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SECTORAL CONVERGENCE ANALYSIS OF PRIMARY ENERGY CONSUMPTION IN TURKEY*

Türkiye'de Birincil Enerji Tüketiminde Sektör Yakınsama Analizi

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Keywords:
Energy Economics, Energy Consumption, Club Convergence Analysis, Moments Quantile Regression.

JEL Codes:
O13, P28, Q40, C31, O47.

Abstract

This study analyzes the energy consumption of sectors using the Phillips-Sul Club Convergence model and examines the relationship between sector value added, energy consumption, and deviations in energy prices via Quantile Moments Regression. First, the consumption of natural gas and petroleum products in the main sectors and sub-sectors in Turkey for the period 1992-2021 is examined using the club convergence method. In the second stage of the study, the factor cost and value-added data of the sectors are considered, and the effect of energy consumption and deviations in energy prices on value added is analyzed. In the first stage of the analysis, one club was identified in natural gas consumption among the sectors, while three clubs were identified in petroleum consumption. In the second stage of the analysis, according to the regression results applied to the converging sectors, it was determined that petroleum consumption positively affects the value added of the sectors in all quantiles. A positive and significant relationship was observed between the value added and natural gas consumption of the sectors.

Anahtar Kelimeler:
Enerji Ekonomisi, Enerji Tüketimi, Kulüp Yakınsama Analizi, Momentler Kantil Regresyonu.

JEL Kodları:
O13, P28, Q40, C31, O47.

Öz

Bu çalışma, sektörlerin enerji tüketimini Phillips-Sul Kulüp Yakınsama modeli ile analiz etmeyi ve sektörlerin katma değeri, enerji tüketimi ve enerji fiyatlarındaki sapmalar arasındaki ilişkiyi Momentler Kantil Regresyonu yöntemi ile ele almayı amaçlamaktadır. Çalışmada ilk olarak, 1992-2021 dönemi için Türkiye'deki temel sektörler ve bunların alt sektörlerinin doğalgaz ve petrol ürünleri tüketimi kulüp yakınsama yöntemiyle incelenmiştir. Çalışmanın ikinci aşamasında ise sektörlerin faktör maliyetiyle katma değer verileri ele alınmış, enerji tüketimi ile enerji fiyatlarındaki sapmaların katma değere etkisi analiz edilmiştir. Analizin ilk aşamasında kulüp yakınsama yöntemi ile doğalgaz ve petrol ürünleri tüketiminde yakınsayan sektörler tespit edilmiştir. Doğalgaz tüketiminde sektörler arasında bir adet alt kulüp oluşurken, petrol tüketiminde ise üç adet alt kulüp tespit edilmiştir. Analizin ikinci aşamasında, yakınsayan sektörler için uygulanan Momentler Kantil Regresyonu sonuçlarına göre, petrol tüketiminin tüm kantillerde sektörlerin katma değerini pozitif etkilediği tespit edilmiştir. Sektörlerin doğalgaz tüketimi incelendiğinde ise sektörlerin katma değeri ile pozitif ve anlamlı bir ilişki söz konusudur.

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1. Introduction

The increase in industrialization, one of the foundations of development, the growth of many sectors such as manufacturing and transportation, economic growth, population increase, and the beginning of the use of energy products in different areas, such as residential areas, have led to an increase in energy demand over the years.

Countries with high dependence on foreign energy products that cannot meet their own energy demand resort to energy imports to secure their energy supply. Turkey also has a high dependence on foreign energy. When examining the widely used natural gas and oil consumption data in the reports of the General Directorate of Energy Affairs, it is seen that in 2020, the total import of crude oil and petroleum products in Turkey was 47.6 million tons, while natural gas imports were 48.1 billion cubic meters (bcm). In contrast, domestic production was 3.2 million tons of crude oil and 458 million standard cubic meters (Sm^3) of natural gas (EİGM, 2022).

Since energy product consumption in Turkey consists mainly of imported energy, this situation has negative effects on the economy. In addition to the impact of high import figures on economic indicators, energy crises that may occur as a result of problems in energy supply will inevitably have sectoral repercussions in countries such as Turkey, which are highly dependent on foreign energy.

The subject of this study is to analyze sector convergence in natural gas and petroleum consumption in Turkey between 1992 and 2021 using the Phillips-Sul Club Convergence (convergence clubs) approach and, as a result of this analysis, to identify converging sectors and perform a second analysis using the Moments Quantile Regression analysis. In this context, a two-stage econometric analysis was applied in the study.

In the study, Turkey's natural gas and oil consumption data by sector between 1992 and 2021 were addressed using the Club Convergence method proposed by Phillips-Sul (2007) from convergence models. At a time when the importance of possessing energy resources is once again understood, the aim is to determine which sectors will be more affected than others in the event of crises in important energy resources such as oil and natural gas, and to reveal their impact on the economy. The study examines the impact of natural gas and oil consumption on sectors, based on Turkey's dependence on foreign energy sources and the fact that it imports almost all of its consumption of products such as oil and natural gas. A review of the literature on energy and convergence reveals that the sectoral aspect of the Phillips-Sul Club Convergence analysis has not yet been addressed in Turkey. The study aims to contribute by addressing this gap in the literature.

The study's scope is defined by the time frame, which covers the period from 1992 to 2021; the sectors considered, which are industry and its subsectors, transportation and its subsectors, housing and services, agriculture and livestock; and the selection of natural gas and petroleum from energy products. The reason for limiting the study to natural gas and petroleum consumption from energy sources is that, while there is dependence on foreign sources for many energy products used in Turkey, it is necessary to examine products that have a proportionally large share and play an important role in energy consumption and imports when considering their effects on macroeconomic variables, the market, and sectors. Regarding the determination of sectors, it is considered necessary to examine the sub-sectors that constitute the sectors rather than just the general consumption data of the sectors. With the aim of contributing to future literature, natural

gas and oil consumption have been preferred over the general total energy consumption data of the sectors.

The primary objective of the study is to examine natural gas and oil consumption by sector over the 30-year period from 1992 to 2021 and to determine whether there is convergence in the consumption of these energy sources among sectors using the Phillips-Sul method. The study determined whether there was a common convergence situation among sectors or whether sub-clubs had formed. Thus, the analysis conducted using the Phillips-Sul Club Convergence test will reveal how sectors will be affected in the event of potential energy crises or price fluctuations and how this will be reflected in macroeconomic variables. In addition, the analysis of whether sectors' energy consumption converges or not will also contribute to the development of energy policy recommendations. In the second stage of the analysis, the factor cost and value added of the sectors, the natural gas and oil consumption of the sectors, and the deviations in natural gas and oil prices were examined for the period 2009-2021. Factor cost and value-added data are not available for the period prior to 2009 due to the lack of data. In the second stage, the Moments Quantile Regression method was used. The effect of energy consumption and energy price deviations in the sectors on the added value of the sectors and the direction of the relationship between them were analyzed.

A review of the literature reveals that no study has yet been published on the sectoral analysis of natural gas and oil consumption in Turkey using the Phillips-Sul Club Convergence method. This study aims to address this gap in the literature. The literature generally shows that convergence analysis is performed by considering carbon dioxide emissions in major sectors or per capita energy consumption within a country's total energy consumption. One of the key points that distinguishes this study is that it examines natural gas and oil consumption data specifically by sector and their associated sub-sectors. Another important point is that this analysis will be conducted using the Phillips-Sul Club Convergence test among the convergence approaches.

In the continuation of the study, the Moments Quantile Regression method was applied as a regression analysis. This method, proposed by Machado and Silva (2019), is a new and original method, and its results are more reliable than those of first-generation quantile regression analyses. It is also a method that can be applied to different groups and conditions. In addition, it is a location-scaled model that allows for the inclusion of individual fixed effects and for individual effects to vary across quantiles. Applying this new approach with fixed effects facilitates the experimental understanding of heterogeneous relationship differences. This method also allows for the examination of heterogeneities at different conditional quantile distribution levels that cannot be obtained using traditional mean regressions (Miao et al., 2022).

Studies conducted using the Moments Quantile Regression method are quite limited, and no study addressing this issue from a sectoral perspective has yet been published in the literature. Studies have mostly focused on carbon dioxide emissions and carbon footprint. No study addressing Turkey has yet been published. It is anticipated that the study will offer unique value and contribute to the literature by addressing sectoral energy consumption, the added value of sectors, and deviations in energy prices.

2. Literature Review

In the literature review section of the study, energy and club convergence-based studies were examined first. Upon reviewing the literature, it was observed that the Phillips-Sul method was used to analyze convergence in terms of data such as energy efficiency, carbon dioxide emissions, and per capita energy consumption.

Although convergence growth models are generally associated with growth literature as a way of understanding income inequalities between countries and regions, convergence tests related to the energy sector have begun to appear in energy economics literature in recent years. If we group the studies, we see convergence analyses between energy intensity, energy efficiency, energy consumption, and energy prices, broken down by country, region, and sector (Apergis et al., 2017a). Studies in the literature that include Phillips-Sul Club Convergence analysis on energy consumption are less common than studies on energy intensity, energy efficiency, and carbon dioxide emissions. The Club Convergence analysis conducted on natural gas and oil consumption by sectors in Turkey, which constitutes the first stage of the study, is not found in the literature. Additionally, the Moments Quantile Regression analysis applied in the second phase of the study is a new method, and there are very few studies conducted using this method. The Moments Quantile Regression analysis conducted on converging sectors in natural gas and oil consumption in Turkey is also not found in the literature. It is believed that these aspects of the study will contribute to the literature and lay the groundwork for other studies.

Panopoulou and Pantelidis (2009) analyzed the convergence of carbon dioxide emissions for 128 countries between 1960 and 2013 using the Phillips-Sul method. They found convergence in per capita carbon dioxide emissions, but also identified two separate convergence clubs converging towards different steady states in recent years. Two different convergence clubs were observed for countries with low and high per capita carbon dioxide emissions. While convergence was demonstrated for high- and middle-income countries, low-income countries were found to diverge.

Kim (2015) examined the convergence of per capita electricity consumption for 109 countries between 1960 and 2010. He addressed the dynamic behavior of electricity consumption using the Phillips-Sul Club Convergence method and stated that all 109 countries converged towards a common stochastic trend in terms of electricity intensity, but did not converge at a common point in terms of per capita electricity consumption, which was better explained by a multi-component model. Within countries, a strong stochastic trend was observed in both indicators in 24 industrialized countries. The application of the clustering algorithm revealed the existence of club convergence in per capita electricity consumption.

Burnett (2016) examined carbon dioxide emissions in the United States between 1960 and 2010 using the Phillips-Sul method within the framework of the club convergence hypothesis. He analyzed convergence through time and space by seeking answers to the question of whether differences in emission levels at the state level tend to disappear or increase over time. The study also addressed conditional convergence analysis. The results revealed that a group of 26 states out of 48 converged toward a steady-state equilibrium, while the remaining states diverged from each other. Based on the club convergence hypothesis, different policy approaches to reducing carbon dioxide emissions can be considered.

Apergis and Christou (2016) investigated the convergence of energy efficiency in 31 countries between 1972 and 2012 within the framework of the Phillips-Sul Club Convergence analysis. Empirical results rejected full convergence and identified the existence of a certain number of clubs. However, transition curves revealed a long-term convergence trend in energy productivity.

Parker and Liddle (2017) examined club convergence in energy efficiency across the economy and in the manufacturing sector for OECD (Organisation for Economic Co-operation and Development) and non-OECD countries between 1971 and 2008. Four clubs emerged for energy productivity across the economy and six clubs for manufacturing sector energy productivity. The convergence towards a common energy productivity model for developed and developing countries was stated to indicate the need to encourage developing countries to sign climate agreements.

Karimu et al. (2017) examined the determinants of energy intensity and energy intensity convergence in the Swedish industrial sector between 1990 and 2008. The study concluded that input prices, including energy prices, were important determinants of energy intensity in Swedish industrial sectors. Finally, the study found evidence of energy intensity convergence across industrial sectors and stated that this was driven more by the activity channel than the efficiency channel.

Apergis et al. (2017b) examined short- and long-term wholesale electricity price convergence in Australia between 1999 and 2014 using the Phillips-Sul method. The study found that there was no short-term convergence when regions were examined, and that there were three price convergence clubs in the long term.

Herrerias et al. (2017) examined residential energy consumption in China between 1995 and 2011, addressing the long-term equilibrium convergence of electricity and coal consumption in rural and urban areas using the club convergence hypothesis. They revealed how urbanization and regional economic concentration affected residential energy consumption in China, identifying regional clusters converging to different equilibrium levels and arguing for the need to implement differentiated energy policies.

Ivanovski et al. (2018) analyzed the convergence in per capita energy consumption across Australia's regions and sectors between 1990 and 2016 using the Phillips-Sul Club Convergence method. For per capita energy consumption, findings regarding multiple convergence clubs were presented in eight of the nine sectors with full club convergence.

Ulucak and Apergis (2018) examined the convergence of the ecological footprint per capita in EU (European Union) countries between 1961 and 2013. The Phillips-Sul Club Convergence method was used as the method, and a small number of convergence clubs were identified. The results of the study shed light on the differences in environmental quality as well as the awareness strategies that EU member countries in each club should implement.

Morales et al. (2019) examined the sectoral convergence process in per capita carbon dioxide emissions in 28 EU countries between 1971 and 2012. The study analyzed whether convergence occurred in carbon dioxide emissions between countries and sectors using the Phillips-Sul Club Convergence method. It emphasized that determining whether European countries' emissions converged to different steady states was important for setting different carbon dioxide reduction targets for them. The analysis found weak convergence for 28 countries.

However, the relative convergence results showed that countries had at least controlled their emission increases. In particular, convergence was found within several clubs or country groups. However, it was also stated that there were significant differences between the sectors and subsectors considered. Furthermore, it was concluded that EU emission policies were effective in reducing emissions.

Zhu and Lin (2020) conducted a club convergence analysis to examine the convergence characteristics of energy intensity in 193 cities in China between 2005 and 2016. The results of the study were emphasized as important for local governments to implement targeted policies aimed at increasing energy efficiency. A sequential probit model was adopted to investigate the factors driving club convergence. The study identified four convergence clubs. These clubs were found to exhibit significant differences in terms of energy intensity. The driving forces behind the formation of convergence clubs are considered to be the degree of marketization, population density, foreign direct investment, and industrial structure.

Ayazoğlu (2022) analyzed per capita carbon dioxide emissions and per capita energy consumption data from 33 selected OECD countries using the Phillips-Sul club convergence hypothesis. Six sub-clubs were identified for per capita carbon dioxide emissions, and seven sub-clubs for total per capita energy consumption. The study found that, while there was no general convergence club, there were sub-convergence clubs. It was also determined that EU member countries were in the same club, partly due to the effect of common policy implementation.

He and Chen (2022) used the club convergence approach in their study to examine the convergence of total energy consumption per capita in China's 30 provinces between 1990 and 2017. The study also discusses various energy-saving scenarios and their convergence. The results show that not all 30 provinces converged to a common level of per capita energy consumption; seven provinces converged to a certain level, while the rest converged to another level. It is emphasized that the convergence of per capita energy consumption among provinces is crucial for the formulation of relevant energy policies.

Saba and Ngepah (2022) examined convergence in renewable energy sources for 183 countries between 2000 and 2018 using the Phillips-Sul method. Based on renewable electricity production and renewable energy consumption data, the study's global panel convergence results showed no convergence in renewable energy sources. Given that the differentiation of countries at the global level can trigger growth in the energy sector, it is thought that this could pose an obstacle to economic growth and the development of the global economy. Furthermore, the study indicates that the policy goal of ensuring the global spread of renewable energy sources for sustainable development has not yet been achieved.

Baležentis et al. (2023) examined the agricultural energy efficiency of EU member states between 2005 and 2019 using the Phillips-Sul club convergence approach. It is stated that the relevant method was used to present evidence-based policy recommendations. As only partial convergence was observed as a result of the study, it was stated that attention should still be paid to agricultural energy efficiency in EU countries. The countries in question were divided into five groups with different levels of agricultural energy efficiency. The study also examined the greenhouse gas intensity of the countries. Greenhouse gas intensity varied across the five identified clusters. As a result, it was found that countries with high energy efficiency do not necessarily use a clean energy mix.

Bangjun et al. (2023) applied the Phillips-Sul Club Convergence method based on per capita energy consumption data from 243 cities in China between 2005 and 2019. The study identified four convergence clubs and one divergence club at the provincial level. It was stated that the factors affecting the convergence of per capita energy consumption were the initial energy infrastructure, the level of urban industrialization, and per capita GDP.

Pinar (2024) examined the convergence in renewable energy innovations for 90 countries between 1993 and 2018. The Phillips-Sul club convergence method was used, and two convergence clubs were identified. The first is a club of more innovative countries, while the second is a club of less innovative countries. In addition, Probit and Logit regression were used to examine the factors driving countries' convergence clubs. The study found that countries with higher per capita income, higher research and development investments, better environmental regulations, and strong institutional structures were more likely to be part of the innovative club.

In the second stage of the literature review, research was conducted on energy consumption, economic growth, and value added. A review of the studies reveals that research into the causality between energy consumption and economic growth began with Kraft and Kraft (1978) and has continued for many years. Bowden and Payne (2009) and Zachariadis (2007) examined the causality between energy consumption and economic growth at both the macro and sectoral levels. The relationship between energy consumption and growth varies across sectors.

The study by Kraft and Kraft (1978) is one of the first studies to address the relationship between energy consumption and economic growth. The study examines the country's total gross energy consumption rather than the energy consumption of specific sectors within the country. The study examined the relationship between energy consumption and GDP (Gross Domestic Product) in the US (United States) between 1947 and 1974. The study found a unidirectional causality relationship from GDP to energy consumption. It was stated that there was no causal link from energy consumption to GDP. Erol and Yu (1987), in their study examining the relationship between energy consumption and income for industrialized countries, analyzed the relationship between energy consumption and real income for the United Kingdom, Italy, France, Germany, Canada, and Japan for the period 1950-1968. After the analysis, a two-way causality was identified for Japan, while a one-way causality relationship from real income to energy consumption was identified for Germany and Italy. For Canada, a one-way causality from energy consumption to real income was noted. For other countries, no causal relationship was identified.

Zachariadis (2007) examined the causal relationship between primary energy consumption and economic growth by compiling aggregate and sectoral data for the United States, Canada, Germany, Italy, France, Japan, and the United Kingdom. The sectors examined were residential, industrial, services, and transportation. Since the complete data could not be accessed, the number of observations differed for each country. The study used the VAR model to enable the application of the vector error correction (VEC) model, the autoregressive distributed lag model, and the Toda-Yamamoto test. For countries other than the United States, different results were obtained for each country using each of the methods.

In their study, Bowden and Payne (2009) examined the causality relationship between aggregate and sectoral primary energy consumption and real GDP in the United States for the period 1949-2006. The Toda-Yamamoto long-run causality tests reveal that the relationship between energy consumption and real GDP is not uniform across sectors. The analysis found no causality between primary energy consumption and real GDP in the transportation sector.

However, a two-way Granger causality was observed between primary energy consumption and real GDP in the trade and residential sectors. Finally, the analysis results show that primary energy consumption in the industrial sector is a Granger cause of real GDP. The study concludes that sectoral differences in the relationship between energy consumption and real GDP should be taken into account when formulating energy and environmental policies.

Gross (2012) examined the relationship between energy consumption and economic growth in the industrial, trade, and transportation sectors in the United States for the years 1970-2007. He applied the ARDL bounds test and Granger causality tests in his study. A unidirectional long-term causality from economic growth to energy consumption was detected in the trade sector. In the transportation sector, however, a long-term bidirectional causality was observed. Zhang and Xu (2012) examined the causality relationship between energy consumption and economic growth in China from a regional and sectoral perspective for the years 1995-2008 using the dynamic panel causality method. The study divided China regionally into East, West, and Central, while selecting the sectors as industry, transportation, housing, and services. The analysis indicated that economic growth led to higher energy consumption at the regional and sectoral levels and that there was a causality from economic growth to energy consumption. The analysis found a bidirectional causal relationship between energy consumption and economic growth in the industrial sector of the Eastern Region.

Doyar (2015) examined the relationship between energy consumption and economic growth in the industrial, agricultural, transportation, and residential sectors in Turkey between 1970 and 2006 using the Granger causality test. The analysis concluded that there was no causality between the energy consumption of the sectors and economic growth and that the neutrality hypothesis was valid. Rahman and Kashem (2017) examined energy consumption, carbon emissions, and industrial sector growth in Bangladesh between 1972 and 2011. In the study, which included cointegration and causality analysis, the Granger causality test results showed a unidirectional causality relationship from energy consumption and industrial production to carbon emissions. It was stated that industrial development negatively affected environmental quality.

Usta and Berber (2017) analyzed the relationship between energy consumption and economic growth in the industrial, transportation, housing, agriculture, and livestock sectors in Turkey between 1970 and 2012 using the Toda-Yamamoto causality test. The analysis revealed a bidirectional causality between energy consumption and economic growth in the transportation and industrial sectors. It was stated that the analysis result confirmed the feedback hypothesis. No causal relationship was found between energy consumption and economic growth in the agriculture and housing sectors. These results confirmed the neutral hypothesis.

Chandio et al. (2019) examined the industrial sector's consumption of oil, natural gas, and electricity and economic growth in Pakistan between 1983 and 2017. It was found that there is cointegration and a long-term relationship between the industrial sector's energy consumption and economic growth. It was stated that the industrial sector's electricity and natural gas consumption had a positive and statistically significant effect on economic growth in both the long and short term. It was found that the industrial sector's oil consumption negatively affected economic growth in the long term but positively affected economic growth in the short term. The analysis concluded that there is a two-way relationship between the oil consumption of the industrial sector and economic growth.

Doğan (2019) analyzed the relationship between energy consumption in the industrial, agricultural, and residential sectors and economic growth in Turkey between 1970 and 2015 using the Toda-Yamamoto causality test. The analysis revealed a bidirectional causality between real GDP and the industrial sector. No causal relationship was observed in the agriculture and housing sectors.

Gökmen (2019) applied the Johansen Cointegration test and Granger causality test to Turkey's total energy consumption in the industrial sector, industrial production data, and employment volume between 1971 and 2015. A positive and significant long-term relationship was found between the employment volume and total energy consumption of the industrial sector and the industrial sector's production. Furthermore, a positive long-term relationship was found between the production volume of the industrial sector and the sector's consumption of electricity, oil, and natural gas. According to the findings after the Granger causality test, a unidirectional causality relationship was indicated from the production volume of the industrial sector to the oil consumption of the relevant sector.

Başar et al. (2020) analyzed the relationship between sectoral electricity consumption and economic growth in Turkey between 1990 and 2018 using the Toda-Yamamoto causality test. The study found that the electricity consumption of the lighting sector and households had a positive effect on growth. The impact of industrial electricity consumption on economic growth was found to be negative. The causality analysis revealed a unidirectional causal relationship from economic growth to electricity consumption in households and government offices, and from electricity consumption in the industrial and lighting sectors to growth.

Bulut (2020) examined the relationship between energy consumption in the industrial, transportation, housing and services, agriculture, and livestock sectors and economic growth in Turkey between 1990 and 2014. The study employed the Least Squares Method and Granger causality tests. The study found that energy consumption in the agriculture and livestock and housing and services sectors negatively affected economic growth, while energy consumption in the transportation and industry sectors positively affected economic growth.

Koç (2020) examined the relationship between the energy consumption of sectors and economic growth for the period 2010-2016, covering 132 countries. The energy consumption of the transportation, industry, services, and agriculture sectors, and real per capita national income were examined using the panel data method. The study found a positive relationship between energy consumption in the transportation, industrial, service, and agricultural sectors and economic growth.

Rahman et al. (2021) examined oil and electricity consumption, infrastructure, capital formation, and industrialization in Bangladesh between 1975 and 2018. Among the variables examined, the added value of the industrial sector in GDP was considered for industrialization. Johansen Cointegration and Granger causality tests were applied in the study. Cointegration analysis revealed that oil and electricity consumption have long-term effects on industrialization in Bangladesh. According to the Granger causality analysis, a bidirectional causality relationship was observed between electricity consumption and industrialization. A unidirectional causality was noted between oil consumption and industrialization. The study also emphasized the importance of energy consumption and energy control in terms of industrial sector growth.

Uçar and Çoban (2023) examined energy consumption, carbon dioxide emissions, oil prices, and GDP variables in the aviation sector of 36 countries, 28 of which are OECD countries, between 1990 and 2018. The System Generalized Moments Method, one of the dynamic panel estimation methods, was used as the methodology. The study concluded that increases in energy consumption and economic growth lead to higher emissions. A relationship was found between environmental quality, economic growth, and energy consumption in the aviation sector in all 36 countries.

Yağış (2023) examined the relationship between natural gas consumption and economic growth in Western European countries (Germany, Austria, Switzerland, Belgium, France, Luxembourg, and the Netherlands) between 1980 and 2020 using the Bootstrap Panel Granger causality test. The analysis revealed a bidirectional causality between natural gas consumption and economic growth. Additionally, it emphasized that the feedback hypothesis is valid. It stated that the growth hypothesis is valid for Germany, Austria, France, and Luxembourg, while the protection hypothesis is valid for the Netherlands.

Following the seminal work by Kraft and Kraft in 1978 on analyzing the relationship between energy consumption and economic growth in countries or various country groups, numerous studies have been conducted in this field in the literature (Kraft and Kraft, 1978). However, as mentioned above, the need for research on energy consumption at the sectoral level has also arisen, and over time, empirical studies in this area have begun to appear in the literature. These studies mainly focus on energy consumption and economic growth. Causality tests are generally used as a method. This situation has actually served as a driving force in researching more up-to-date analysis methods suitable for the study in order to create original value in the study.

When examining studies on Moment Quantile Regression, it is seen that there are a very limited number of studies applying this method in the energy field, partly due to the novelty of the method. Since the sectoral aspect that forms the basis of the study has not yet been addressed in the literature, all studies applying the method were examined, and the literature on energy economics was compiled. It is seen that this method is particularly applied in studies focused on carbon dioxide emissions and carbon footprint. Anwar et al. (2021) used the Moments Quantile Regression method in their study to examine the relationship between non-renewable energy consumption, renewable energy consumption, income, and carbon emissions in ASEAN (Association of Southeast Asian Nations) member countries between 1991 and 2018. The analysis revealed that non-renewable energy consumption increased carbon emissions in all quantiles, while renewable energy consumption led to a decrease in carbon emissions. The study also confirmed the Environmental Kuznets Curve relationship in the middle and higher quantiles. The study concluded that the government should promote and subsidize green energy sources to combat environmental degradation.

Du et al. (2022) analyzed the impact of the high-tech industry and renewable energy on consumption-based carbon dioxide emissions in MINT (Mexico, Indonesia, Nigeria, and Turkey) countries between 1990 and 2018 using the Moments Quantile Regression method. The study also considered factors such as economic growth and foreign direct investment. The analysis concluded that economic growth, the high-tech industry, and foreign direct investment increase carbon emissions, while renewable energy consumption reduces carbon emissions.

In the study by Miao et al. (2022), the Moment Quantile Regression method was used to analyze the role of renewable energy consumption and financial globalization in newly industrialized countries between 1990 and 2018 on the ecological footprint. The study also included other drivers of the ecological footprint, such as natural resources and economic growth. The analysis revealed that financial globalization and renewable energy consumption contributed to environmental quality in each quantile, while economic growth and natural resources increased the ecological footprint in all quantiles. It was stated that financial globalization had an indirect positive effect on the environment in the middle and higher quantiles.

Khaddage-Soboh et al. (2023) examined the impact of natural resource revenues, environmental regulations, and taxes on carbon emissions for G-7 countries between 1990 and 2020. Using the Moment Quantile Regression method, the study found a negative relationship between natural resource revenues and carbon emissions at lower quantiles, but this relationship became positive and statistically insignificant at higher quantiles. The study emphasizes that environmental regulations and taxes play an important role in reducing carbon emissions and highlights the importance of implementing sustainable policies that encourage environmental protection. It also notes that increasing renewable energy consumption has made a significant contribution to reducing carbon emissions in G-7 economies.

3. Data Set and Method

This section of the study presents the data set used in the study, the theoretical framework of the Club Convergence and Moments Quantile Regression methods, and the mathematical representations of the econometric models in question.

3.1. Data Set

In the empirical part of the study, natural gas and oil consumption data for the sectors used in the Club Convergence analysis, which constitutes the first stage, were compiled from reports by the General Directorate of Energy Affairs of the Ministry of Energy and Natural Resources of the Republic of Turkey. For the Moments Quantile Regression used in the second stage of the study, the factor cost and value-added data for the sectors were compiled using data from the Turkish Statistical Institute (TÜİK), while natural gas and oil prices were compiled using data from the World Bank databases.

3.2. Method

In the analysis section of the study, the Club Convergence analysis was applied in the first stage using the Phillips and Sul (2007) approach. Within this scope, data on the total natural gas and oil consumption of sectors in Turkey between 1992 and 2021 were compiled. In the study, the Club Convergence method was applied to the annual natural gas and oil consumption data of the sectors.

In the second stage, the Moments Quantile Regression method, a relatively new method proposed by Machado and Silva (2019), was applied. The literature on this method is still developing. In addition to being new and original, this method provides more reliable results than

first-generation quantile regression models. In this context, Moment Quantile Regression was applied to data on the factor costs and value added of the sectors, the natural gas and oil consumption data of the sectors, and the deviations in natural gas and oil prices.

3.2.1. Club Convergence Method

The foundations of the club convergence method were laid by the club convergence hypothesis, one of the convergence hypotheses. Upon examining convergence hypotheses, it is seen that there are three types of convergence hypotheses. Galor (1996) stated that these three hypotheses compete in terms of validity. The hypotheses in question are the absolute convergence hypothesis, the conditional convergence hypothesis, and the club convergence hypothesis (Galor, 1996).

1) Absolute convergence hypothesis: Countries' per capita incomes converge in the long run, regardless of their initial conditions.

2) Conditional convergence hypothesis: Countries' per capita incomes are the same in terms of structural characteristics (preferences, technologies, population growth rates, government policies, etc.) and converge in the long run, regardless of their initial conditions.

3) Club convergence hypothesis: Countries with the same structural characteristics converge in terms of per capita income over the long term, provided that their initial conditions are also similar (Galor, 1996).

Sala-i Martin (1996), when discussing beta and sigma convergence types, states that beta convergence is divided into conditional and absolute beta convergence. Beta convergence is expressed as the faster growth of poor countries or regions compared to rich countries or regions. In beta convergence, structural characteristics are taken into account when there is conditional convergence, while in absolute conditional convergence, structural characteristics are not taken into account. Sala-i Martin (1996) explains beta convergence in his work as a situation where there is a negative relationship between per capita income level and growth. Sigma convergence is defined as the convergence or reduction of the difference in GDP per capita between certain regions or countries in the economy. In short, sigma convergence examines how income distribution has developed over time, while beta convergence examines the mobility of income within the same distribution.

Beta convergence is divided into conditional and absolute convergence. In conditional convergence, structural characteristics are taken into account and added to the model, while in absolute convergence, structural characteristics are disregarded. In absolute convergence, it is assumed that economies are similar in terms of factors such as institutional structure, technology level, and savings rate (Baktemur and Özmen, 2016).

The club convergence hypothesis can be expressed as the convergence of groups of countries with similar initial conditions and structural characteristics towards a common steady-state equilibrium (Şahin, 2022). This hypothesis states that groups with similar initial conditions will converge towards a steady-state equilibrium in the long term, resulting in the emergence of convergence clubs.

It has been observed that countries that are fundamentally the same but differ in their initial per capita output levels can cluster around different steady-state equilibria (Galor, 1996).

Baumol (1986), one of the first empirical applications in this field, paved the way for applying this hypothesis to different groups. By applying this test between various economic groups or countries, differences between groups could be examined in terms of their level of development.

Another study that contributes to and forms the basis of convergence literature is that of Barro and Sala-i Martin (1992), who examined whether convergence occurred using per capita income and GDP data from 48 US states between 1840 and 1963. The starting point of the study is one of the fundamental economic issues: whether poor countries or regions grow faster than rich countries or regions. The study found that when the regional economy falls below its steady-state equilibrium, per capita income shows a faster growth trend, proving the existence of convergence.

Similarities in the structural characteristics of specific economic groups may lead to convergence. The club convergence hypothesis is based on the assumption that groups with similar initial conditions will reach a steady state equilibrium.

Phillips and Sul (2007), in their study describing the test they developed regarding the club convergence approach, conducted an empirical application using consumer price index data to test convergence in the cost of living in 19 major US cities. Empirical results show that there is no convergence in the cost of living among the cities examined. It was found that the cost of living in large cities in California increased faster than in the rest of the United States, while the cost of living in Louisville and Houston decreased relative to the rest of the United States.

In this study, the club convergence approach selected in the first stage has comparative advantages (Phillips and Sul, 2007; Apergis and Payne, 2017). These are as follows:

1) The test to be applied performs better than standard panel unit root tests that can classify serially converging series as non-stationary.

2) It measures the comparative convergence of cross-sectional means, which contradicts the concept of absolute level convergence.

3) It can detect convergence that cannot be detected in a panel cointegration test (if the series are slowly approaching a long-term trend in a non-linear manner, a standard cointegration test may reject a long-term stable relationship between the variables).

4) Deviations may occur as a result of the coexistence of stationary and non-stationary series in the panel, but the steps of the Phillips and Sul (2007) test do not rely on unit root or cointegration tests for the variables in the panel. This is one of the advantages of this method.

The panel data compiled in the study were analyzed using Phillips and Sul (2007), the clustering method, and the log t-test. With this method, sectors are grouped according to their similarities. Thus, it will be possible to analyze whether convergence exists within each group (Apergis and Payne, 2017).

Phillips and Sul (2007) developed a panel data model that allows for heterogeneity in order to analyze the behavior of transition economies. The model is formulated as a nonlinear and time-varying model. The model also provides flexibility in unique behavior over time and across sections while maintaining some commonalities across the panel. The study discusses the validity of panel convergence, which is similar to the concept of sigma convergence, where variables converge to a steady state over time. The study presents a new regression test for the convergence

model and an analysis of the clustering of panel data into clubs with similar convergence characteristics. The clustering algorithm reveals whether club convergence groups are formed. The convergence regression test mentioned here is referred to as the log t test.

This model was selected as the first method of analysis due to its advantages mentioned above and its applicability to different economic groups.

Heterogeneity is considered an important issue in many empirical panel data studies. In the Phillips-Sul method, a time-varying factor model has been proposed to capture heterogeneity and classify according to convergence clubs. In this study, the natural gas and oil consumption of sectors; i = 1,..., N, and the time dimension; t = 1,..., T has been used as. Here, i represents the number of sectors and t represents the time dimension (Liu et al., 2018). The objective of this method is to test whether economic variables X_{it} , i =1, 2, …, N tend to converge to a single steady state as $t \rightarrow \infty$. The Phillips-Sul method provides a framework for modeling both transition dynamics and long-term behavior using a nonlinear time-varying factor model (Apergis et al., 2013).

The variable in the panel data format is represented by two variables, as in equation X_{it} (1).

$$X_{it} = g_{it} + a_{it} \tag{1}$$

In the above equation X_{it} represents the dependent variable. X_{it}, consist of two components, g_{it} and a_{it}. In the equation g_{it} represents the systematic components, including the permanent common components that cause the horizontal section dependency, while a_{it} represents the temporary components.

Since the variables g_{it} ve a_{it} in the equation may contain a combination of common and unique elements, the following equation 2 is written to separate the common elements in the panel from the unique components.

$$X_{it} = \left(\frac{g_{it} + a_{it}}{\mu_t}\right)\mu_t = \delta_{it}\mu_t \tag{2}$$

In Equation 2, δ_{it} represents the unique components and μ_t represents the common components. μ_t is a single common component and common effect multiplier. μ_t has deterministic and stochastic components.

δ_{it} , is a unique component that changes over time and measures the distance between μ_t ve X_{it}. Additionally, it measures the share of the common effect multiplier μ_t for each unit in the δ_{it} panel. In this model, convergence is a dynamic process. It is divided by the μ_t panel average expressed as a common component, thereby revealing the relative transition path. The δ_{it} coefficient represents the relative transition path.

$$h_{it} = \frac{X_{it}}{N^{-1}\,\Sigma_{i=1}^{N} X_{it}} = \frac{\delta_{it}}{N^{-1}\,\Sigma_{i=1}^{N} X_{it}\delta_{it}} \tag{3}$$

Equation 3 shows the relative transition parameter h_{it}. This parameter captures the transition path relative to the panel mean. As the relative transition parameter approaches 1, it indicates convergence in the long run, but for convergence to exist, the cross-sectional variance must approach zero. The relative transition parameter may vary across sectors.

$$h_{it} = \log X_{it}\sqrt{log_t} \tag{4}$$

The relative transition parameter h_{it} is used to calculate the average of the logarithmic value of the horizontal transition variance.

$H_t = \frac{1}{N}\Sigma_{i=1}^{N}(h_{it}-1)^2$ The variance of the cross-section is calculated using the equation. This equation represents the distance of the panel from the common value. The hypotheses used to test the distance of each cross-section from the common value are as follows:

H_t: $\delta_{it} = \delta_t$, α≥0

H_t: $\delta_{it} \neq \delta_t$, α<0

After the hypotheses, the log t regression equation is tested. The null hypothesis is empirically examined using the log t regression model below.

$$\log\left(\frac{H_1}{H_t}\right) - 2\ log\ log\ L\ (t)\ = c + b\ logt + u_t \quad (5)$$

After Equation 5, the t-test result is examined. If the t-test result is less than 1.65 at a 5% error margin, the conditional convergence hypothesis is rejected. This test is repeated for convergence analysis in all subgroups.

3.2.2. Moments Quantile Regression Method

Quantile regression is an estimation strategy that allows for a richer explanation of the relationships between dependent and independent variables. Koenker and Bassett Jr (1978) found that their first-generation quantile regression approach led to misleading estimates because it did not account for unobserved heterogeneity between data points and panel cross-sections (Khan et al., 2023). As a result of developments in the literature, quantile regression analysis was expanded to include individual fixed effects within the panel data framework, avoiding the random parameter problem under different assumptions, resulting in the emergence of Moment Quantile Regression analysis (Machado and Silva, 2019; Rios Avila et al., 2024).

The Moments Quantile Regression method is a new method introduced in 2019, and there are still very few studies in the literature. Machado and Silva (2019) proposed a location-scaled estimation model that allows for the inclusion of individual fixed effects within a panel data framework and for individual effects to vary across quantiles. Applying this new approach with fixed effects facilitates the experimental understanding of heterogeneous relationships, i.e., differences in relationships under different groups or conditions. This method also allows for the examination of heterogeneity at different conditional quantile distribution levels, which cannot be obtained using traditional mean regressions (Miao et al., 2022).

Machado and Silva (2019) introduced the Moments Quantile Regression method for the first time in their study. This new method addresses how estimating regression quantiles can be achieved by estimating conditional means. The study did not aim to replace the existing quantile regression estimation method but only to provide an additional tool for situations where such estimations are difficult. It was stated that this method allows for the estimation of panel data models containing individual effects and regression quantiles with finite explanatory variables. Quantile regressions with individual effects face the random parameter problem. Koenker (2004), Lamarche (2010), and Canay (2011) are some of the studies that propose various methods for such problems, but they have not had a broad impact in terms of application, either due to

computational complexity or because they contain very restrictive assumptions about how fixed effects influence quantiles.

Moments have a significant advantage in Quantile Regression because they take into account that individual effects can influence not only shifts in the central tendency (location shift) but also the entire distribution. This method does not rely on estimating conditional means. It is based on moment conditions that define conditional means under the assumption of exogenous variability. The advantage of the method is that it can be applied to nonlinear models and, in particular, the calculation is much simpler in models with multiple finite explanatory variables. In this study, a new approach is presented for estimating regression quantiles based on the conditional location-scale model. This method is simpler and faster to compute than traditional quantile regression (Machado and Silva, 2019).

Moments Quantile Regression can handle data distribution more effectively than linear estimation methods that focus primarily on means. The following methodology is followed for this regression (Machado and Silva, 2019; Liu et al., 2024).

The conditional quantiles of the random variable Y, which expresses the location and scale parameters dependent on the K-vector of X, are estimated as follows:

$$Y_{it} = \alpha_i + X_{it}\beta + (\delta_i + Z_{it}\,\lambda)U_{it} \quad (6)$$

In the above equation, Y_{it} represents the dependent variable. α_i represents individual fixed effects, X_{it} represents independent variables, β represents the coefficients of independent variables, and U_{it} represents error terms. Z_{it} is considered a transformation of X_{it}. It shows the nonlinear relationships in the model. λ, represents the coefficient of the Z_{it} vector.

The probability in the equation {(i + Zit λ)>0}=1. $\alpha i,,i$ are the estimated parameters; $\alpha i,\delta i,i$=1,….,n represent the individual fixed effects.

Z denotes a K-dimensional vector composed of the applied, differentiable transformations of X's components and is represented as follows:

$$Z_l = Z_l(X), l = 1,\ldots.K \quad (7)$$

Y's conditional quantifier is shown as follows:

$$Q_\tau\left(\frac{\tau}{X_{it}}\right) = \alpha_i + \delta_i q(c) + X_{it}\beta + Z_{it}\,\lambda\, q(\tau) \quad (8)$$

τ, the quantile function (e.g., τ=0.5 is median regression) is the estimated quantile of the dependent variable.

Then $q\ (\tau)$ is estimated as follows:

$$\Sigma_t\Sigma_i\ P_\tau(R_{it} - (\delta_i + z_{it}\lambda)\mathrm{q}) \quad (9)$$

In the empirical application of the study, sectoral value added is treated as the dependent variable. This variable is defined as lncost, which represents the natural logarithm of sectoral value added calculated at factor costs for the period 2009-2021. The analysis considers two alternative empirical settings. In the first, sectoral oil product consumption is included as an explanatory variable through lnoil, which denotes the natural logarithm of oil product consumption, together with a dummy variable capturing deviations in oil prices. In the second,

sectoral natural gas consumption is examined using lnngs, defined as the natural logarithm of natural gas consumption, along with a dummy variable reflecting deviations in natural gas prices.

Within the framework of the Moments Quantile Regression approach, a conditional location–scale structure is adopted. Accordingly, the scale component is modeled through the variable Z_{it}, which is defined as a vector of differentiable transformations of the explanatory variables X_{it}. In this study, for the sake of model simplicity and consistency, these transformations are specified as identity transformations. As a result, the same set of explanatory variables is included in both the location and scale equations.

4. Empirical Results

In the first stage of the study, the Club Convergence analysis was applied to examine the natural gas and oil consumption of sectors in Turkey. As a result of this analysis, clubs emerged in energy consumption, and converging sectors were identified. Moment Quantile Regression was applied to the converging sectors, and this analysis included the factor cost and added value of the sectors in question, the natural gas and oil consumption of the relevant sectors, and deviations in natural gas and oil prices.

4.1. Empirical Results of the Club Convergence Analysis

The coefficients obtained from the Club Convergence analysis indicate the convergence speed of the variables. The coefficients also show the extent to which equilibrium is approached for each period. In the Club Convergence analysis, a log t-test is performed on all data in the first stage. Subgroups and clubs are identified based on the log t-test results, and convergence coefficients are obtained.

Phillips and Sul (2007) state in their convergence analysis that hypotheses are accepted or rejected based on the t-statistic value. If the t-statistic value is greater than -1.65 at a 5% significance level, the H_0 hypothesis is accepted. In this case, convergence is accepted. If the value is less than or equal to -1.65, the H_0 hypothesis is rejected, and thus it is stated that there is no convergence in the entire panel. In this case;

H_0 = t > -1.65

H_1 = t ≤ -1.65

The oil and natural gas consumption of sectors in Turkey for the period 1992-2021 was examined using convergence analysis. Table 1 below shows the convergence coefficients for oil consumption in the panel formed by the sectors.

Table 1. Log t Test Results for the Oil Consumption Variable

Variable	Coefficient	Standard Error	t-statistic
Oil Consumption	-2.2552	0.0336	-67.1992

If the t-statistic critical value is less than -1.65, the H_0 hypothesis that convergence is accepted is rejected. In the Club Convergence analysis conducted for 13 sectors in the table, the

t-statistic with a 5% margin of error was calculated as -67.19 for the 1992-2021 period. When the critical value of the t-statistic is less than -1.65, the hypothesis that convergence is accepted is rejected. The relevant value indicates that no convergence was observed in the entire panel created for the oil consumption variable among the 13 sectors.

The results of the log t-test performed for the subgroups and clubs included in the panel are shown in Table 2. As shown in Table 2, the 13 sectors are divided into three different clubs. Club 1 (Transportation, Cement, Highways) has a t-statistic value of 5.9516, which is greater than -1.65. In this case, the hypothesis is accepted, indicating convergence. Club 2 (Industry, Agriculture, and Livestock) has a t-statistic value of -0.1928, which is greater than -1.65. The hypothesis is accepted, and convergence is understood to exist. Club 3 (Housing, Trade and Services, Maritime Transport, Air Transport) has a t-statistic value of 8.5356, and convergence is accepted. The bottom row of the table shows the group of sectors that do not converge. Here, the t-statistic value is -34,0098.

In the non-converging sectors listed in the last row of Table 2, the t-statistic value is -34.0098. The value in question is less than -1.65, and the H_0 hypothesis is rejected. In this case, the H_1 hypothesis is accepted. As a result, no convergence has been detected.

Table 2. Log t Test Results for Subgroups of the Oil Consumption Variable

Clubs	Sectors	Coefficient	t-stat
Club 1	Transportation, Cement Manufacturing, Highways	1.3503	5.9516
Club 2	Industry, Agriculture and Livestock	-0.5273	-0.1928
Club 3	Housing, Trade and Services, Maritime Transport, Air Transport	0.2696	8.5356
Non-Converging Sectors	Sugar Production, Fertilizer Manufacturing, Iron and Steel, Non-Ferrous Metals, Railways	-5.4712	-34.009

A log t-test is also applied to the clubs identified in the club convergence analysis. This indicates the degree of convergence between the clubs. As shown in Table 3 above, the Club Convergence analysis examined convergence among clubs for the period 1992-2021. The log t test statistic for the sectors in Club 1 and Club 2 is 4.8795 for the long term, which is greater than the critical value of -1.65. Convergence is accepted for the sectors in Clubs 1 and 2. Looking at Club 2 and Club 3, the log t statistic value is -8.7439. This value is less than -1.65, and the H_0 hypothesis is rejected. It is understood that there is no convergence among the sectors in Club 2 and Club 3. According to this result, it is accepted that in the long term, there is convergence only for the sectors in Clubs 1 and 2.

Table 3. Results of the Log t Test for the Oil Consumption Variable Among Clubs

Clubs	Coefficient	t-statistic
Club 1+ 2	0.7628	4.8795
Club 2 + 3	-0.6577	-8.7439
Club 3+ Non-converging sectors	-3.4056	-49.0605

Table 4 below shows the convergence coefficients for natural gas consumption of the panel formed by the sectors as a result of the analysis. Table 4 shows that in the Club Convergence

analysis conducted for 10 sectors, the t-statistic for the 1992-2021 period was calculated as 16.0215, with a 5% margin of error. When the t-statistic critical value is greater than -1.65, the null hypothesis H_0 of the convergence analysis is accepted. The relevant value indicates convergence for the entire panel created for the natural gas consumption variable across 10 sectors.

Table 4. Log t Test Results for Natural Gas Consumption Variable

Variable	Coefficient	Standard Error	t-statistic
Natural Gas Consumption	1.1464	0.0716	16.0215

In Table 5, in the log t test applied to the subgroups of the natural gas consumption variable, the log t test statistic for Club 1 is 16.0215, which is greater than the critical value of -1.65. All sectors examined in Club 1 are included. In this case, the H_0 hypothesis is accepted, indicating convergence for the entire panel.

Table 5. Log t Test Results for Subgroups of the Natural Gas Consumption Variable

Clubs	Sectors	Coefficient	t-stat.
Club 1	Industry, Transportation, Agriculture and Livestock, Housing, Trade and Services, Sugar Production, Fertilizer Manufacturing, Cement Manufacturing, Iron and Steel, Non-Ferrous Metals, Highways	1.1464	16.0215

4.2. Empirical Results of Moments Quantile Regression Analysis

When conducting Moments Quantile Regression analysis, the Club Convergence analysis first considered sectors converging in terms of oil consumption (Transportation, Cement Manufacturing, Highways, Industry, Agriculture and Livestock, Housing, Trade and Services, Maritime Transport, Air Transport). The value added of these sectors formed the dependent variable, while the independent variables were the sectors' oil consumption and deviations in oil prices.

Table 6. Moments Quantile Regression Location and Scale Analysis Results (lncost, lnoil dummy)

Location	Coeffcient	Std. Err.	t-statistic	p-value	95% Confidence Interval
lnoil	0.1599	0.04098	3.90	0.000	[0.0796, 0.2402]
dummy	-0.099	0.1334	-0.74	0.458	[-0.3606, 0.1624]
cons	22.6324	0.3297	68.64	0.000	[21.9862, 23.2787]
Scale					
lnoil	0.0099	0.0208	0.48	0.633	[-0.0308, 0.0507]
dummy	-0.2942	0.0678	-4.34	0.000	[-0.4271, - 0.1613]
cons	0.6029	0.0167	3.6	0.000	[0.2745, 0.9313]

Table 6 presents the location and scale results of the Moments Quantile Regression according to the variables. Here, the location parameter indicates the central tendency of the distribution. When examining the p-value for oil consumption in the location parameter, it is seen to be 0.000. The p-value is less than 0.05, indicating that an increase in oil consumption increases the average effect on the value added of the sectors. It is seen that each unit increase in oil consumption increases the average value of the value added of the sectors, which is the dependent

variable, by 0.1599 units. When the 95% confidence interval (CI) is examined, the coefficient is seen to be reliable and positive. In the dummy variable, the p-value is 0.458, indicating that its effect on location is not significant. Deviations in oil prices do not have a significant effect on the average value of the dependent variable. When examining the constant term, the coefficient is 22.63, and the result is statistically significant. The p-value here is 0.000, which is less than 0.05. When the independent variables are zero, the added value is approximately 22.63. While oil consumption has a significant effect on location, it is understood that the dummy variable does not have such a significant effect.

Another parameter, the scale parameter, indicates the spread of the distribution and the distribution of the error terms. Moments in Quantile Regression analysis show the extent to which estimates can vary in each quantile. When examining the effect of oil consumption on the scale, the p-value is 0.633. This value is not statistically significant and indicates that oil consumption does not change the variance in the added value of the sectors. When the dummy variable is examined, the p-value is 0.000, indicating that it has a significant negative effect on the scale. The dummy variable, which represents deviations in oil prices, reduces the variability of sectoral value added.

Table 7. Moments Quantile Regression Analysis Results (lncost, lnoil dummy)

MMQREG		**Quantiles**			
Lncost		**Q_25**	**Q_50**	**Q_75**	**Q_90**
lnoil	**Coefficient**	0.1495	0.1595	0.1679	0.1783
	Std. Err.	0.0407	0.0407	0.0484	0.0634
	t-statistic	3.67	3.91	3.47	2.81
	p-value	0.000	0.000	0.001	0.005
	CI	[0.0695, 0.2294]	[0.0796, 0.2394]	[0.0730, 0.2629]	[0.0539, 0.3026]
dummy	**Coefficient**	0.2102	-0.0859	-0.3363	-0.6414
	Std. Err.	0.1328	0.1457	0.1671	0.2048
	t-statistic	1.58	-0.59	-2.01	-3.13
	p-value	0.113	0.555	0.044	0.002
	CI	[-0.0500, 0.4706]	[-0.3715, 0.1996]	[-0.6638, -0.0087]	[-1.0429, -0.2398]
cons	**Coefficient**	21.9986	22.6056	23.1187	23.7439
	Std. Err.	0.3289	0.3451	0.4021	0.5109
	t-statistic	66.87	65.49	57.49	46.47
	p-value	0.000	0.000	0.000	0.000
	CI	[21.3538, 22.6433]	[21.9291, 23.2821]	[22.3305, 23.9069]	[22.7425, 24.7453]

The descriptions of the variables are as follows:

lncost: Represents the logarithm of the value added calculated using factor costs for the sectors between 2009 and 2021.

lnoil: Represents the logarithm of the oil product consumption of the sectors between 2009 and 2021.

dummy: Represents deviations in oil prices. This variable shows the deviations in oil prices between 2009 and 2021.

For oil consumption (lnoil),

H_0: The oil consumption of sectors has no significant effect on the added value of sectors.

H_1: The oil consumption of sectors has a significant impact on the added value of sectors.

For deviations in oil prices (dummy);

H_0: Deviations in oil prices have no significant impact on the added value of sectors.

H_1: Deviations in oil prices have a significant impact on the added value of sectors.

P-values less than 0.05 ($p<0.05$) indicate that H_0 hypothesis will be rejected and the alternative hypothesis H_1 will be accepted.

Table 7 presents the results of the Moments Quantile Regression analysis conducted for dummy variables indicating the value added of sectors based on factor costs, oil product consumption, and deviations in oil prices. The sectors represent those that converged according to the club convergence analysis. Non-converging sectors were not considered. The effect of oil product consumption on the value added of sectors based on factor costs is positive and significant.

Oil product consumption is positive and statistically significant in every quantile. This indicates that oil consumption increases the value added of sectors calculated based on factor costs. At the 25th quantile, the coefficient is 0.1495, and the p-value is 0.000. In this case, petroleum product consumption positively affects the added value of sectors with factor costs. At the 50th quantile, the results are similar to those at the 25th quantile. In this case, it is understood that there is a positive relationship between oil product consumption and added value in the 50th quantile as well. In the 75th quantile, the coefficient is 0.1679, and the p-value is 0.001. This result reveals that oil consumption has a stronger effect on sectors with high added value. In the 90th quantile, the coefficient is 0.1783, and the p-value is 0.005. The effect of petroleum product consumption in sectors is more pronounced in sectors with the highest added value. The analysis shows that this effect is stronger in the 75th and 90th quantiles, i.e., in the higher quantiles. A positive and statistically significant relationship is observed across all quantiles. The p-values are less than 0.05 across all quantiles. When examining the coefficients, they are observed to be in the range of 0.1495 to 0.1783. The coefficients, which represent the estimated effect size, reveal a positive relationship. In conclusion, oil consumption positively affects the factor cost and value added of all sectors. The H_0hypothesis is rejected, and the H_1 hypothesis is accepted. It is found that sectors with relatively higher oil consumption have higher value added.

The dummy variable indicates deviations in oil prices. The dummy variable generally has a negative effect on the added value of the sectors. The coefficient at the 25th quantile is 0.210 and the p-value is 0.113. Here, the result is not statistically significant. At the 50th quantile, the coefficient is -0.086 and the p-value is 0.555. Since the p-value is greater than 0.05, no significant effect can be stated. At the 75th quantile, the coefficient is -0.336 and the p-value is 0.044. There is a significant effect at the 75th quantile, indicating that deviations in oil prices negatively affect value added in high value-added sectors. At the 90th quantile, the coefficient is -0.641 and the p-value is 0.002. The result is statistically significant at the 90th quantile. The effect of oil price deviations is more pronounced in the groups with the highest added value. Oil price deviations negatively affect added value. While the dummy variable shows an insignificant effect at the 25th and 50th quantiles, the results are significant at the 75th and 90th quantiles, showing a negative effect. The analysis shows that deviations in oil prices negatively affect sectors. It is understood that when energy costs are difficult to predict, the added value of sectors will decrease.

The constant term in the model shows the value of the dependent variable (value added with factor costs) when the independent variables are zero. The constant term coefficients have a

significant and positive effect in all quantiles. When the confidence intervals are examined, it is seen that the intervals widen towards the upper quantiles. This increases the uncertainty in the estimates. The effect of oil consumption and price deviations on the added value of sectors is heterogeneous, and this effect is seen to increase in high-value-added sectors.

Moments Quantile Regression analysis, sectors converging in terms of oil consumption were first examined in the Club Convergence analysis. Below, sectors converging in natural gas consumption (industry, transportation, agriculture and livestock, housing, trade and services, sugar production, fertilizer manufacturing, cement manufacturing, iron and steel, non-ferrous metals, highways) are analyzed. The value added of these sectors forms the dependent variable, while the independent variables are the sectors' natural gas consumption and deviations in natural gas prices.

Table 8. Moments Quantile Regression Location and Scale Analysis Results (lncost, lnngs dummy)

Location	Coefficient	Std. Err.	t-statistic	p-value	95% Confidence Interval
lnngs	0.3484	0.0574	6.06	0.000	[0.2358, 0.4611]
dummy	0.5076	0.1069	4.75	0.000	[0.2979, 0.7173]
cons	21.3291	0.3329	64.06	0.000	[20.6766, 21.9817]
Scale					
lnngs	0.0472	0.3625	1.30	0.192	[-0.0237, 0.1183]
dummy	-0.1679	0.0674	-2.49	0.013	[-0.3002, -0.0357]
cons	0.2194	0.2099	1.05	0.296	[-0.1921, 0.6310]

Table 8 shows the location and scale results of the Moments Quantile Regression by variables. Here, the location parameter represents the central tendency of the distribution. An examination of the p-value for natural gas consumption in the location parameter reveals that it is 0.000. The p-value is less than 0.05, indicating that an increase in natural gas consumption increases the average effect on the sectors' value added. It is observed that each unit increase in natural gas consumption increases the average value of the sectors' value added at factor cost by 0.3484 units. The 95% confidence interval is [0.2358, 0.4611], indicating a reliable positive effect. The p-value for the dummy variable is 0.000, indicating a positive effect. The coefficient of this variable is 0.5076. Each unit increase in the dummy variable, which indicates deviations in natural gas prices, will increase the average value of the dependent variable by 0.5076 units. The 95% confidence interval is [0.2979, 0.7173], indicating that this effect is reliable. Examining the constant term reveals that the coefficient is 21.32, making the result statistically significant. The P value here is 0.000, which is less than 0.05. When the independent variables are zero, the value added is approximately 21.32. The dummy variable, which indicates deviations in natural gas consumption and natural gas prices, has a significant effect on location, that is, the average value added, the dependent variable. Both variables were found to increase the average value added.

When examining the effect of natural gas consumption on the scale of another parameter, the scale parameter, the p-value is found to be 0.192. This value is not statistically significant, indicating that natural gas consumption does not change the variance of value added across sectors. When examining the dummy variable, the p-value is 0.013, and its effect on the scale is statistically significant. The coefficient is -0.1679. A one-unit increase in the dummy variable will reduce the spread of value added. The 95% confidence interval (CI) is [-0.3002, -0.0357],

demonstrating reliability and a negative effect. The dummy variable, which represents deviations in natural gas prices, negatively affects the value added of sectors. The coefficient for the constant term is 0.2194, and the p-value is 0.296. The constant term is not significant in the scale parameter. It is observed that the constant term has no specific effect. In short, while deviations in natural gas prices have a negative and significant relationship with the scale parameter, no significant effect of natural gas consumption on the scale was found.

Table 9. Moments Quantile Regression Analysis Results (lncost, lnngs dummy)

MMQREG		**Quantiles**			
Lncost		**Q_25**	**Q_50**	**Q_75**	**Q_90**
	Coefficient	0.3049	0.3302	0.3865	0.4196
	Std. Err.	0.0498	0.0523	0.0764	0.0983
lnngs	**t-statistic**	6.13	6.31	5.06	4.27
	p-value	0.000	0.000	0.000	0.000
	CI	[0.2074, 0.4024]	[0.2280, 0.4327]	[0.2367, 0.5363]	[0.2270, 0.6122]
	Coefficient	0.6626	0.5727	0.3725	0.255
	Std. Err.	0.0927	0.0999	0.1419	0.1882
dummy	**t-statistic**	7.15	5.73	2.62	1.36
	p-value	0.000	0.000	0.009	0.175
	CI	[0.4809, 0.8442]	[0.3768, 0.7687]	[0.0943, 0.6506]	[-0.1138, 0.6238]
	Coefficient	21.1268	21.2441	21.5058	21.6593
	Std. Err.	0.2884	0.3010	0.4435	0.5651
cons	**t-statistic**	73.26	70.58	48.49	38.33
	p-value	0.000	0.000	0.000	0.000
	CI	[20.5615,21.6920]	[20.6541,21.8341]	[20.6365,22.3751]	[20.5516,22.7669]

The explanations of the variables are as follows:

lncost: It is the dependent variable and represents the logarithm of the value added of the sectors calculated with factor cost between 2009 and 2021.

lnngs: It expresses the logarithm of natural gas consumption of the sectors between 2009-2021.

dummy: Refers to deviations in natural gas prices. This variable shows the deviations in natural gas prices between 2009 and 2021.

For natural gas consumption (lnngs),

H_0: Natural gas consumption of sectors does not have a significant impact on the value added of sectors.

H_1: Natural gas consumption of sectors has a significant impact on the added value of sectors.

For deviations (dummy) in natural gas prices;

H_0: Deviations in natural gas prices do not have a significant impact on the value added of sectors.

H_1: Deviations in natural gas prices have a significant impact on the value added of sectors.

P values less than 0.05 ($p<0.05$) indicate that H_0 hypothesis will be rejected and the alternative hypothesis H_1 hypothesis will be accepted.

Table 9 presents the results of the Moment Quantile Regression analysis conducted for dummy variables showing deviations in sectors' value added at factor cost, natural gas

consumption, and natural gas prices. Sectors represent sectors that converge as a result of the Club Convergence analysis. Natural gas consumption is observed to be positive and statistically significant in every quantile. This indicates that sectors' natural gas consumption positively affects value added calculated at factor costs in low, medium, and high value-added sectors. The coefficient in the 25th quantile is 0.3049, and the p-value is 0.000. In the 25th quantile, natural gas consumption positively affects value added. This relationship is statistically significant. As natural gas consumption increases in low-value-added sectors, the value added of the sectors also increases. In the 50th quantile, the coefficient is 0.3302, and the p-value is 0.000. The confidence interval is [0.2280, 0.4327], proving that there is a positive and significant relationship. In the 50th quantile, it is understood that there is a positive relationship between natural gas consumption and value added of sectors. In the 75th quantile, the coefficient is 0.3865, and the p-value is 0.000. The confidence interval is [0.2367, 0.5363]. The results reveal that natural gas consumption affects sectors with high value added more strongly. In high-value-added sectors, an increase in natural gas consumption increases value added more. In the 90th quantile, the coefficient is 0.4196, and the p-value is 0.000. Looking at the 95% confidence interval, it is [0.2270, 0.6122]. As a result of the analysis, it is seen that the effect of natural gas consumption on sectors is stronger in sectors with the highest value added. There is a positive relationship between natural gas consumption and value added of sectors. The analysis reveals that this effect is stronger at higher quantiles. A positive and statistically significant relationship is observed across all quantiles. P values are less than 0.05 across all quantiles. An examination of the coefficients reveals that they range from 0.3049 to 0.4196. The coefficients representing the estimated effect size reveal a positive relationship. Consequently, as a sector's natural gas consumption increases, its factor cost and value added also increase. H_0 hypothesis is rejected, and H_1 hypothesis is accepted. It is understood that sectors with relatively higher natural gas consumption have higher value added.

The dummy variable represents deviations in natural gas prices. In the 25th quantile, the coefficient is 0.6626, and the p-value is 0.000. The effect of deviations in natural gas prices is positive in low-value-added sectors. In the 50th quantile, the coefficient is 0.5727, and the p-value is 0.000. This result shows that deviations in prices at the 50th quantile, also referred to as the median, i.e., sudden increases or decreases, have a positive effect on value-added. In the 75th quantile, the coefficient is 0.3725, and the p-value is 0.009. The effect coefficient is less than in the low- and medium-value-added sectors. The 95% confidence interval is [0.0943, 0.6506], which has a wide confidence interval. In this case, it indicates a weaker effect. The p-value is statistically significant. However, it is also understood that there is a weaker relationship compared to the 25th and 50th quantiles. Looking at the 90th quantile, the coefficient is 0.2550, and the p-value is 0.175. It is observed that deviations in natural gas prices do not have a significant effect on the value added of sectors with high value added. While there is a positive and significant relationship between deviations in natural gas prices and the value added of sectors in the 25th and 50th quantiles, this relationship is still positive in the 75th quantile, but weaker than the previous two quantiles. In the 90th quantile, it was determined that deviations in natural gas prices do not have a significant effect on value added. High-value-added sectors have no significant relationship with deviations in natural gas prices. However, deviations in natural gas prices have a stronger effect on sectors with low value added.

The constant term in the model represents the value of the dependent variable (value added at factor cost) when the independent variables are zero. In the 25th quantile, the coefficient is

21.1268, and the p-value is 0.000. The initial range for the effect of the independent variables, namely, deviations in natural gas consumption and natural gas prices across sectors, will be 21.1268 units of value added. In the 50th quantile, the coefficient is 21.2441, and the p-value is 0.000. In the 75th quantile, the coefficient is 21.5058, and the p-value is 0.000. In the 90th quantile, the coefficient is 21.6593, and the p-value is 0.000. The coefficients of the constant term are significant and positive in all quantiles. If the results of deviations in natural gas consumption and natural gas prices across sectors are zero, the linkage between sectors' value added is positive and significant.

5. Conclusion and Policy Implications

One of the key inputs for industries is energy products. In Turkey, the lack of sufficient domestic resources, limited reserves, and high consumption levels result in a high degree of external dependency. This situation poses significant risks for industries and also increases production costs. Energy policies, deviations in energy prices, and cyclical fluctuations increase vulnerability and negatively affect sectors. Given the importance of energy as a production input, this study examines the impact of energy consumption and energy prices on sectors, particularly natural gas and oil products, where Turkey's dependence on imports is very high.

In this study, Turkey's sectoral energy consumption between 1992 and 2021 was analyzed using the Phillips-Sul Club Convergence model. Subsequently, the relationship between sectoral energy consumption, sectoral value added, and deviations in energy prices between 2009 and 2021 was analyzed using the Moments Quantile Regression method. Natural gas and oil products, for which we are largely dependent on imports, were chosen for energy consumption. Although natural gas and oil reserves have been discovered in Turkey in recent years, work in this area is ongoing, and we remain dependent on imports for natural gas and oil products. Natural gas and oil prices were considered for energy prices, and deviations in prices were determined. The findings of the study show that energy consumption and deviations in energy prices in Turkey's key sectors and their sub-sectors have significant effects on the added value created in the production process of these sectors.

In the first phase of the study, a Club Convergence analysis was conducted on sectoral energy consumption to identify sectors that converge and do not converge in terms of energy consumption. Since natural gas and oil product consumption constitute a large part of sectoral energy consumption in Turkey, the analysis conducted on these energy sources shows that sectoral differences are decreasing or increasing over time. The analysis of natural gas consumption for 10 sectors showed that all sectors converged and formed a single sub-club. These sectors are: industry, transportation, agriculture and livestock, housing, trade and services, sugar production, fertilizer manufacturing, cement manufacturing, iron and steel, non-ferrous metals, and highways. In oil consumption, it was observed that there was no convergence for all 13 sectors included in the analysis and that three sub-clubs were formed. The converging sectors for oil consumption are transportation, cement manufacturing, highways, industry, agriculture and livestock, housing, trade and services, maritime transport, and air transport. The findings show that energy consumption tends to converge when examined from a sectoral perspective, but some sectors do not follow this trend.

The findings of this study are consistent with the existing literature, which reveals that convergence in energy consumption is not a uniform process. Phillips and Sul (2007) emphasize

that convergence can occur among groups with similar dynamics and that this process can manifest as club structures. Studies in the literature on energy intensity, energy efficiency, and total energy consumption show that multiple convergence clubs can form between countries and sectors (Apergis et al., 2017b; Ivanovski et al., 2018; Ayazoğlu, 2022). In this context, the formation of multiple sub-clubs in oil consumption in this study aligns with the heterogeneous convergence structure emphasized in the literature. In contrast, the formation of a single convergence club among sectors in natural gas consumption in this study is a less discussed finding in the literature and can be explained by the expansion of natural gas infrastructure in Turkey and the similarity of usage patterns across sectors over time.

In the second stage of the study, the relationship between the added value of converging sectors, energy consumption, and deviations in energy prices was examined using the Moments Quantile Regression method. The findings reveal that increased oil consumption increases the factor cost and added value of the transportation, cement manufacturing, highways, industry, agriculture and livestock, housing, trade and services, maritime, and aviation sectors. This effect is more pronounced in higher quantiles. At the 25th quantile, the coefficient is 0.1495, and the p-value is 0.000. In this case, oil product consumption is seen to positively affect the factor cost and added value of the sectors. At the 50th quantile, the results are similar to those at the 25th quantile. In this case, it is understood that there is a positive relationship between oil product consumption and the added value of sectors at the 50th quantile as well. At the 75th quantile, the coefficient is 0.1679, and the p-value is 0.001. This result reveals that oil consumption has a stronger effect on sectors with high added value. In the 90th quantile, the coefficient is 0.1783, and the p-value is 0.005. The effect of oil product consumption in sectors is more pronounced in sectors with the highest added value. The analysis shows that this effect is stronger in the 75th quantile and the 90th quantile, i.e., in the higher quantiles. A positive and statistically significant relationship is observed across all quantiles. The p-values are less than 0.05 across all quantiles. When examining the coefficients, they are observed to be in the range of 0.1495 to 0.1783. The coefficients, which represent the estimated effect size, indicate a positive relationship. In conclusion, as oil consumption increases, the factor cost and added value of the sectors also increase. The H_0 hypothesis is rejected, and the H_1 hypothesis is accepted. It is found that sectors with relatively higher oil consumption have higher added value. It has been understood that fluctuations in oil prices negatively affect high-value-added sectors. Fluctuations in oil prices have been seen to negatively affect the added value of the transportation, cement manufacturing, highways, industry, agriculture and livestock, housing, trade and services, maritime, and aviation sectors, particularly at high quantiles. At the 25th quantile, the coefficient is 0.210, and the p-value is 0.113. The result is not statistically significant. In the 50th quantile, the coefficient is -0.086, and the p-value is 0.555. Since the p-value is greater than 0.05, there is no significant effect. In the 75th quantile, the coefficient is -0.336, and the p-value is 0.044. A significant effect is present, indicating that deviations in oil prices negatively affect value added in high-value-added sectors. At the 90th quantile, the coefficient is -0.641, and the p-value is 0.002. This result is statistically significant. The effect of deviations in oil prices is more pronounced in the groups with the highest value added. Deviations in oil prices negatively affect added value. While there is no significant effect at the 25th and 50th quantiles, the results are significant at the 75th and 90th quantiles, showing a negative effect. The analysis shows that deviations in oil prices negatively affect sectors. It is understood that when energy costs are difficult to predict, the added value of sectors will decrease.

A positive relationship was also found between natural gas consumption and the added value of the industrial, transportation, agriculture and livestock, housing, trade and services, sugar production, fertilizer manufacturing, cement manufacturing, iron and steel, non-ferrous metals, and highways sectors. At the 25th quantile, the coefficient is 0.3049, and the p-value is 0.000. At the 25th quantile, natural gas consumption positively affects added value. This relationship is statistically significant. As natural gas consumption increases in low-value-added sectors, the added value of these sectors also increases. At the 50th quantile, the coefficient is 0.3302, and the p-value is 0.000. At the 50th quantile, there is a positive relationship between natural gas consumption and added value in these sectors. At the 75th quantile, the coefficient is 0.3865, and the p-value is 0.000. At the 90th quantile, the coefficient is 0.4196, and the p-value is 0.000. The results at the 75th and 90th quantiles show that an increase in natural gas consumption in high-value-added sectors increases added value even more. The results are positive and significant at all quantiles. Consequently, as natural gas consumption increases in sectors, both factor costs and value added also increase. The null hypothesis H_0 is rejected, and the alternative hypothesis H_1 is accepted. It is understood that sectors with relatively higher natural gas consumption have higher value added.

For natural gas prices, the coefficient is 0.6626 and the p-value is 0.000 in the 25th quantile. The effect of deviations in natural gas prices is seen to be positive in sectors with low added value. The coefficient is 0.5727 and the p-value is 0.000 in the 50th quantile. This result shows that deviations in prices, i.e., sudden increases or decreases, have a positive effect on added value. At the 75th quantile, the coefficient is 0.3725 and the p-value is 0.009. The effect coefficient is lower than for low and medium value-added sectors. It is understood that there is a weaker relationship compared to the 25th and 50th quantiles. Looking at the 90th quantile, the coefficient is 0.2550 and the p-value is 0.175. It is seen that deviations in natural gas prices do not have a significant effect on the added value of sectors with high added value. While there is a positive and significant relationship between natural gas price deviations and the added value of sectors in the 25th and 50th quantiles, this relationship is still positive in the 75th quantile but weaker than in the previous two quantiles. In the 90th quantile, it has been determined that natural gas price deviations have no significant effect on added value. There is no significant relationship between natural gas price deviations and sectors with high added value. It has been determined that natural gas price deviations have a stronger effect on sectors with low added value. The analysis results show that energy consumption and energy price deviations can have varying degrees of impact on sectors.

The fact that fluctuations in oil prices have more negative effects, especially in high value-added sectors, can be explained by the direct dependence of these sectors on oil products in their production processes and the difficulty in predicting production costs due to fluctuations in oil prices. Volatility in oil prices increases cost pressure in energy-intensive sectors, negatively impacting the value added generated by these sectors. In contrast, the fact that changes in natural gas prices have more limited or positive effects on low and medium value-added sectors is attributed to the fact that in Turkey, natural gas prices are determined within the framework of long-term contracts and public regulations, resulting in a delayed and limited reflection of fluctuations in international markets on sector costs. In this context, the study demonstrates that the sectoral effects of energy price fluctuations are not homogeneous and that these effects differ depending on both the type of energy and the structural characteristics of the sectors, thus offering a unique contribution to the literature through the example of Turkey.

While the findings of this study are methodologically consistent with the studies of Anwar et al. (2021), Du et al. (2022), and Khaddage-Soboh et al. (2023), they reveal some differences specific to Turkey in terms of the effects of energy price deviations on the value added of sectors. In these studies, Anwar et al. (2021) and Du et al. (2022) evaluate the effects of energy consumption and prices primarily within the framework of countries' energy supply structure, market depth, and institutional arrangements, while Khaddage-Soboh et al. (2023) show that the effects of natural resource revenues and energy-related policies on environmental indicators are heterogeneous among quantiles. In the case of Turkey, this study highlights high external dependence on energy, the rapid reflection of energy price and exchange rate movements on production costs, and differences in cost structures between sectors. The type and share of inputs used by sectors in the production process are extremely important here. The amount of energy used by sectors in production and the share of energy in total costs vary.

In conclusion, natural gas and oil product consumption in Turkey significantly affects sectors. The analysis conducted using the Phillips-Sul Club Convergence approach shows that there are convergence trends among sectors in energy consumption, but some sectors do not follow this trend. Following the Club Convergence and Moments Quantile Regression analysis, it is thought that possible supply problems and price deviations in the energy sector will affect sectors, and that these effects will be reflected in macroeconomic indicators.

This study can serve as an important resource for shaping energy policies, considering Turkey's dependence on foreign energy and the energy needs of various sectors. In particular, developing policies to counter fluctuations in energy prices for sectors with high energy consumption in terms of imported energy products, increasing investments and incentives for renewable energy sources, and reducing energy dependence can minimize economic vulnerability. In addition, the Russia-Ukraine war has caused concern in many countries regarding energy supply, reminding them of the importance of energy supply security policies, which have been reviewed. Within the scope of energy supply security, important policy steps will include increasing the number of countries from which energy is imported and avoiding reliance on a single country for energy supply, increasing energy diversity, increasing efforts regarding the transit of pipelines through Turkey for producer and consumer countries, and developing transmission and distribution infrastructure. In addition to transmission and distribution infrastructure, energy storage infrastructure must also be strengthened and storage capacity increased to counter crises, wars, or embargoes.

Dependence on fossil energy sources such as oil and natural gas is an important factor affecting a country's foreign relations. While energy supply security becomes a critical tool in foreign policy, innovative solutions must be developed to reduce energy dependence in the long term. It is crucial for countries with high energy dependence to take steps towards renewable energy sources, even if they cannot meet their entire energy consumption. In this context, investments in energy production in Turkey should be developed and encouraged for renewable energy sources with potential. Looking at the reserves discovered and current production of natural gas and oil, which are non-renewable energy sources, it is seen that they have a limited reserve life on a global scale. The reserve life of natural gas is 48 years, while that of oil is 53 years. Instead of investing in energy sources with an average reserve life of 50 years, except for necessary investments such as transmission, distribution, and storage capacity, investments should be made in sustainable and clean energy systems. A transition should be made from fossil fuels with limited reserve lives to renewable and inexhaustible energy sources. This transition

will provide a price advantage for sectors affected by energy prices in the long term and will also be beneficial from an environmental perspective. Turning to energy sources that will reduce energy dependence will also reduce the risks that sectors have to bear.

Among energy sources, dependence on foreign countries, especially for oil products, increases the vulnerability of sectors to exchange rate fluctuations. Therefore, more stable exchange rate policies can help control increases in energy prices.

Increases in energy prices have negative effects on sectors with high energy consumption. Price advantages can be provided to balance energy costs in these sectors. For example, in sectors with high energy costs, tax exemptions or subsidies on energy prices can be applied to provide a competitive advantage in these sectors. Such policy choices must be consistent with the country's overall economic policies. For example, if increasing employment is a priority in economic policies, tax incentives and support can be provided to sectors with high employment creation potential.

Sudden fluctuations in energy prices and the consumption of energy products with high external dependency increase the costs of sectors. Such situations are reflected in macroeconomic indicators. These cost increases lead to a current account deficit and budget deficits. In addition, many factors such as employment, inflation, and economic growth are also affected.

The findings of this study should be evaluated within the context of the dataset used and the scope of the analysis. The limitation of the econometric analysis applied in the second phase to the period 2009-2021 indicates that the results reflect the energy market conditions and the country's macroeconomic structure of this period. The study covers a period characterized by volatility in global energy prices and the significant impact of exchange rate movements on energy costs. Furthermore, the study's focus solely on petroleum products and natural gas consumption limits direct generalizations to other energy sources. Additionally, the exclusion of sectors that do not show convergence in energy consumption from the second-phase analysis reveals that the findings are applicable only to sectors with similar energy consumption dynamics and convergence, not to all sectors. Therefore, the results and policy recommendations should be evaluated considering the period, energy types, and sector groups in question. Future studies should include data covering longer periods and energy consumption from sources such as coal and electricity to increase the generalizability of the findings and provide a broader perspective on energy policies.

The results obtained reveal the effects of sectoral energy consumption and energy prices on the added value of sectors, while enabling advanced analysis to better understand their impact on economic growth and development. Monitoring energy consumption by sector and examining deviations in energy prices play an important role in shaping future energy policies.

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
The authors declare that they have contributed equally to the article.

Declaration of Researcher's Conflict of Interest
There is no potential conflicts of interest in this study.

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References

Anwar, A., Siddique, M., Dogan, E. and Sharif, A. (2021). The moderating role of renewable and non-renewable energy in environment-income nexus for ASEAN countries: Evidence from Method of Moments Quantile Regression. *Renewable Energy*, 164, 956-967. https://doi.org/10.1016/j.renene.2020.09.128

Apergis, N. and Christou, C. (2016). Energy productivity convergence: New evidence from club converging. *Applied Economics Letters*, 23(2), 142-145. https://doi.org/10.1080/13504851.2015.1058899

Apergis, N. and Payne, J.E. (2017). Per capita carbon dioxide emissions across US states by sector and fossil fuel source: Evidence from club convergence tests. *Energy Economics*, 63, 365-372. https://doi.org/10.1016/j.eneco.2016.11.027

Apergis, N., Christou, C. and Hassapis, C. (2013). Convergence in public expenditures across EU countries: Evidence from club convergence. *Economics & Finance Research*, 1(1), 45–59. https://doi.org/10.1080/21649480.2013.862735

Apergis, N., Ewing, B.T. and Payne, J.E. (2017a). Introduction: Symposium on energy sector convergence. *Energy Economics*, 62, 335-337. https://doi.org/10.1016/j.eneco.2016.09.015

Apergis, N., Fontini, F. and Inchauspe, J. (2017b). Integration of regional electricity markets in Australia: A price convergence assessment. *Energy Economics*, 62, 411-418. https://doi.org/10.1016/j.eneco.2016.06.022

Ayazoğlu, B. (2022). *Seçilmiş OECD ülkelerinde kişi başi CO2 emisyonu ve toplam enerji tüketimleri yakınsama kulüpleri analizi* (Master's thesis). Pamukkale University, Türkiye.

Baktemur, F.İ. and Özmen, M. (2016). AB-27 ülkeleri için gelir yakınsamasının mekânsal ekonometrik analiz ile tahmini. *Çukurova Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 20(1), 1-10. Retrieved from https://dergipark.org.tr/tr/pub/cuiibfd

Baležentis, T., Butkus, M. and Štreimikienė, D. (2023). Energy productivity and GHG emission in the european agriculture: The club convergence approach. *Journal of Environmental Management*, 342, 118238. https://doi.org/10.1016/j.jenvman.2023.118238

Bangjun, W., Linyu, C., Feng, J. and Yue, W. (2023). Research on club convergence effect and its influencing factors of per capita energy consumption: Evidence from the data of 243 prefecture-level cities in China. *Energy*, 263, 125657. https://doi.org/10.1016/j.energy.2022.125657

Barro, R.J. and Sala-i-Martin, X. (1992). Convergence. *Journal of Political Economy*, 100(2), 223-251. Retrieved from https://www.jstor.org/journal/jpoliecon

Başar, S., Tosun, B. and Bartik, A. (2020). Türkiye'de büyüme ve sektörel bazda elektrik tüketimi arasındaki ilişki. *Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi*, 34(3), 1089-1109. https://doi.org/10.16951/atauniiibd.724638

Baumol, W.J. (1986). Productivity growth, convergence, and welfare: What the long-run data show. *American Economic Review*, 76(5), 1072-85. Retrieved from https://www.jstor.org/

Bowden, N. and Payne, J.E. (2009). The causal relationship between US energy consumption and real output: A disaggregated analysis. *Journal of Policy Modeling*, 31(2), 180-188. https://doi.org/10.1016/j.jpolmod.2008.09.001

Bulut, M. (2020). *Sektörel enerji tüketimi ve ekonomik büyüme ilişkisi* (Master's thesis). Nevşehir Hacı Bektaş Veli University, Türkiye.

Burnett, J.W. (2016). Club convergence and clustering of US energy-related CO2 emissions. *Resource and Energy Economics*, 46, 62-84. https://doi.org/10.1016/j.reseneeco.2016.09.001

Canay, I.A. (2011). A simple approach to quantile regression for panel data. *The Econometrics Journal*, 14(3), 368-386. https://doi.org/10.1111/j.1368-423X.2011.00349.x

Chandio, A.A., Rauf, A., Jiang, Y., Ozturk, I. and Ahmad, F. (2019). Cointegration and causality analysis of dynamic linkage between industrial energy consumption and economic growth in Pakistan. *Sustainability*, 11(17), 4546. https://doi.org/10.3390/su11174546

Doğan, B. (2019). Enerji tüketimi ve büyüme ilişkisinin Türkiye'de sektörel uygulaması. B. Yuvalı ve T. Eğri (Eds.), *8.Türkiye Lisansüstü Çalışmaları Kongresi Bildiriler Kitabı-II* içinde (ss. 191-207). *8. Türkiye Lisansüstü Çalışmaları Kongresi'nde sunulan bildiri, Malatya.* Malatya: İLEM.

Doyar, B.V. (2015). *Enerji tüketimi–ekonomik büyüme ilişkisi: Türkiye ekonomisi örneği* (Master's thesis). Nevşehir Hacı Bektaş Veli Üniversitesi, Türkiye.

Du, L., Jiang, H., Adebayo, T.S., Awosusi, A.A. and Razzaq, A. (2022). Asymmetric effects of high-tech industry and renewable energy on consumption-based carbon emissions in MINT countries. *Renewable Energy*, 196, 1269-1280. https://doi.org/10.1016/j.renene.2022.07.028

EİGM. (2022). *EIGM reports.* Retrieved from https://www.enerji.gov.tr/eigm-raporlari

Erol, U. and Yu, E.S. (1987). On the causal relationship between energy and income for industrialized countries. *The Journal of Energy and Development*, 113-122. Retrieved from https://www.jstor.org/

Galor, O. (1996). Convergence? Inferences from theoretical models. *The Economic Journal*, 106(437), 1056-1069. https://doi.org/10.2307/2235378

Gökmen, B. (2019). *Sanayi sektörü çıktı hacmi ve enerji tüketimi ilişkisi: Türkiye üzerine ampirik bir analiz* (Master's thesis). Necmettin Erbakan University, Türkiye.

Gross, C. (2012). Explaining the (non-) causality between energy and economic growth in the U.S.—A multivariate sectoral analysis. *Energy Economics*, 34(2), 489-499. https://doi.org/10.1016/j.eneco.2011.12.002

He, W. and Chen, H. (2022). Will China's provincial per capita energy consumption converge to a common level over 1990–2017? Evidence from a club convergence approach. *Energy*, 249, 123624. https://doi.org/10.1016/j.energy.2022.123624

Herrerias, M.J., Aller, C. and Ordonez, J. (2017). Residential energy consumption: A convergence analysis across Chinese regions. *Energy Economics*, 62, 371-381. https://doi.org/10.1016/j.eneco.2016.06.006

Ivanovski, K., Churchill, S.A. and Smyth, R. (2018). A club convergence analysis of per capita energy consumption across Australian regions and sectors. *Energy Economics*, 76, 519-531. https://doi.org/10.1016/j.eneco.2018.10.035

Karimu, A., Brännlund, R., Lundgren, T. and Söderholm, P. (2017). Energy intensity and convergence in Swedish industry: A combined econometric and decomposition analysis. *Energy Economics*, 62, 347-356. https://doi.org/10.1016/j.eneco.2016.07.017

Khaddage-Soboh, N., Safi, A., Rasheed, M.F. and Hasnaoui, A. (2023). Examining the role of natural resource rent, environmental regulations, and environmental taxes in sustainable development: evidence from G-7 economies. *Resources Policy*, 86, 104071. https://doi.org/10.1016/j.resourpol.2023.104071

Khan, Z., Hossain, M. R., Badeeb, R.A. and Zhang, C. (2023). Aggregate and disaggregate impact of natural resources on economic performance: Role of green growth and human capital. *Resources Policy*, 80, 103103. https://doi.org/10.1016/j.resourpol.2022.103103

Kim, Y.S. (2015). Electricity consumption and economic development: Are countries converging to a common trend? *Energy Economics*, 49, 192-202. https://doi.org/10.1016/j.eneco.2015.02.001

Koç, Ü. (2020). Sektörel enerji tüketimi ve ekonomik büyüme. *Third Sector Social Economic Review*, 55(1), 508-521. https://doi.org/10.15659/3.sektor-sosyal-ekonomi.20.03.1289

Koenker, R. (2004). Quantile regression for longitudinal data. *Journal of Multivariate Analysis*, 91(1), 74-89. https://doi.org/10.1016/j.jmva.2004.05.006

Koenker, R. and Bassett Jr, G. (1978). Regression quantiles. *Econometrica: Journal of the Econometric Society*, 33-50. https://doi.org/10.2307/1913643

Kraft, J. and Kraft, A. (1978). On the relationship between energy and GNP. *The Journal of Energy and Development*, 3(2), 401-403. Retrieved from https://www.jstor.org/

Lamarche, C. (2010). Robust penalized quantile regression estimation for panel data. *Journal of Econometrics*, 157(2), 396-408. https://doi.org/10.1016/j.jeconom.2010.03.042

Liu, C., Hong, T., Li, H. and Wang, L. (2018). From club convergence of per capita industrial pollutant emissions to industrial transfer effects: An empirical study across 285 cities in China. *Energy Policy*, 121, 300-313. https://doi.org/10.1016/j.enpol.2018.06.039

Liu, F., Li, A. and Khan, Y. (2024). PM2.5 Neutrality goals: The role of government strengthen and digitalization in BRICS Countries. *Air Quality, Atmosphere & Health*, 17(11), 2615-2629. https://doi.org/10.1007/s11869-024-01592-5

Machado, J.A. and Silva, J.S. (2019). Quantiles via moments. *Journal of Econometrics*, 213(1), 145-173. https://doi.org/10.1016/j.jeconom.2019.04.009

Miao, Y., Razzaq, A., Adebayo, T.S. and Awosusi, A.A. (2022). Do renewable energy consumption and financial globalisation contribute to ecological sustainability in newly industrialized countries? *Renewable Energy*, 187, 688-697. https://doi.org/10.1016/j.renene.2022.01.073

Morales-Lage, R., Bengochea-Morancho, A., Camarero, M. and Martínez-Zarzoso, I. (2019). Club convergence of sectoral CO2 emissions in the European Union. *Energy Policy*, 135, 111019. https://doi.org/10.1016/j.enpol.2019.111019

Panopoulou, E. and Pantelidis, T. (2009). Club convergence in carbon dioxide emissions. *Environmental and Resource Economics*, 44(1), 47-70. https://doi.org/10.1007/s10640-008-9260-6

Parker, S. and Liddle, B. (2017). Economy-wide and manufacturing energy productivity transition paths and club convergence for OECD and non-OECD countries. *Energy Economics*, 62, 338-346. https://doi.org/10.1016/j.eneco.2016.07.018

Phillips, P.C. and Sul, D. (2007). Transition modeling and econometric convergence tests. *Econometrica*, 75(6), 1771-1855. https://doi.org/10.1111/j.1468-0262.2007.00811.x

Pinar, M. (2024). Convergence in renewable energy innovation and factors influencing convergence club formation. *Renewable Energy*, 220, 119607. https://doi.org/10.1016/j.renene.2023.119607

Rahman, M.H., Ruma, A., Hossain, M.N., Nahrin, R. and Majumder, S.C. (2021). Examine the empirical relationship between energy consumption and industrialization in Bangladesh: Granger causality analysis. *International Journal of Energy Economics and Policy*, 11(3), 121-129. https://doi.org/10.32479/ijeep.10843

Rahman, M.M. and Kashem, M.A. (2017). Carbon emissions, energy consumption and industrial growth in Bangladesh: Empirical evidence from ARDL cointegration and Granger causality analysis. *Energy Policy*, 110, 600-608. https://doi.org/10.1016/j.enpol.2017.09.006

Rios Avila, F., Siles, L. and Canavire-Bacarreza, G.J. (2024). Estimating quantile regressions with multiple fixed effects through method of moments (IZA DP No. 17262). Retrieved from https://www.jstor.org/stable/pdf/resrep69218.pdf?acceptTC=true&coverpage=false&addFooter=false

Saba, C.S. and Ngepah, N. (2022). Convergence in renewable energy sources and the dynamics of their determinants: An insight from a club clustering algorithm. *Energy Reports*, 8, 3483-3506. https://doi.org/10.1016/j.egyr.2022.01.190

Şahin, B.Y. (2022). Orta gelir grubu ülkelerde gelir yakınsaması: Phillips Sul kulüp yakınsama analizi. *Asya Studies*, 6(19), 179-188. https://doi.org/10.31455/asya.1023118

Sala-i-Martin, X.X. (1996). Regional cohesion: Evidence and theories of regional growth and convergence. *European Economic Review*, 40(6), 1325-1352. https://doi.org/10.1016/0014-2921(95)00029-1

Uçar, M. and Çoban, S. (2023). Ulaştırma sektöründeki enerji tüketimi, ekonomik büyüme ve çevresel kalite ilişkisi. *Nevşehir Hacı Bektaş Veli Üniversitesi SBE Dergisi*, 13(1), 485-506. https://doi.org/10.30783/nevsosbilen.1228732

Ulucak, R. and Apergis, N. (2018). Does convergence really matter for the environment? An application based on club convergence and on the ecological footprint concept for the EU countries. *Environmental Science & Policy*, 80, 21-27. https://doi.org/10.1016/j.envsci.2017.11.002

Usta, C. and Berber, M. (2017). Türkiye'de enerji tüketimi ekonomik büyüme ilişkisinin sektörel analizi. *Ekonomik ve Sosyal Araştırmalar Dergisi*, 13(1), 173-187. Erişim adresi: https://dergipark.org.tr/tr/pub/esad

Yağış, O. (2023). Doğalgaz tüketimi ve ekonomik büyüme ilişkisi: Batı Avrupa ülkeleri için Bootstrap panel nedensellik testi. *Journal of Economic & Social Research*, 10(20), 2148-1407. Erişim adresi: https://openurl.ebsco.com/

Zachariadis, T. (2007). Exploring the relationship between energy use and economic growth with bivariate models: New evidence from G-7 countries. *Energy Economics*, 29(6), 1233-1253. https://doi.org/10.1016/j.eneco.2007.05.001

Zhang, C. and Xu, J. (2012). Retesting the causality between energy consumption and GDP in China: Evidence from sectoral and regional analyses using dynamic panel data. *Energy Economics*, 34(6), 1782-1789. https://doi.org/10.1016/j.eneco.2012.07.012

Zhu, J. and Lin, B. (2020). Convergence analysis of city-level energy intensity in China. *Energy Policy*, 139, 111357. https://doi.org/10.1016/j.enpol.2020.111357