0.1704)	-6.6442 (0.0000)***
lnman	c	-0.4993 (0.8825)	-6.7142 (0.0000) ***	-0.4938 (0.8836)	-6.8901 (0.0000) ***
	c & t	-0.8157 (0.9553)	-6.6418 (0.0000) ***	-2.8162 (0.1985)	-6.7956 (0.0000) ***
lntropn	c	-1.3088 (0.6185)	-5.7889 (0.0000) ***	-1.3088 (0.6185)	-6.3782 (0.0000) ***
	c & t	-1.4677 (0.8275))	-5.8983 (0.0001) ***	-1.4436 (0.8354)	-6.4088 (0.0000) ***
lnrnw	c	-1.4356 (0.5575)	-8.2030 (0.0000) ***	-1.2994 (0.6229)	-8.6379 (0.0000) ***
	c & t	-2.7481 (0.2228)	-8.1714 (0.0000) ***	-2.6707 (0.2527)	-8.7923 (0.0000) ***

Note:
1. c; constant, c & t; constant & trend.
2. For the ADF test, the lag length is determined by the Akaike Information Criterion (AIC), and the maximum lag is 1
3. The spectral estimation method Bertleet Kernel and Newey-West Bandwidth is chosen for the PP test.

Following the unit root tests, the ARDL bounds test approach is implemented. However, for the ARDL bounds testing, first, optimal lag lengths should be determined. Optimal lag lengths are determined by VAR analysis. The lag lengths determined by VAR analysis are given in Table 5, and

the results show that the optimal lag is 1. For this reason, 1 lag length and Akaike Information Criteria (AIC) are chosen while estimating the model.

Table 5: Optimal Lag Lengths

Lag	LogL	LR	FPE	AIC	SC	HQ
0	101.8786	NA	1.67E-07	-4.25559	-4.09658	-4.19603
1**	***294.5717***	***343.4963****	***7.71e-11****	***-11.93790****	***-11.14284****	***-11.64006****
2	300.0322	8.78441	1.24E-10	-11.4797	-10.0486	-10.9436
3	315.9432	22.82882	1.30E-10	-11.4758	-9.40863	-10.7014
4	330.6056	18.4873	1.50E-10	-11.4176	-8.71442	-10.405
5	348.7335	19.70423	1.58E-10	-11.5102	-8.17089	-10.2592

5.2. Co-integration Results

Peseran et al. (2001) recommend using the Fisher (F) test to determine the long-run co-integration relationship. The long-run co-integration is determined according to lower bounds I(0) and upper bounds I(1) critical values (Peseran, Shin & Smith, 2001). If the F-statistic is lower than the critical value I(0), the H_0 hypothesis (Equation 3) cannot be rejected. However, if the calculated F value is higher than the I(1) critical value, the H_0 hypothesis is rejected, and the alternative H_1 hypothesis (Equation 4) is accepted, and it will be decided that there is a long-term co-integration relationship. The bounds test (F-statistic) result is presented in Table 6, showing a long-run co-integration relationship between variables.

Table 6: ARDL Bounds Test (F-statistic) for Co-integration

F-statistic		10%		5%		1%	
	Sample Size	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
9.55681	45	2.560	3.428	3.078	4.022	4.270	5.412
	50	2.538	3.398	3.048	4.002	4.188	5.328
	Asymptotic	2.370	3.200	2.790	3.670	3.650	4.660

According to the F-statistics, there is a co-integration relationship. Long-run and short-run coefficients were estimated, and the long-run and short-run coefficient estimates are shown in Table 7. In the long-run, the estimated coefficient of manufacturing industry production is positive and statistically significant, indicating that a 1% increase in manufacturing industry production increases the GDP by 0.87909%. The coefficient of trade openness is also positive and statistically significant, which shows that a 1% increase in trade openness increases GDP by 0.25792%. However, the coefficient of renewable energy consumption per capita is positive and statistically insignificant, which reveals that a 1% increase in renewable energy consumption per capita increases GDP by 0.01055%.

In the short-run, the estimated coefficient of manufacturing industry production has a positive and significant effect on GDP, which indicates that a 1% increase in manufacturing industry production increases the GDP by 0.557935%. The coefficient of renewable energy consumption per capita also has a positive and significant impact on GDP, which reveals that a 1% increase in renewable energy consumption per capita increases GDP by 0.034933%. However, in the short-run, the estimated coefficient of trade openness has a negative and insignificant effect on GDP. The coefficient of trade openness indicates that a 1% increase in trade openness decreases GDP by -0.034933%.

Error correction model (ECM) is implemented to test whether the ARDL model works in the long-run. The ECM expresses how long it will take for a deviation in the short-run equilibrium to converge to the long-run equilibrium. The ECM coefficient is between -1 and 0, as expected and is statistically significant. This means that any short-run imbalance in the model converges to the long-run equilibrium. In other words, a fluctuation in the short-term means that it will converge to the long-term equilibrium after approximately 30 per cent.

Table 7: ARDL Estimated Results

Long-Run		Short-Run	
Variables	**Coefficient**	**Variables**	**Coefficient**
lnman	0.87909 (0.00000)	Δlnman	0.557935 (0.0000)
lntropn	0.25792 (0.00603)	Δlntropn	-0.034933 (0.4975)
lnrnw	0.01055 (0.73581)	Δlnrnw	0.038035 (0.0013)
		ECM	***-0.307675 (0.0000)***

Note: 1-) Parenthesis shows p-value.

5.3. Stability Test and Diagnostic Tests

This paper conducts several diagnostic tests to confirm the estimation model's results. Diagnostic test results are presented in Table 8, and diagnostic results show no diagnostic problem in the model. Again, stability tests are performed, and Figure 4 (CUSUM) and Figure 5 (CUSUM-Squares) show the results of stability tests. The figures show that the ARDL model is stable over the specified periods (1970-2020), and there is no structural break. Because, in both figures, blue lines lie between the critical limits.

Table 8: Diagnostic Tests Results

	F-stat.	**Obs*R^2**
Autocorrelation Test (Breuch-Godfrey Serial Correlation LM Test)	1.1789 (0.3181)	2.7833 (0.2487)
Heteroscedasticity Test (Breusch-Pagan-Godfrey)	0.9382 (0.4877)	6.7615 (0.4541)
	t-statistic	**F-statistic**
Ramsey RESET Test	0.7079 (0.4830)	0.5011 (0.4830)
Normality Test (Jarque-Bera)	3.7048 (0.1568)	

Note: 1-) Parenthesis shows p-value.

Figure 4: CUSUM Test

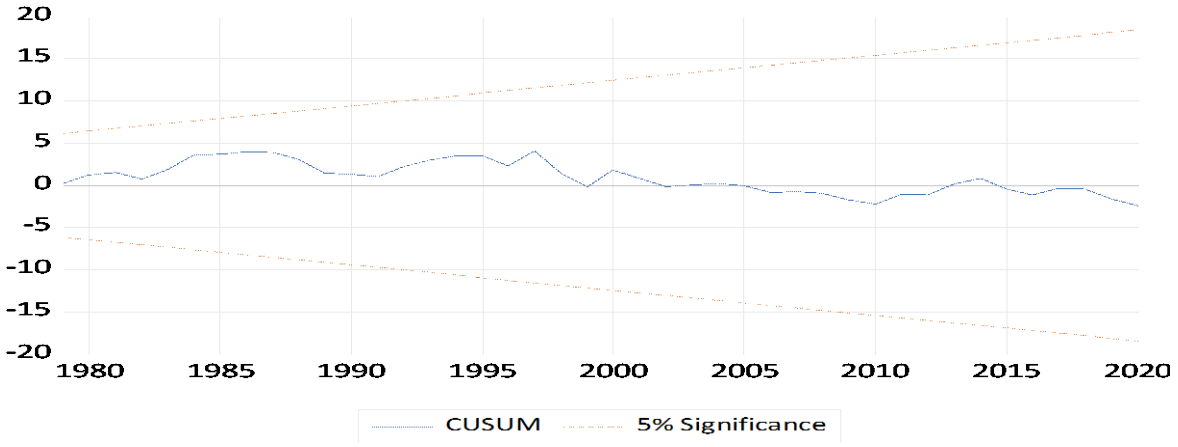
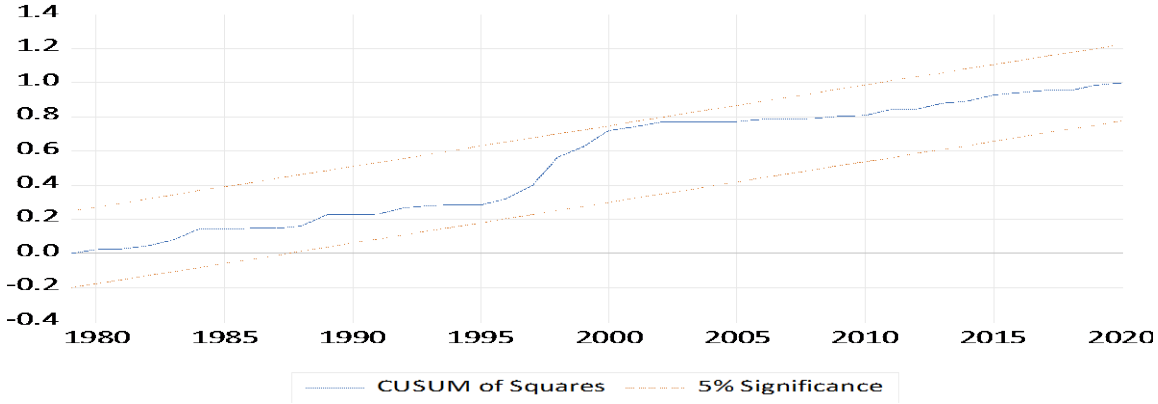


Figure 5: CUSUM-Squares Test



5.4. Robustness Check

The current paper employs the Johansen co-integration test to validate the findings of the ARDL bounds test (F-statistic). This paper also employs the FMOLS, the DOLS, and the CCR estimators to validate the findings of the ARDL long-run coefficients. In order to apply the Johansen co-integration test and FMOLS, DOLS, CCR estimators, all variables in the model must be stationary at first difference I(1). As seen in Table 4, all variables are stationary at the first difference I(1). The results of the Johansen co-integration test are present in Table 9. As can be seen in Table 9, Johansen co-integration provides trace and maximum eigenvalue test statistics. To confirm a long-term co-integration relationship in a Johansen co-integration analysis, the trace and max-eigenvalue statistical values must be more than the critical value (0.05). As shown in Table 9, the trace and max-eigenvalue tests indicate three long-run co-integration relationship between the variables at the 5% significance level.

Table 9: Results of Johansen Co-integration Test

Hypothesised No. of CE(s)	Eigenvalue	Statistics	Critical Value (0.05)	Prob.
Trace Values				
None*	0.519427	89.99695	55.24578	0.0000
At most 1*	0.468477	55.55647	35.01090	0.0001
At most 2*	0.375844	25.85202	18.39771	0.0038
At most 3	0.075672	3.698351	3.841465	0.0545
Max-Eigen Values				
None*	0.519427	34.44048	30.81507	0.0172
At most 1*	0.468477	29.70445	24.25202	0.0086
At most 2*	0.375844	22.15367	17.14769	0.0081
At most 3	0.075672	3.698351	3.841465	0.0543

Table 10 presents the outcomes of applying FMOLS, DOLS and CCR methods. Estimators indicate that the effects of the manufacturing industry production and trade openness on growth are positive and significant over the 1970-2020 period. Additionally, the impact of renewable energy consumption per capita is positive, although not statistically significant. Consequently, the estimators' results align with those of the ARDL model (Table 7).

Table 10: Results of FMOLS, DOLS and CCR

Variables	FMOLS	DOLS	CCR
lnmva	0.87455 (0.0000)	0.87724 (0.0000)	0.87751 (0.0000)
lntropn	0.27656 (0.0000)	0.28074 (0.0000)	0.27435 (0.0000)
lnrnw	0.00862 (0.6826)	0.00730 (0.7916)	0.00921 (0.6707)

Note: 1-) Parenthesis shows p-value.

6. DISCUSSION

Since the Industrial Revolution, it has been accepted that the manufacturing industry is the engine of economic growth, and structural change has become synonymous with the manufacturing industry (Kaldor, 1967; Kuznets, 1973). Particularly, in the post-1950 period, manufacturing has been seen as an important driver of economies. Therefore, manufacturing industry production increased in both developed and developing countries. Since the mid-1970s, however, the role of the manufacturing industry has started to be questioned, and the services sector has started to gain importance. Consequently, foreign trade and outward-oriented policies have also become more critical in this process. At the same time, renewable energy has recently been considered a crucial factor for economic growth, and it is believed that renewable energy reduces environmental damage. In this context, this paper utilises the effect of trade openness, structural change, and renewable energy on growth in Türkiye for the period 1970-2020.

The study's empirical results documented that manufacturing industry production positively affects growth. This result is in line with Arısoy (2013), Szirmai and Verspagen (2015), Rauf et al. (2018), Sarıdoğan (2020), Canbay and Kırca (2020), and Pata and Zengin (2022). The manufacturing industry is a critical sector for economic growth and development. Because it affects the overall

economy in two ways. First, the static effect of the manufacturing industry is related to the internal scale economies of the firm, which allows for large-scale production that reduces the firm's average cost. The second is the dynamic effect, which refers to the effect of production growth on capital accumulation through productivity gains resulting from factors such as learning by doing, technological transformation, external economies in production, spillover effects, etc. (Ateş, 2017; Cantore et al., 2016). Therefore, due to static and dynamic effects, Kaldor (1967) suggests that manufacturing is the growth engine.

Trade openness is another crucial dynamic in our empirical model. Our study's results indicate that trade openness positively and significantly affects growth. This result is in line with Özcan, Özmen & Özcan (2018), Raghutla (2019), Pata (2020), Kong et al. (2021), Nguyen and Bui (2021), Şahin and Temelli (2022), Yu and Meng (2023), and Çetin et al. (2023). The effect of trade openness is controversial. For example, the results of the study by Beri, Mhonyera and Nubong (2022) suggest an insignificant impact of trade openness on growth. Çeştepe et al. (2018) and Ersungur and Demirci (2018) have all pointed to the absence of a causality between trade openness and economic growth. Moreover, according to Ümit (2016), trade openness leads to a decline in economic growth. Compared with closed economies, open economies may have faster economic growth rates. Trade openness can provide several advantages: i-) trade openness can improve domestic technology, increase production efficiency, and increase production, ii-) trade openness can provide more opportunities for export and import, and iii-) trade openness can lead to new employment opportunities. Therefore, trade openness can significantly affect economic growth (Nguyen & Bui, 2021; Raghutla, 2019).

Another control variable in our model is renewable energy consumption. Based on our empirical findings, the impact of renewable energy on economic growth is positive but statistically insignificant. This result is in line with Alper (2018), Apaydın, Güngör and Taşdoğan (2019), Çandarlı and Unakıtan (2021), and Çınar (2023). Energy is a key determinant of economic growth and sustainable development. Also, it is a crucial intermediate input in industrial production and a part of every stage of the manufacturing process. Moreover, it is a crucial intermediate input in industrial production and a part of every stage of the manufacturing process. Therefore, economies depend heavily on energy. However, increasing energy demand, limited primary energy resources, and negative environmental impacts have led economies to shift towards renewable energy. Renewable energy has the potential to impact economic growth in the following ways positively: i) creating opportunities for businesses, employment, and entrepreneurs and ii) fostering an overall increase in welfare through the heightened consumption of renewable energy (Alper, 2018; Kilci, 2023; Xie et al., 2023).

7. CONCLUSION AND POLICY RECOMMENDATIONS

While the neoclassical approach neglects the connection between structural change and economic growth, it emphasises that economic growth depends on dynamics such as saving, technological progress, and capital accumulation. On the other hand, the structuralist approach sees innovation and technological progress as the primary source of productivity growth and believes that the manufacturing industry is the main factor in spreading technological progress. Moreover, according to the structuralist approach, manufacturing is the primary sector that increases overall productivity, and structural change is seen as an essential factor for developing countries to catch up with developed countries. In this context, in the 1950-1975 period, when industrialisation gained importance, an important structural change process was experienced, especially in developing countries, and an important development in economic growth occurred. For this reason, the 1950-1975 period is defined as the golden age of growth. However, in the post-1980 period, globalisation and neoliberal policy trends gained importance in the world economy. As a result, import substitution and inward-oriented growth policies were abandoned, and export-oriented and outward-oriented policies were adopted in the world economy. As a result, industrialisation and structural change lost importance, and the services sector gained importance. Especially in the post-1980 period, factors such as foreign trade, trade openness, and energy have become essential dynamics for economic growth.

The Türkiye’s economy also reflected the economic change and transformation process experienced in this period. With this process, Kılıçaslan and Taymaz (2006) stated that industrial

production lost importance, the services sector came to the fore, and labour-intensive sectors increased production and employment in Türkiye. In this context, this paper analysed the impact of structural change, trade openness and renewable energy consumption on economic growth in Türkiye over the period 1970-2020. For this purpose, this paper employed the ARDL model, FMOLS, DOLS, and CCR estimators to reveal the relationship between variables. According to the results of the ARDL model: i) the manufacturing sector has a positive and significant impact on growth in the long-run and short-run, ii) trade openness contributes significantly to economic growth in the long run but has a negative and significant impact in the short run, iii) the consumption of renewable energy has a positive and insignificant impact on economic growth in the long run but has a positive and significant impact in the short run. Following the ARDL model, this paper utilised the FMOLS, DOLS, and CCR estimators for robustness checks. The findings from these estimators demonstrated that the manufacturing industry and trade openness have a positive and significant impact on long-run economic growth. In addition, the results from the same estimators revealed that renewable energy consumption has a positive yet insignificant effect on long-run economic growth. As a result, the findings obtained in this paper show that the manufacturing industry is the main driver of growth in the Türkiye's economy over the period 1970-2020.

As Tregenna (2013, 2015) stated, re-industrialisation policies gained importance after the 2008-2009 global crisis and accelerated industrialisation trends. Therefore, in the context of the findings of our paper, i-) industrialisation policies should be emphasised, ii-) high value-added products should be produced, iii-) medium- and high-tech manufacturing industry production should be supported, iv-) policies to increase productivity in the manufacturing industry should be implemented, v- to increase productivity, policies to direct skilled labour force to the right sectors should be implemented, vi-) export-oriented policies should be produced in the manufacturing industry, vii-) exports of technology-intensive products should be supported and encouraged to reduce the impact of external shocks in the process of trade liberalisation, viii-) to minimise the effect of imported intermediate inputs on inflation, policies to reduce imported intermediate input dependency should be implemented, ix-) in developing economies, renewable energy consumption is still low compared to developed economies; therefore, investments should be increased so that renewable energy can affect economic growth.

Etik Beyan: *Bu çalışmada "Etik Kurul" izini alınmasını gerektiren bir yöntem kullanılmamıştır*
Yazar Katkı Beyanı*: Tüm yazarların katkı oranı eşittir.*
Çıkar Beyanı*: Yazarlar arasında çıkar çatışması yoktur.*
Ethics Statement: *In this study, no method requiring the permission of the "Ethics Committee" was used.*
Author Contributions Statement: *All authors contribute in same proportion.*
Conflict of Interest: *There is no conflict of interest among the authors.*

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