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FACTORS AFFECTING ENERGY EFFICIENCY IN EMERGING ECONOMIES: MIXED MODELS

YÜKSELEN EKONOMİLERDE ENERJİ ETKİNLİLİĞİNİ ETKİLEYEN FAKTÖRLER: KARMA MODELLER*

Mustafa NAİMOĞLU[1], Mustafa AKAL[2], Çisem BEKTUR[3]

1. Arş. Gör. Dr., Bingöl Üniversitesi, İktisadi ve İdari Bilimler Fakültesi, İktisat Bölümü, mnaimoglu@bingol.edu.tr, https://orcid.org/0000-0001-9684-159X
2. Prof. Dr., Sakarya Üniversitesi, Siyasal Bilgiler Fakültesi, İktisat Bölümü, akal@sakarya.edu.tr, https://orcid.org/0000-0002-0504-100X
3. Dr. Öğr. Üyesi, Sakarya Üniversitesi, Siyasal Bilgiler Fakültesi, Ekonomi Bölümü, ciembektur@sakarya.edu.tr, https://orcid.org/0000-0001-9220-5932

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Abstract

This study aims to explain energy efficiency by social, political, institutional, and economic variables for emerging countries during the 1990-2018 period. The estimated models exhibited cointegrated relationships. According to the predicted models, while GDP per capita and total factor productivity have the most positive effect on energy efficiency, on the other hand, fossil fuel use has the most negative effect on energy efficiency among economical variables. Social globalization, government efficiency, and control of corruption are positive; on the other hand, urbanization is negatively effective on energy efficiency. A 1% increase in GDP per capita improves the energy efficiency between 0.78% and 0.86%, and a 1% increase in total factor productivity increases it by about 0.48%. On the other hand, a 1% increase in fossil fuel consumption reduces energy efficiency between 0.56% and 0.70%. A 1% increase in the energy use of the service and industry sectors causes a decrease in the energy efficiency of about 0.43% and 0.19%, respectively. A 1% increase in social globalization, government efficiency, and control of corruption increase energy efficiency by about 0.15%, 0.10%, and 0.03%, respectively, while a 1% increase in urbanization decreases it by about 1.18%.

Keywords: Emerging Economies, Energy Efficiency, Mixed Models.

Öz

Bu çalışma, 1990-2018 döneminde yükselen ekonomiler için enerji etkinliğini sosyal, politik, kurumsal ve ekonomik değişkenlerle açıklamayı amaçlamaktadır. Tahmin edilen modeller eşbütünleşik ilişkiler sergilemiştir. Öngörülen modellere göre, kişi başına düşen GSYİH ve toplam faktör verimliliği, enerji verimliliği üzerinde en olumlu etkiye sahipken, fosil yakıt kullanımı ise ekonomik değişkenler arasında enerji etkinliği üzerinde en olumsuz etkiye sahiptir. Sosyal küreselleşme, hükümetin etkinliği ve yolsuzluğun kontrolü olumludur; Öte yandan, kentleşme enerji verimliliği üzerinde olumsuz bir etkiye sahiptir. Kişi başına GSYİH'deki %1'lik bir artış, enerji etkinliğini %0,78 ile %0,86 arasında, toplam faktör verimliliğindeki %1'lik bir artış ise onu yaklaşık %0,48 oranında artırmaktadır. Öte yandan fosil yakıt tüketimindeki %1'lik bir artış enerji etkinliğini %0,56 ile %0,70 arasında azaltmaktadır. Hizmet ve sanayi sektörlerinin enerji kullanımındaki %1'lik bir artışı enerji etkinliğinde sırasıyla yaklaşık %0.43 ve %0.19'luk bir azalmaya neden olmaktadır. Sosyal küreselleşmede, hükümet verimliliğinde ve yolsuzluğun kontrolünde %1'lik bir artış enerji etkinliğini sırasıyla yaklaşık %0,15, %0,10 ve %0,03 oranında artırırken, kentleşmedeki %1'lik bir artış, enerji etkinliğini yaklaşık %1,18 oranında azaltmaktadır.

Anahtar Kelimeler: Yükselen Ekonomiler, Enerji Etkinliği, Karma Modeller.

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GENİŞLETİLMİŞ ÖZET

Çalışmanın Amacı

Bu çalışma, 1990-2018 döneminde 23 yükselen ekonomi için enerji etkinliğini sosyal, politik, kurumsal ve ekonomik değişkenlerle açıklamayı amaçlamaktadır.

Araştırma Soruları

1990-2018 döneminde yükselen ekonomilerde ekonomik küreselleşme, sosyal küreselleşme, politik küreselleşme, doğal kaynak kiraları, reel enerji fiyatları, orta-yüksek teknoloji ihracatı, sektörel enerji kullanımları, kentleşme, fosil yakıt kullanımı, yenilenebilir enerji kullanımı, ekonomik büyüme, ekonomik karmaşıklık, yolsuzluğun kontrolü, hükümet etkinliği, hukukun üstünlüğü ve toplam faktör verimliliği değişkenlerinin enerji etkinliği üzerindeki etkilerinin büyüklükleri ve yönleri nasıldır?

Literatür Araştırması

Literatürde konu ile ilgili yapılan birçok çalışmada genellikle ekonomik değişkenler ile enerjinin nasıl daha etkin/verimli kullanılabileceği üzerine yeni çalışmalar vardır. Ancak enerjinin etkin kullanımının ekonomik verilerle olduğu kadar sosyal, siyasal ve kurumsal değişkenlerle de ilişkisinin bulunduğu düşünülmelidir. Dolayısıyla bu çalışmada Yükselen ekonomilerde enerji etkinliğini açıklamaya yönelik değişkenler diğer benzeri çalışmalardan yararlanılarak belirlenmesi gerekmiştir. Enerji etkinliğini etkileyen faktörlerin doğru analizleri ve doğru politikaları bu ekonomilerin aynı üretim miktarı için enerji talebini azaltıcı yönde etki yapacak, bu ise enerji etkinliğini artıracaktır. Ayrıca enerji etkinliği/verimliliğini açıklamaya yeni bir boyut getirerek enerji ekonomisi literatürüne katkı sağlayacaktır.

Yöntem

Öncelikle değişkenler için birimler arası korelasyon testi yapıldı ve ardından değişkenlere durağanlık testleri uygulandı. İkinci olarak, tüm modeller için eğim parametrelerinin yatay kesit bağımlılığı ve homojenliği testleri uygulanmıştır. Daha sonra tahmin edilen modeller için Durbin-Hausman panel eşbütünleşme testi kullanılmıştır. Son olarak, uzun dönemli ilişkiyi araştırmak için Ortak İlişkili Etkiler Ortalama Grup (CCEMG) ve Genişletilmiş Ortalama Grup (AMG) tahmin edicileri kullanılmıştır.

Sonuç ve Değerlendirme

Tahmin edilen modellere göre enerji etkinliğini en fazla olumlu etkileyen kişi başı GSYİH ve toplam faktör verimliliği iken en fazla olumsuz etkileyen fosil yakıt kullanımı bulunmuştur. Model4 ve Model7'de kişi başı GSYİH ve Model11'de toplam faktör verimliliğinde meydana gelen %1'lik artışların enerjinin etkin kullanımını sırasıyla %0,78-%0,86 ve %0,48 artırdığı bulunmuştur. Model4, Model7 ve Model11 için fosil yakıt tüketiminde meydana gelen %1'lik bir artış ise enerji etkinliğini yaklaşık olarak sırasıyla %0,60-%0,70 ve %0,56 oranında azalış meydana getirmektedir. Hizmet ve sanayi sektörleri enerji kullanımında meydana gelen %1'lik bir artış ise yaklaşık olarak sırasıyla %0,43 ve %0,19 oranında etkinlikte azalış meydana getirmektedir. İleri sürülen politik, sosyal ve kurumsal

değişkenler arasında enerji etkinliğini en fazla sosyal küreselleşme, hükümet etkinliği, yolsuzluğun kontrolü etkiler iken en fazla olumsuz etkileyen ise kentleşme bulunmuştur. Sosyal küreselleşme, hükümet etkinliği ve yolsuzluğun kontrolünde meydana gelen %1' lik bir artış enerji etkinliğini yaklaşık olarak sırasıyla %0,15, %0,10 ve %0,03 oranında artırırken en fazla olumsuz etkileyen kentleşmede %1'lik bir artış enerji etkinliğini %1,18'lik azaltmaktadır.

1. INTRODUCTION

Since energy considers many physical resources such as coal, oil, gas, uranium etc. the process of increasing energy efficiency means the maximization of the productivity of these resources used.

Energy consumption has increased with the intensification of globalization since 1990. Emerging economies must consume energy in the most efficient way and developed alternative energy sources renewable to sustain their economic growth and keep environment clean as well through the global reputation periods. However, despite today's technologies, the efficiency of oil, coal, gas, biomass, nuclear, renewable energy inputs have a meager rate of 11% (Gurler et al. 2020). While this situation seriously threatens the future of a livable world, it also points out that there is a huge gap in energy efficiency and indicates the need for studies and policies to increase energy efficiency.

In the world economic report of the IMF published in 2015, Argentina, Bangladesh, Brazil, Bulgaria, Chile, China, Colombia, Hungary, India, Indonesia, Malaysia, Mexico, Pakistan, Peru, Philippines, Poland, Romania, Russia, South Africa, Thailand, Turkey, Ukraine and Venezuela in the form of 23 countries are classified as emerging economies. Emerging economies have high growth figures and generally provide this growth with the energy they import. The importance of this study arises from the indices such as the increases by 286.41% GDP, 568% import, 441% export, 38.18% population (World Bank, 2021), 106.82% total energy consumption, 118.12% fossil fuel use, 52.72% loss during transmission, transportation, and energy distribution, and 132.56% CO_2 emission increases in 2018 compared to 1990 (IEA, 2021). Hence, social, political (political), and institutional variables are needed to be used together with economic variables to explain energy efficiency in these countries.

Indeed, anti-corruption, government effectiveness, the rule of law, political globalization, social globalization, and urbanization are used as political, social, and demographic variables. Accordingly, variables that affect energy efficiency such as globalization, natural resource rents, energy prices, income, technology exports, renewable and non-renewable energy use were literaturely discovered and used.

The literature review was preferred to be discussed under methodology and variables section to save place, and to be more efficiently understandable in presenting paper because of adopting new variables for modelling. And the methods were shortly mentioned in the model and estimation sections in an order. Finally, the study was terminated by interpreting the findings obtained.

2. LITERATURE REVIEW

In many studies in the literature on the subject, there are generally new studies on economic variables and how can use energy more efficiently. However, the effective use of energy should be considered to be related to social, political, and institutional variables as well as economic variables.

Therefore, in this study, variables to explain energy efficiency for Emerging Economies were determined by using other similar studies. Correct analyses and correct policies of the factors affecting energy efficiency will reduce the energy demand of these economies for the same production amount, increasing energy efficiency. Also, it will contribute to the energy economy literature by bringing a new dimension to explaining energy efficiency.

Price: According to economic theory, the price of a good is an essential factor determining the demand for that good. Gamtessa and Olani (2018) found an increase in the energy price decreased the energy-capital and energy-output ratios in a study conducted by Canada for the industrial sector in general. Similarly, Hang and Tu (2007) found that increasing energy prices is an effective policy to increase energy efficiency while investigating the effects of energy prices on energy intensity for China. This is because energy price increases cause a reduction in energy intensity in the long run through substitution between energy sources or mainly through pure efficiency gains at the sector level (Lescaroux, 2008).

In general, it aims to obtain more products with less energy and cost by using an alternative instead of the fuel whose price has increased. On the other hand, renewable energy, which will be an alternative to fossil fuels, also offers significant opportunities to increase the energy efficiency of an economy. Because renewable energy is environmentally friendly and has no cost other than initial costs, it is also an essential tool for countries dependent on foreign energy to reduce this dependency. Therefore, the adoption of renewable energy use is an essential alternative for substituting fossil energy resources (Chang et al., 2009).

The world is now turning to cleaner energy sources for the uncertainty of energy prices, reduction of dependence on fossil fuels, and a cleaner environment. Bird et al. (2005), since the increases in natural gas prices, increase the electricity production costs of generators whose source is natural gas, the use of wind energy has increased. Marques et al. (2010) stated that due to the high prices of oil, natural gas, coal, and nuclear energy resources, they increased the use of renewable energy according to the degree of substitution. Similarly, according to Menz and Vachon (2006), price increases in fossil fuels will become more attractive for consumers for environmentally friendly alternative energies.

Antonietti and Fontini (2019), on the other hand, while investigating the effect of energy prices on energy efficiency for 120 countries, stated that a global policy aiming to increase the price of oil would cause a limited increase in energy efficiency. However, this increase would differ significantly between regions in the world. On the other hand, according to Sadorsky (2009), increases in oil prices have a slightly negative effect on the use of renewable energy. Similarly, according to Van Ruijven and Van Vuuren (2009), high natural gas and oil prices are an essential driving force of coal use. Also, high oil and natural gas prices will result in i) a decrease in energy use and small growth figures, ii) how to use energy more effectively, and iii) the search for and substitution of alternative energy sources.

Income: Another essential variable determining the demand for a good in economic theory is income. Energy use in economies and most of the output due to this use is generated by industry, services, and agriculture sectors. The increase in the income and/or production of economies spread to all sectors and brings technological developments. Therefore, income is the primary determinant of energy efficiency. Akal (2016) found that an increase in per capita production increase will increase energy efficiency. Hatzigeorgiou et al. (2011) found that there is a one-sided causality from income towards efficient use of energy. Chen et al. (2019) found that one unit of a marginal increase in income will contribute to an improvement of 0.735% - 0.852% inefficient use of energy.

Total Natural Resource Rents: Total natural resource rents consist of the sum of oil, natural gas, coal (hard and soft), mineral and forestry rents (World Bank, 2021). It is observed that countries rich in natural resources will attract more Foreign Direct Investment (FDI) to countries that are at the same level but have scarce resources in terms of natural resources, as their rental costs will generally below. However, it is thought that foreign and domestic investors will cause environmental degradation when excessive waste is in question due to the low rent. Bekun et al. (2019), while investigating the effect of natural resource rent on carbon dioxide emission (CO2) for 16 European Union (EU) countries, emphasized the need for studies and effective policies on energy, as natural resource rent cheapness increases energy consumption and thus environmental degradation. On the other hand, Ross (1999), Sachs and Warner (2001), Papyrakis and Gerlagh (2004) and Robinson et al. (2006) stated that natural resource rents for oil-rich countries generally negatively affect economic growth as a result of their cheapness and excessive waste, hence; bringing about inefficient use of energy.

Globalization: There is no clear definition of globalization, but it has been defined differently by different people and institutions. Globalization is defined as "international liberalization of an economy is integrating a country's local economic system with world economic markets and institutions through foreign capital, technology, knowledge, and experience" by the United Nations. However, although the definitions of globalization are different, globalization, in general, includes international trade and capital flows and a wide range of international indicators such as human, idea, technology, and cultural transfer (Altıner et al., 2018). This definition reflects the multidimensional aspect of globalization. The Swiss Institute of Economics (KOF) has classified the general indicator of globalization into economic, social, and political sub-indexes.

Energy consumption will increase as economic activity will increase in countries with high globalization (Cole, 2006). As energy consumption is directly related to economic activities, the increasing economic activity requires more energy use. On the other hand, considering globalization in terms of trade and foreign capital, it may also reduce energy consumption through technology transfer without creating any obstacle to the economic activities of countries (Antweiler, Copeland and Taylor, 2001). Pan et al. (2020) found that globalization increased energy efficiency in their study covering the

2003-2006 period for 30 provinces in China. Similarly, the researchers (Wang, 2017; Mingyong et al., 2006; Adom, 2015; Zhao and Lin, 2019; Boqiang and Hongxun, 2015; Dawei et al., 2010) stated that globalization has a positive impact on the economy in terms of technology transfer and development, affecting both the conservation of energy and its more efficiency use. Therefore, globalization makes it essential for a country to use energy efficiently.

Total Factor Productivity: Many variables are used in the literature representing technology to measure the relationship between technological innovation and energy consumption. Patents was used as an indicator of technological change in Griliches (1998) study. Irandoust (2016) arguing that FDI plays a vital role at the technological innovation level of a country, FDI as an indicator of technological change. Liv et al. (2014) arguing that a more significant investment in R&D reflects a greater incentive of technological innovation, R&D as an indicator of technological change. Total factor productivity (TFP) was used as a measure of technological innovation by Zhang (2014). TFP expresses the combined effect of institutional innovation, technological innovation, industrial structure regulation, and resource allocation optimization, including labor and capital as resources. Thus, TFP is a more comprehensive measure of technological innovation than FDI or R&D.

Huang et al. (2017), while exploring the drivers of energy intensity for China, found that technological progress significantly reduced overall energy intensity in China. Similarly, Tan and Lin (2018) found that technological development is the essential factor in reducing energy density while investigating the factors that cause energy density reduction in China's energy-intensive industries. Similarly, Lin and Wang (2016), Golder (2011), Medlock (2009) and Boyd and Pang (2000) stated that technological development is significant in improving energy efficiency.

Exports of Products Including Advanced Technology: The quality of exports and exports of an economy determines the international competitiveness of that economy (Trabold, 1995). The literature states that countries' technology exports will determine the competitive power of countries in the international arena. An increase in technology exports means an increase in the number of knowledges, experience and qualified employment experienced in that field (Nur and Dilber, 2017). This situation is expected to positively reflect the country's growth, policies, and technological developments, and thus improve energy efficiency. In some developed countries, the decrease in energy losses and the technological development, and the increase in energy efficiency make it reflected in more production and export.

Economic Complexity Index: The economic complexity index developed by the Massachusetts Institute of Technology (MIT) is shown as a criterion for measuring the quality of products exported by economies. Higher economic complexity means more productivity. The High Economic Complexity Index shows that high-complexity products and large-scale products are produced together. This means more knowledge, skills, and experience. Therefore, countries with higher economic complexity can produce products with more productivity. However, in a country with increased economic complexity, fossil fuel dependency is high in energy inputs. There is little or no use of renewable energy infrastructure or energy-efficient technology. It is expected that energy will be used inefficiently and increase environmental degradation in such countries. Otherwise, energy will be more efficiently, and environmental quality will increase.

The researchers (Gözgör and Can, 2017; Jin and Kim, 2019; Lapatinas et al., 2019) found that the increase in economic complexity increases energy efficiency, reduces CO2 emissions, and leads to a higher environmental quality. However, Neagu and Teodoru (2019) found that the increase in economic complexity increases energy consumption and causes higher pollution for EU countries. The reason for this is that each country has a heterogeneous structure. As the energy input decreases in the use of renewable energy in parallel with the increase in economic complexity, there will be a decrease in energy efficiency and an increase in environmental degradation.

Sectoral Energy Use: Economies have to use energy in order to develop, produce and survive. Mechanization, which started with industrialization and then increased, has caused the development of the industrial sector, which is the essential wheel in developing countries, thus increasing energy consumption in this field. Today, the world is constantly striving to ensure the sustainability of energy use by increasing energy use and consumption.

With 118% increase in the World GDP, energy use in industry, services, and agriculture sectors increased by approximately 57%, 63%, and 30%, respectively, in 2018 compared to 1990 (IEA, 2021). The fact that the world's fossil fuel share for 2018 has approximately 81% (oil 32%, coal 27%, and natural gas 23%) within the total energy share demonstrates the importance of using energy more efficiently and turning to alternative energy sources in the world.

Zhang and Xu (2012) found that economic growth in China led to more intensive use of energy and the intensity experienced in all sectors reduced energy efficiency for China between 1995-2008. With the development of mechanization and technology in the agricultural sector, human and animal power has decreased. With these developments, the use of energy-intensive inputs, agricultural machinery, and chemicals in the agricultural sector is increasingly becoming widespread in agricultural production systems (Soni, 2013). In 2018, the world agriculture (agriculture, forest, and fishing) industry had a 65% share as fossil fuel among energy resources. Also, oil took the highest share in fossil fuels with 53%, followed by coal with 7% and natural gas with 5% (IEA, 2021). Having such high rates of fossil fuels in the agricultural sector causes many environmental negativities and carbon dioxide emissions. Therefore, the negative environmental impacts caused by the development of the agricultural sector, the cost of energy inputs, and the ending of fossil fuels are essential for energy efficiency and alternative resources in this field. In support of this situation, Chen et al. (2020), stated that energy efficiency applications due to the high share of fossil fuels among energy sources in the agricultural sector are significant for this sector.

Fossil Fuel Use: Due to the high share of fossil fuels among energy sources, the world still does not have good scenarios for a livable future. Compared to 1990, the total energy consumption in the world increased by 63% in 2018, while fossil fuels (coal, oil, natural gas) increased by 62.97%. Also, the share of fossil fuels among the world's energy resources in 2018 has a high share of 81.20%. The share of renewable energy has a low rate of 4.54%, which unfortunately worsens these bad scenarios (IEA, 2021). In addition, considering the negative effects of fossil fuel use on the environment, the temperature change in the world increased by 131.6% in 2019 compared to 1990 (FAOSTAT, 2021). Increases in these temperature changes threaten hydro resources, which have a share of 55.84% among the world's renewable energy resources in 2018 (IEA, 2021). In addition, while 2 billion tons of CO2 gas was emitted in the world in the early 1900s, it increased by 1600% in 2018 and reached 36.2 billion tons (Gurler et al., 2020). In addition, a 43.83% increase in the world population in 2018 compared to 1990 will further increase the need for energy (World Bank, 2021). In addition to all these negative situations, fossil fuel reserves have a lifespan of 51 years for oil, 53 years for natural gas, and 114 years for coal (ETKB, 2017). Also, despite today's technologies, the efficiency of oil, coal, gas, biomass, nuclear, renewable energy inputs the fact that it has a meager rate of 11% shows how important energy efficiency, renewable energy, and alternative energy sources are (Gurler et al., 2020).

Renewable Energy Use: Renewable energy offers many opportunities to improve energy efficiency. Renewable energy, which positively affects energy independence and energy efficiency, is of great importance, especially for developing countries. Countries that increase energy efficiency by increasing the share of renewable energy help achieve many objectives such as increasing overall sustainability, reducing energy bills, energy dependency, and greenhouse gas and greenhouse gas emissions while maintaining or increasing economic activity.

Control of Corruption: As the level of corruption increases in a country, there is a decrease in Foreign Direct Investments (FDI) entering the country, a decrease in the independence of public institutions, and a weakening in the quality of the institutions. Corruption generally emerges and increases as a result of political instability and weakness. Therefore, the impact of corruption on the harshness of environmental policy depends on the degree of political instability. Corruption will also reduce the implementation of environmental and energy-related policies, reducing the stringency of environmental regulations. Researhers (Sarmidi et al., 2015; Fredriksson et al., 2003; Kellenberg, 2009; Barassi and Zhou, 2012; Mudambi et al., 2013) found that countries that succeed in combating corruption have an essential advantage in attracting foreign capital and FDI.

Government Effectiveness: It is thought that political factors that can affect the rigidity of energy policies and the quality of government and administrative efficiency affect the implementation process of energy policies. Chang et al. (2018) investigated the impact of higher government efficiency on energy use efficiency over 1990-2014 for 31 OECD countries. It is found that the institution's quality in the respective economies increases social welfare, which is important to governments, leads to more effective environmental policy and higher energy efficiency, and that government efficiency significantly affects energy efficiency. They also stated that the quality of government and administrative efficiency affect implementing energy efficiency policies. Mandal (2010) found that when the government understands the dangers of environmental problems in energy-intensive industries, it significantly impacts India's energy efficiency with effective policies.

Sheikh et al. (2016) investigated the social and political effects of renewable energy. The findings indicate that strong government policies and incentives that support the deployment of renewable energy are part of the political perspective and that the government can play an essential role in accelerating the development and deployment of renewable energy technology by funding research and providing a supportive Research and Development (R&D) framework. A higher government efficiency can increase energy efficiency through environmental and energy policies (Chang et al., 2018).

The Rule of Law: The rule of law is implementing the laws without distinguishing between domestic and foreign companies, small and large companies, providing equality of opportunity and an environment of trust to companies in the entire market. As the rule of law increases, the competitiveness of foreign capital investment companies in the market and the transparency of the policies applied and implemented will increase (Nur and Dilber, 2017). The rule of law mostly affects energy efficiency positively via easily implementing renewable energies. Erdinç and Aydınbaş (2020), on the other hand, investigated the determinants of renewable energy consumption for 16 countries and found that the increase in the rule of law positively affects renewable energy.

The relationship between environmental issues, including energy use and emissions, has been extensively studied in recent years. Some researchers have stated that urbanization increases energy demand and generates more emissions (Parikh and Shukla, 1995). On the other hand, other researchers have argued that urbanization and urban density reduce energy use and emissions by improving the efficient use of public infrastructure (e.g., public transport and other public services) (Chen et al. 2008). Although urbanization is frequently discussed in economic modernization, it is a demographic indicator that increases urban density and transforms the organization of human behavior, affecting household energy use patterns (Barnes et al. 2005).

Poumanyvong and Kaneko (2010) investigated the relationship between urbanization and energy demand for 99 countries in 1975-2005. The findings show that the impact of urbanization on energy use will differ according to the country's development level. Surprisingly, urbanization reduces energy consumption in low-income economies and increases it in middle and high-income economies.

Alam et al. (2010) found that urbanization in Pakistan increased energy consumption. Liu (2009) stated that urbanization reduces energy demand by using resources more efficiently due to its industrial and technological infrastructure for China. Holtedahl and Joutz (2004) stated that urbanization in Taywan increases the energy demand especially in the housing sector, and Parikh and Shukla (1995) stated that urbanization increases energy consumption in developing countries.

3. METHODOLOGY

The factors affecting energy efficiency for emerging economies are needed to be analyzed here. While doing this, using similar studies in the literature, mixed variables including social, political, and institutional variables were used as well as economic variables. To confirm whether our proposed variables are significant in influencing energy efficiency, 11 Models were created by using 21 variables by considering the importance of these variables for emerging economies. While these models were being created, the maximum number of variables that would be meaningful and obtain more information was taken into consideration, and the VIF values were not exceeded 10.

In the way of econometric methodolgy, first of all, an inter-unit correlation test will be performed for the variables, and then stationarity tests will be applied to the variables. After taking the first differences, considering that the series is stationary and there may be a cointegration relationship between the dependent variable and the explanatory variables, cross-section dependency and homogeneity of slope parameters tests will be applied for all models. Then, Durbin-Hausman's cointegration tests will be applied to all models. Finally, CCEMG and AMG long-term coefficient estimators will be used for models with cointegration relationships as primary tests leaded us to use CCEMG and AMG techniques.

3.1. Variables

Table I presents the definition, aims of uses, the expected signs of the parameters and coefficient of variations of related variables.

Table 1. Definition of variables, sources, intended use, aims of uses, expected signs of parameters, coefficient of variation (CV)

Variable	Description/ Source	Aim of Use	Exp. Sign	CV	Obs.
LEE	Log((GDP (Constant 2010 US$) / Total Energy Supply (ktoe)) GDP:World Data Bank, databank.worldbank.org, TES: International Energy Agency, www.iea.org	It was used as the dependent variable while investigating the energy efficiency with mixed variables.		3.83	667
LECO	Log(Economic globalization index)	With increasing globalization; increasing trade and foreign capital inflow, it is expected to increase energy	+	8.28	667

	KOF index of globalization, www.kof.ethz.ch	efficiency through technology, knowledge, and experience transfer.			
LSOC	Log(Social globalization index) KOF index of globalization, www.kof.ethz.ch	Since tourism represents an increase in internet usage and welfare, it is thought that energy efficiency will be positively affected by the increase in environmental quality.	+	9.41	667
LPOL	Log(Political globalization index) KOF index of globalization, www.kof.ethz.ch	It is expected that a more effective government will have a positive impact on energy efficiency by being among the countries that have signed international agreements such as the Paris Agreement, which includes the obligation to reduce the use of fossil fuels and use environmentally friendly energy sources, which are important for climate change.	+	3.16	667
LNRR	Log(Total Natural Resources Rents(Constant 2010 US$)) World Data Bank, databank.worldbank.org	The increase in natural resource rents will cause an increase in costs for domestic and foreign investors who will operate in the host country. It is thought that this situation will negatively affect energy efficiency by increasing the use of fossil fuels such as coal since it does not require easily accessible and high technology to reduce energy costs in production.	-	107	667
LCOA	Log(Inflation-adjusted Brent price x average nominal exchange rate w.r.t. USD) Brent Petrol, www.bp.com, World Data Bank, databank.worldbank.org, inflationdata.com	It is thought that countries that import most of their energy, will be pushed to seek ways to use energy resources more effectively in the face of the increase in energy prices.	+	27.8	667
LOIL	Log(Inflation-adjusted Brent price x average nominal exchange rate w.r.t. USD) Brent Petrol, www.bp.com, World Data Bank, databank.worldbank.org, inflationdata.com			30.4	667
LTCH	Log(Medium and high-tech embodied goods exports (% manufactured exports)) World Data Bank, databank.worldbank.org	It will give information about the production technology level, quality, knowledge, and experience of human capital in the country where the ratio of medium and advanced technology included goods exports to total industry exports has increased. It is thought that this increase will reflect positively on the effective use of energy.	+	24.5	667
LIND	Log(Industry sector total energy use(ktoe))	The energy used in the sectors causes an increase in production. However, it is thought that this increase will negatively affect energy efficiency as it will increase the use of imported fossil fuels, which is a feature in most of these countries.	-	13.5	667

	International Energy Agency, www.iea.org				
LSRV	Log(Services sector total energy use (ktoe)) International Energy Agency, www.iea.org			10.9	667
LAGR	Log(Agriculture, forestry, Fishing sector total energy use (ktoe)) International Energy Agency, www.iea.org			29.1	667
LURB	Log(Urban population) World Data Bank, databank.worldbank.org	It is thought that the population density experienced in urbanization will cause an increase in the general energy density, especially in the housing sector, for countries whose technology infrastructure is not advanced, and therefore, energy efficiency will be negatively affected.	-	6.34	667
LFOS	Log(Coal, oil and natural gas total energy(ktoe)) International Energy Agency, www.iea.org	For countries dependent on foreign energy in the field of energy, the increase in the use of fossil fuels is expected to adversely affect energy efficiency, as it will cause more foreign exchange needs, more current account deficit, and more environmental degradation.	-	11.3	667
LREN	Log(Hydro, wind, solar, etc. total energy (ktoe)) International Energy Agency, www.iea.org	Countries that increase energy efficiency by increasing their share of renewable energy, while maintaining or increasing the level of economic activity, also increase overall sustainability, reduce energy bills, reduce energy dependence, and reduce greenhouse gas emissions. Therefore, it is thought that this situation will have a positive effect on energy efficiency.	+	23.0	667
LGDP	Log(GDP per capita (constant 2010 US$)) World Data Bank, databank.worldbank.org	It is expected to increase energy efficiency as the increase in the income of the economies will increase the demand and use of technological developments and energy-saving machines and devices.	+	10.6	667
LECI	Log(Economic Complexity Index) The Observatory of Economic Compexity, oec.world	The increase in economic complexity is expected to increase energy efficiency. However, it is expected that the increase in economic complexity in emerging economies will adversely affect energy efficiency, as emerging economies increase the use of fossil fuels in response to their increased production and do not have sufficient technological infrastructure for renewable energy.	-	100	529
LCOR	Log(Control of Corruption) World Data Bank, databank.worldbank.org	In economies with higher corruption, it is expected that the effective implementation of environment-oriented energy policies may be compromised, and it is expected to adversely affect energy efficiency by reducing the rigidity of energy policies, causing weakening of government efficiency. On the other hand, increased control of corruption will increase energy efficiency.	+	3900	529

LGOV	Log(Government Effectiveness) World Data Bank, databank.worldbank.org	It is thought that higher government efficiency will positively affect energy efficiency by influencing the implementation and success of environmentally oriented energy policies.	+	200	529
LLAW	Log(Rule of Law) World Data Bank, databank.worldbank.org	The weakening of law in a country is considered to be one of the obstacles to the implementation of energy policies that will increase energy efficiency by leading to lower market transparency, less accountability, inadequate regulatory and legal restrictions in the energy field.	+	86.2	529
LTFP	Log(Real total factor productivity index) Penn World Table, fred.stlouisfed.org	It is thought that the increase in total factor productivity, which represents technology as a technological innovation in the literature, will positively affect energy efficiency.	+	-700	483

It is possible to encounter a multi-collinearity problem if the correlation coefficient between two explanatory variables used in the models is higher than 0.80 (Gujarati, 2003). In addition, the variance inflation factor (VIF) above 10 may imply multicollinearity problem (Assaf et al., 2019). The only mean VIF values for all models are shown in the last lines of Table 6 to save place. Simple correlation coefficients were calculated to obtain information about the degree and direction of the simple relationship between the series; however, they were not given for space-saving here. It has been observed that some pairs of independent variables have a correlation coefficient over 0.80, which is higher than the correlation ratio between a pair of dependent and independent variables. Therefore, 11 models were created to avoid the multicollinearity problem and predict the direction and magnitude of the impact without bias considering all VIF calculations.

3.2. Variables

Firstly, the first 4 models were created by various combinations of 15 explanatory variables (economic globalization, social globalization, political globalization, natural resource rents, oil price, coal price, natural gas price, technology export, industrial sector energy use, services sector energy use, agricultural sector energy use, urbanization, fossil fuel consumption, renewable energy use and GDP per capita) for 23 countries covering the period 1990-2018, as follows:

$$LEE_{it} = \beta_0 + \beta_1 LGDP + \beta_2 LNRR_{it} + \beta_3 LECO_{it} + \beta_4 LSRV_{it} + \beta_5 LAGR_{it} + \beta_6 LREN_{it} + u_{it} \quad \text{(Model1)}$$

$$LEE_{it} = \beta_0 + \beta_1 LGDP_{it} + \beta_{2L} NRR_{it} + \beta_3 LFOS_{it} + \beta_4 LPOL_{it} + \beta_5 LOIL_{it} + u_{it} \quad \text{(Model2)}$$

$$LEE_{it} = \beta_0 + \beta_1 LGDP_{it} + \beta_2 LNRR_{it} + \beta_3 LIND_{it} + \beta_4 LNTR_{it} + \beta_5 LURB_{it} + u_{it} \quad \text{(Model3)}$$

$$LEE_{it} = \beta_0 + \beta_1 LGDP_{it} + \beta_2 LSOC_{it} + \beta_3 LFOS_{it} + \beta_4 LCOA_{it} + \beta_5 LAGR_{it} + u_{it} \quad \text{(Model4)}$$

Then, the next 5 models were created by adding 4 more variables (economic complexity index, control of corruption, government effectiveness, and rule of law) to the first 15 variables covering the

1996-2018 period because of not having data for the 1990-1995 period data for these 4 variables. The following models were created for 23 countries:

$$LEE_{it} = \beta_0 + \beta_1 LLAW_{it} + \beta_2 LURB_{it} + \beta_3 LAGR_{it} + \beta_4 LNRR_{it} + \beta_5 LFOS_{it} + \beta_6 LOIL_{it} + \beta_7 LSOC_{it} + \beta_6 LECI_{it} + u_{it} \quad \text{(Model5)}$$

$$LEE_{it} = \beta_0 + \beta_1 LGOV_{it} + \beta_2 LNRR_{it} + \beta_3 LIND_{it} + \beta_4 LREN_{it} + \beta_5 LECO_{it} + \beta_{6L} COA_{it} + \beta_7 LSOC_{it} + u_{it} \quad \text{(Model6)}$$

$$LEE_{it} = \beta_0 + \beta_1 LECI_{it} + \beta_2 LFOS_{it} + \beta_3 LGDP_{it} + \beta_4 LOIL_{it} + \beta_5 LECO_{it} + \beta_6 LTCH_{it} + u_{it} \quad \text{(Model7)}$$

$$LEE_{it} = \beta_0 + \beta_1 LGOV_{it} + \beta_2 LNRR_{it} + \beta_3 LSRV_{it} + \beta_4 LGDP_{it} + \beta_{5L} ECO_{it} + \beta_6 LCOA_{it} + u_{it} \quad \text{(Model8)}$$

$$LEE_{it} = \beta_0 + \beta_1 LCOR_{it} + \beta_2 LECI_{it} + \beta_3 LOIL_{it} + \beta_4 LSRV_{it} + \beta_5 LURB_{it} + u_{it} \quad \text{(Model9)}$$

Finally, Model10 and Model11 were created by using a total of 20 explanatory variables together with the total factor productivity variable, since the total factor productivity data were not available for Pakistan and Bulgaria. These models were created for 21 countries covering the period 1996-2018 as follows;

$$LEE_{it} = \beta_0 + \beta_1 LTFP_{it} + \beta_2 LGOV_{it} + \beta_3 LSRV_{it} + \beta_4 LECO_{it} + \beta_5 LPOL_{it} + \beta_6 LNRR_{it} + \beta_7 LREN_{it} + u_{it} \quad \text{(Model10)}$$

$$LEE_{it} = \beta_0 + \beta_1 LTFP_{it} + \beta_2 LFOS_{it} + \beta_3 LURB_{it} + \beta_4 LCOA_{it} + \beta_5 LNRR_{it} + \beta_6 LLAW_{it} + \beta_7 LAGR_{it} + u_{it} \quad \text{(Model11)}$$

3.3. Preliminary Tests

3.3.1. Cross-Section Dependency Test

Looking at the cross-sectional dependency will enable one to examine unobservable common effects and determine the estimation method to be used. Before investigating whether the variables contain unit root or not, the inter-unit correlation of variables shall be tested. This test will determine the reliability of the coefficients and standard errors to be obtained. Because if there is no correlation between units, 1st generation unit root tests shall be preferred, and if there is, 2nd generation unit root tests shall be preferred. In panel data analysis, Breusch-Pagan (1980) CDLM1 test and Pesaran (2004) CDLM2 and (Pesaran-Ullah-Yamagato (2008) CDLM-Adj tests are used when the time size is greater than the section size (T> N).

Pesaran (2004) CDLM test can be used for cross-section dependency when N and T are large enough. However, Pesaran (2004) CDLM test may deviate results when individual averages are different from zero and the group mean zero. On top of that, Peseran (2008) developed the CDLM-Adj test; Pesaran (2004) succeeded in correcting the CDLM test by adding the variance and mean to the CDLM test statistics. Therefore, this test deviation is expressed as a corrected LM test. Hypothesis tests belonging to these tests are in the form of $H_0: cov(\varepsilon_{it}\varepsilon_{jt}) = 0, H_0: cov(\varepsilon_{it}\varepsilon_{jt}) \neq 0$. Here H0: There is no correlation between units. Breusch and Pagan (1980) developed an LM statistic in

$$LM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2 \quad (1)$$

for the H hypothesis. Where, $\hat{\rho}_{ij}^2$ is the square of the correlation estimates for the Ordinary Least Squares (OLS) errors. Pesaran (2004) formulated another inter-unit correlation test, the CDLM test, which has many features such as non-homogeneous dynamic models and multiple breaks in slopes, as

$$CD = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^2 \tag{2}$$

Also, Pesaran (2004) developed the CDLM test statistics in the form of

$$CD_{LM} = \sqrt{\frac{1}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} (T\hat{\rho}_{ij}^2 - 1) \tag{3}$$

which shows an asymptotic distribution with a mean-variance of 0 and 1 under the H0 hypothesis, when time and unit go to infinity. However, in cases where the time is fixed, and the number of units (N) is much greater than the time dimension (T), the value of $E(T\hat{\rho}_{ij}^2) \neq 0$ will be valid for the entire time dimension, so this test statistic will not exhibit a normal distribution. Therefore, Pesaran, Ullah and Yamagata (2008), who added the mean and variance of the parameters to the test statistics, formulated the corrected bias-corrected LM test statistic as

$$LM_{adj} = \sqrt{\frac{2}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \frac{(T-k)\hat{\rho}_{ij}^2 - \mu_{ij}}{\sigma_{ij}} \tag{4}$$

Where $\mu_{ij} = (T-k)\hat{\rho}_{ij}^2$, and $\sigma_{ij} = Var((T-k)\hat{\rho}_{ij}^2)$, k is the number of explanatory variables.

Table 2. Inter-Unit Cross-Section Dependency Test Results Based on Variables

	CD_{LM1}		CD_{LM2}		$CD_{LM\text{-}Adj}$	
Variable	Intercept	Intercept and Trend	Intercept	Intercept and Trend	Intercept	Intercept and Trend
LEE	362.9***	369.9***	4.9***	5.2***	18.6***	18.1***
LECO	1434.6***	1319.5***	52.5***	47.4***	44.0***	37.5***
LSOC	1298.1***	1281.8***	46.5***	45.7***	49.8***	40.2***
LPOL	1136.9***	1137.4***	39.3***	39.3***	28.4***	18.5***
LNRR	1464.0***	1439.8***	53.8***	52.8***	51.6***	21.8***
LCOA	1380.6***	1368.7***	50.1***	49.6***	59.8***	17.8***
LOIL	1483.8***	1581.1***	54.7***	59.0***	70.0***	33.9***
LNTR	1674.4***	1705.0***	63.2***	64.5***	51.9***	24.6***
LTCH	1727.1***	1604.5***	65.5***	60.1***	50.4***	25.6***
LIND	1800.8***	1718.4***	68.8***	65.1***	72.0***	25.6***
LSRV	1403.7***	1378.3***	51.2***	50.0***	62.0***	32.2***

LAGR	1226.8***	1267.8***	43.3***	45.1***	43.9***	17.1***
LURB	1094.5***	1049.5***	37.4***	35.4***	55.8***	39.7***
LFOS	1782.2***	1776.8***	68.0***	67.7***	69.4***	33.4***
LREN	1294.1***	1239.4***	46.3***	43.9***	69.6***	25.9***
LGDP	1667.9***	1610.1***	62.9***	60.3***	74.1***	35.3***
LECI	2656.1***	2658.5***	106.8***	106.9***	56.7***	19.2***
LCOR	2068.8***	2056.0***	80.7***	80.2***	34.0***	21.5***
LGOV	1986.3***	1999.2***	77.1***	77.6***	41.0***	20.8***
LLAW	3271.8***	3241.7***	134.2***	132.9***	56.5***	20.2***
LTFP	411.7***	407.0***	7.1***	6.8***	17.4***	16.4***

Note: * denotes significance at the 1%. The null hypothesis is no cross-sectional dependence.

Table 2 shows the results of the cross-section dependency tests CDLM1, CDLM2 and CDLM-Adj tests for variables. According to all test results, there is cross-section dependency in all models with "constant" and "with constant and trend" for all variables, referring the application of the 2nd generation unit root tests.

3.3.2. Unit Root Test

Not working with stationary series in panel estimation methods may cause spurious regression and reduce the reliability of estimation results. In the panel data, it becomes essential which stationarity tests will be chosen for this. For this, there is a need for inter-unit correlation tests. If there is a correlation between units, the results of first-generation unit root tests such as LLC (Levin, Lin and Chu (2002)), IPS (Im, Pesaran, and Shin, (2003)), MW (Maddala and Wu (1999)) cannot be relied on, so the second generation unit root tests must be used.

Unit root tests that take into account the correlation between units are needed in the study. Therefore, CIPS (Cross-Sectionally Augmented IPS) developed by Pesaran (2007) and PANIC (Panel Analysis of Nonstationary in Idiosyncratic and Common components) tests developed by Bai and Ng (2010) will be used.

The PANIC test considers the correlation between units by separating the error terms obtained with common factors in the form of $X = A_{it} + \delta_i' B_t + e_{it}, \quad e_{it} = \alpha_i e_{it-1} + \varepsilon_{it}$ with the principal components approach. Also, while performing the PANIC test; P_a, P_b and PMSB in the form of

$$P_{a1} = \frac{T\sqrt{N}(\theta^{+}-1)}{\sqrt{2\vartheta^4/\mu^4}}, P_{a2} = \frac{T\sqrt{N}(\theta^{+}-1)}{\sqrt{(36/5)\vartheta^4\partial^4/\mu^8}} \quad (5)$$

$$P_{b1} = T\sqrt{N}(\theta^{+} - 1)\sqrt{\frac{\frac{1}{NT^2 tr(\hat{\epsilon}'_{-1}\hat{\epsilon})\mu^2}}{\vartheta^4}} \;,\; P_{b2} = T\sqrt{N}(\theta^{+} - 1)\sqrt{\frac{\frac{1}{NT^2 tr(\hat{\epsilon}'_{-1}\hat{\epsilon})5\mu^6}}{6\vartheta^4}}\,\partial^4 \quad (6)$$

$$P_{MSB1} = \frac{\sqrt{N}\left(tr\left(1/NT^2\hat{\epsilon}'\hat{\epsilon}\right)-\mu^2/2\right)}{\sqrt{\vartheta^4/3}}, P_{MSB2} = \frac{\sqrt{N}\left(tr\left(1/NT^2\hat{\epsilon}'\hat{\epsilon}\right)-\mu^2/6\right)}{\sqrt{\vartheta^4/45}} \quad (7)$$

are pooled modified Sargan-Bhargava (Sargan and Bhargava (1983); Stock (1999)) test statistics. Here, calculations are made for Pa1, Pb1 and PMSB1 fixed and trend models for the fixed or non-fixed Model, and Pa2, Pb2 and PMSB2 for the models with fixed or trend. Short-term, long-term and one-sided variance estimates for the ε_{it} error term are ∂^2, μ^2 and ϑ^2, respectively. For all Pa, Pb and PMSB, the H0 hypothesis states that the series is not stationary. Another unit root test to be used in the study is the CIPS (Cross Sectionally Augment Im, Pesaran and Shin (2003)) test developed by Pesaran (2007). In the CIPS test, He performs factor decomposition with cross-section averages and performs the test using the mean of the cross-sectional mean of expanded individual cross-section (ADF) regressions. The Ho hypothesis of this test is that there is a unit root in the panel groups, and it is stationary in the alternative hypothesis. For the hypothesis test, the test statistics calculated as Extended Dickey-Fuller (CADF)

$$CADF_{ist} = t_i(a_i) = \frac{(\Delta y_i' \mathrm{M} w_i y_{i-1})}{\sqrt{\hat{\sigma}^2_{\varepsilon i}(y_{i-1}' \mathrm{M} w_i y_{i-1}}} \quad (8)$$

are used. The cross-sectional expanded (CIPS) statistic, calculated by taking the individual averages of CADF statistics, is calculated as

$$CIPS_{ist} = (1/N)\sum_{i=1}^{N} CADF_i \quad (9)$$

Table 3. Unit Root Test Results

	Pa		Pb		Pmsb		CIPS	
Level	Intercept	Intercept and T rend	Intercept	Intercept and T rend	Intercept	Intercept and T rend	Intercept	Intercept and Tr end
LEE	-0.404	0.98	-0.446	1.129	0.8	1.301	-1.865	-2.333
LECO	-1.148	-0.292	-1.01	-0.284	-0.565	-0.217	-2.400***	-2.646*
LSOC	-5.215**	0.458	-3.427***	0.489	-1.783**	0.554	-2.903***	-2.955***
LPOL	-1.387*	0.003	-1.181	0.003	-0.566	0.086	-3.415***	-3.813***
LNRR	-3.498***	-1.623*	-2.543***	-1.418*	-1.628*	-1.040	-2.169**	-2.986***
LCOA	-2.291**	0.698	-1.382*	0.949	-0.749	-1.278*	-3.698***	-3.742***
LOIL	-1.901**	0.579	-1.238	0.742	-0.653	0.940	-3.927***	-4.315***
LNTR	-2.360***	0.305	-1.416*	0.341	-0.742	0.387	-3.507***	-4.713***
LTCH	0.600	0.940	1.069	1.314	3.378	1.824	-2.631***	-3.037***
LIND	1.638	0.456	2.406	0.488	3.872	0.551	-2.315***	-2.635*

LSRV	0.065	0.935	0.071	1.064	0.779	1.217	-2.114*	-2.009
LAGR	0.534	0.655	0.519	0.736	0.074	0.855	-1.795	-2.418
LURB	-3.534***	-1.659**	-2.519***	-1.394*	-1.718*	-1.130	-1473	-2.296
LFOS	0.895	0.869	0.966	0.986	0.773	1.117	-2.271**	-2.344
LREN	2.400	-2.188**	3.598	-1.779**	3.784	-1.262	-2.441***	-2.554
LGDP	0.036	0.446	0.041	0.478	0.805	0.482	-2.197**	-2.210
LECI	-0.812	-1.260	-0.651	-0.960	-0.388	-0.620	-1.548	-2.463
LCOR	-1.401*	-0.446	-0.723	-0.413	-1.116	-0.281	-2.068	-3.106***
LGOV	-0.078	-3.502***	-0.060	-2.389***	-0.474	-1.285*	-2.215**	-3.469***
LLAW	-2.803***	0.567	-1.561*	0.712	-0.941	0.914	-2.352***	-3.249***
LTFP	-2.112**	0.009	-1.254	0.009	-0.655	0.001	-0.980	-1.951
1st Dif.	Pa	Pb	Pmsb	CIPS	Pa	Pb	Pmsb	CIPS
	Intercept	Intercept and Trend	Intercept	Intercept and Trend	Intercept	Intercept and Trend	Intercept	Intercept and Trend
ΔLEE	-4.887***	-5.768***	-3.504***	-4.804***	-1.493*	-1.675**	-4.814***	-4.888***
ΔLECO	-5.850***	-5.768***	-3.191***	-3.504***	-1.611*	-1.675**	-5.065***	-5.061***
ΔLSOC	-13.284***	-9.195***	-6.169***	-5.684***	-2.751***	-2.684***	-5.179***	-5.501***
ΔLPOL	-3.098***	-5.132***	-2.274***	-3.506***	-1.283*	-1.900**	-5.346***	-5.514***
ΔLNRR	-8.035***	-8.982***	-4.169***	-5.089***	-1.935**	-2.162**	-5.534***	-5.576***
ΔLCOA	-35.544***	-30.833***	-10.904***	-14.041***	-2.800***	-3.203***	-5.682***	-5.986***
ΔLOIL	-44.169***	-24.986***	-11.976***	-11.713***	-2.657***	-3.282***	-5.746***	-6.011***
ΔLNTR	-73.023***	-1.425*	-12.488***	-1.199	-2.299**	-0.861	-5.242***	-5.857***
ΔLTCH	-19.874***	-20.510***	-7.413***	-9.734***	-2.395***	-2.994***	-4.462***	-4.664***
ΔLIND	-15.144***	-15.876***	-6.381***	-8.431***	-2.514***	-3.238***	-4.799***	-5.011***
ΔLSRV	-14.243***	-10.177***	-6.076***	-5.943***	-2.441***	-2.598***	-4.621***	-4.798***
ΔLAGR	-21.380***	-21.236***	-7.361***	-9.593***	-2.361***	-2.842***	-5.186***	-5.378***
ΔLURB	-7.035***	-7.982***	-3.169***	-4.089***	-0.935	-1.162	-2.544***	-2.269***
ΔLFOS	-3.207***	-3.001***	-2.307**	-4.007***	-1.343*	-1.689*	-4.444***	-4.877***
ΔLREN	-15.685***	-12.956***	-5.754***	-6.791***	-1.975**	-2.522***	-5.077***	-5.200***
ΔLGDP	-4.885***	-5.794***	-3.155***	-3.943***	-1.832**	-2.197**	-3.804***	-3.917***
ΔLECI	-21.870***	-7.278***	-6.185***	-3.800***	-1.453*	-1.26	-4.753***	-4.783***
ΔLCOR	-10.440***	-9.518***	-3.964***	-4.674***	-1.597*	-1.587*	-5.539***	-5.572***
ΔLGOV	-30.324***	-15.492***	-9.129***	-7.314***	-2.458***	-1.915**	-5.450***	-5.606***
ΔLLAW	-0.86	-4.027***	-0.417	-2.327**	-0.8	-1.023	-5.371***	-5.646***

ΔLTFP	-1.887**	-2.400***	-1.488*	-1.856**	-0.784	-1.068	-2.837***	-2.964***

Note: ∗∗∗, ∗∗ and ∗ denote significance at the 1%, 5%, and 10% levels respectively. Δ signifies the first difference. For PANIC and CIPS tests the null hypothesis is nonstationarity.

In short, Table 3 indicates that all variables commonly become stationary after taking the first differences at mostly under 1% probability level to show cointegrated relationship.

3.3.3. Cross-Section Dependency and Homogeneity Tests of Slope Parameters

Cointegration tests will be done according to the stationarity levels of dependent variables and explanatory variables. For this, first of all, a cross-section dependency test will be made over error terms in models. If there is a cross-sectional dependency in the models, the 2nd generation cointegration tests will be used. However, the cross-section dependency existed in the estimated models. Therefore, the 2nd generation cointegration tests have been carried out, and the results are shown in Table 4.

One of the advantages of panel estimation methods is that the slope parameters pool information from unit and time dimensions under homogeneity. Pesaran et al. (1996) suggested Hausman (1978) test when unit size is greater than time dimension. In this test, he compares the fixed effects estimator and the mean group estimators according to the homogeneity and heterogeneity of the slope parameters. On the other hand, in cases where the time dimension is greater than the unit dimension, Swamy (1970) proposed his own Swamy test using the coefficients of units obtained from Pooled Least Squares (POLS) results. Pesaran and Yamagata (2008) developed the Δ˜ and Δ˜adj tests in which the obtained statistical values were normally distributed even if the model errors do not have a normal distribution in all cases.

$$\tilde{\Delta}= \sqrt{N}\left(\frac{N^{-1}\check{S}-k}{\sqrt{2k}}\right),\ \tilde{\Delta}_{adj}= \sqrt{\frac{N(T+1)}{T-k-1}}\left(\frac{N^{-1}\check{S}-k}{\sqrt{2k}}\right) \quad (10)$$

While developing this test, and S˘, which is also in the formula, they modified the Swamy test statistics. The homogeneity of the slope parameters that will determine the feature of the estimation method has been tested for each model and shown in Table 4.

Table4. Inter-unit cross-section dependency test results based on variables

	Cross-Section Dependency Tests		Homogeneity Tests	
Models	CD_{LM1}	CD_{LM2}	$\tilde{\Delta}$	$\tilde{\Delta}_{adj}$
Madel1	366.69***	5.05***	22.02***	25.71***
Model2	386.01***	5.91***	27.52***	31.43***
Model3	346.93***	4.18***	24.50***	27.98***
Madel4	397.39***	6.42***	24.97***	28.52***
Model5	245.81***	1.75***	13.63***	17.85***

Model6	329.61***	3.41***	13.34***	16.88***
Madel7	354.32***	4.50****	14.26***	17.46***
Model8	315.57***	2.78***	13.27***	16.26***
Model9	474.81***	9.86***	16.45***	19.55***
Madel10	248.00**	1.85**	12238.0***	15.48***
Model11	317.79***	5.26***	14.62***	18.49***

Notes: $***$ denotes significance at the 1%. For the homogeneity test, the null hypothesis is slope homogeneity. For the cross-section dependency test between error terms of units, the null hypothesis is no cross-sectional dependence.

If one pays attention to Table 4, it is seen that both cross-section dependency exist and slope parameters are heterogeneous in all models. In the following steps, estimates will be made by considering these situations.

3.3.4. Cointegration Test

The Durbin-Hausman cointegration test, one of the second generation panel cointegration tests, was used in this study, whose data set is also suitable for macro panels. Westerlund (2008) investigated a cointegration relationship by factor decomposition over residuals in the case of cross-section dependency. Also, the test can investigate the cointegration relationship when the dependent variable is I(1), and the cointegration degree of the explanatory variables is not essential. And, DHp gives the panel statistics when the slope parameters of the model are homogeneous while DHg gives the group statistics when the slope parameters are heterogeneous.

General equation of Durbin-Hausman cointegration test;

$$y_{it} = \beta_i x_{it} + \alpha_i' \delta_t + u_{it} \ , \quad x_{it} = \gamma_i x_{it-1} + \varepsilon_{it} \tag{11}$$

δ_t in the equation expresses deterministic terms. If $\delta_t = (1)$, model becomes fixed, when $\delta_t = (1, t)$, model becomes fixed and trended. For the explanatory variable, there is no requirement of $\gamma_i = 1 (x_{it} \sim I(1))$ in the Dickey-Fuller (DF) function. Ho hypothesis for the Durbin-Hausman cointegration test means that there is no cointegration relationship. To test this hypothesis, test statistics obtained by Choi (1994) are used. Durbin-Hausman test statistics are calculated as

$$DHg = \sum_{i=1}^{N} \hat{S}_i (\hat{\rho}_{i,OLS} - \hat{\rho}_{i,IV})^2 \sum_{t=2}^{T} \hat{e}_{it-1}^2 \tag{12}$$

$$DHp = \hat{S}_N (\widehat{\rho}_{OLS} - \hat{\rho}_{IV})^2 \sum_{i=1}^{N} \sum_{t=2}^{T} \hat{e}_{it-1}^2 \tag{13}$$

A cointegration test will be run to investigate whether there is a long-term relationship in models. Considering the cross-sectional dependency in models and the heterogeneity of the slope parameters, 2nd generation cointegration tests will be used. In addition, the Durbin-Hausman (Westerlund, 2008) test, one of the second generation cointegration tests, will be used because the dependent variable is stationary after taking the first differences and the independent variables are stationary at different levels. Durbin-Hausman cointegration test results are shown in Table 5.

Table 5. Durbin-Hausman Cointegration Test Results in Models

	DHG		DHP	
Models	Intercept	Intercept and Trend	Intercept	Intercept and Trend
Madel1	8.598*** (0.000)	3.838*** (0.000)	2.675*** (0.004)	0.382 (0.351)
Madel2	1.436* (0.075)	2.809*** (0.002)	5.503*** (0.000)	6.649*** (0.000)
Madel3	3.019*** (0.001)	5.711*** (0.000)	-1.035 (0.850)	-1.488 (0.932)
Madel4	0.084 (0.466)	2.400*** (0.008)	0.836 (0.202)	0.139 (0.445)
Madel5	12.791*** (0.000)	0.703 (0.241)	0.112 (0.456)	0.482 (0.315)
Madel6	4.400*** (0.000)	1.654** (0.049)	1.266 (0.103)	1.027 (0.152)
Madel7	4.859*** (0.000)	2.156** (0.016)	0.476 (0.317)	2.276*** (0.010)
Madel8	-1.533 (0.937)	5.176*** (0.000)	0.205 (0.419)	2.414*** (0.008)
Madel9	6.283*** (0.000)	2.348*** (0.009)	-0.780 (0.782)	-2.095 (0.982)
Madel10	11.299*** (0.000)	13.156*** (0.000)	1.725*** (0.042)	1.467* (0.071)
Model11	13.892*** (0.000)	115.829*** (0.000)	-0.131 (0.552)	0.293 (0.385)

Notes: ∗∗∗, ∗∗ and ∗ denote significance at the 1%, 5%, and 10% levels, respectively. The expressions in parentheses show probability values. The null hypothesis is no cointegration.

Table 5 gives the Durbin-Hausman cointegration test results for both group (DHG) and panel (DHP) statistics. If one pays attention to Table 4, it is seen that the slope parameters in all models are heterogeneous. Therefore, the DHG value, which is the group statistic, will be used for all models. Looking at Table 5, it is seen that according to the DHG statistics, the H0: No Cointegration Relationship hypothesis is rejected for all models. Therefore, it is concluded that there is a long-term relationship between energy efficiency and explanatory variables for all models. Therefore, in the next step, the long-term relationship between energy efficiency and explanatory variables will be investigated for the models.

4. ESTIMATES MODELS

The estimators that consider the heterogeneity of the slope parameters and the cross-section dependency will be used. For this, the Common Correlated Effects Mean Group (CCEMG) developed by Pesaran (2006) and the Augmented Mean Group (AMG) estimators developed by Eberhardt & Bond (2009) and Eberhardt & Teal (2010) will be used.

Pesaran obtained the CCEMG by expanding the general panel equation in the form of

$$y_{it} = a_i d_t + \beta_{ki} x_{kit} + u_{it} \text{ , } \; u_{it} = \gamma_{im} f_{tm} + \varepsilon_{it} \tag{14}$$

and by making N group regressions. The Model in the form of

$$y_{it} = a_i d_t + \beta_{ki} x_{kit} + \theta_{1i} \bar{y}_t + \theta_{2i} \bar{x}_{kt} + u_{it} \tag{15}$$

is estimated for each section. Pesaran assumes a random process in the form of $\beta_i = \beta + v_i$ for each slope parameter under heterogeneity, expanded by the cross-sections of dependent and explanatory variables instead of common unobservable factors and $f_t = (f_{1t}, f_{2t}, \ldots, f_{mt})'$ is an m-dinensional vector, common unobservable factors in this equation. $\gamma_i = (\gamma_{i1}, \gamma_{i2}, \ldots, \gamma_{im})'$ is the associated mx1 vector of factors loading. The average effect is calculated as

$$\hat{\beta}_{CCEMG} = N^{-1} \sum_i^N \hat{\beta}_i \tag{16}$$

by dividing these coefficients by N, taking their arithmetic mean. Similarly, the Extended Mean Group (AMG) estimators developed by Eberhardt and Bond (2009) and Eberhardt and Teal (2010) take into account cross-section averages. It does this by including the common dynamic effects of AMG instead of the cross-sectional averages of the variables, taking into account the unobservable common factors. AMG firstly includes the dummy variables to the Model and estimates the POLS differed as

$$\Delta y_{it} = \beta \Delta x_{it} + \sum_{t=2}^{T} c_i \Delta D_t + u_{it} \tag{17}$$

Then, by subtracting or adding the standard dynamic process ($\hat{c}_t \equiv \hat{u}_t^*$) dependent variable, each section's estimation is made for each section in the form of

$$y_{it} - \hat{u}_t^* = a_i + \beta_i x_{it} + u_{it} d_i x_{it} \text{ or} \tag{18}$$

$$y_{it} = a_i + \beta_i x_{it} + d_i \hat{u}_t^* + u_{it} \tag{18'}$$

Finally, in the estimated model, the slope parameters are divided into N in the form of

$$\hat{\beta}_{AMG} = N^{-1} \sum_i^N \hat{\beta}_i \tag{19}$$

and their arithmetic average is obtained.

In line with the above findings, the estimation of long-term coefficients between energy efficiency and explanatory variables was investigated using the CCEMG estimation method. AMG was used as the second estimation method to increase the reliability of CCEMG estimation results. Both CCEMG and AMG estimation methods can be used in the cases of the existences of heterogeneous parameters and cross-sectional dependency in models.

Table 6. CCEMG Long-Term Coefficient Estimation Results of The Models

LEE	Model1	Model2	Model3	Model4	Model5	Model6	Model7	Model8	Model9	Model10	Model11
LECO	0.061 (0.065)					-0.050 (0.108)	0.020 (0.036)	0.137 (0.089)		0.207 (0.145)	
LSOC				0.005 (0.060)	-0.090 (0.121)	-0.102 (0.179)					
LPOL		0.126 (0.111)								0.405 (0.840)	
LNRR	-0.013 (0.009)	-0.008 (0.007)	-0.017 (0.011)		-0.029 (0.013)**	-0.041 (0.021)**		-0.011 (0.017)		-0.060 (0.015)***	-0.022 (0.014)
LCOA				0.010 (0.019)		0.001 (0.086)		-0.058 (0.070)			0.042 (0.048)
LOIL		0.024 (0.021)			-0.033 (0.049)		0.060 (0.030)*		0.013 (0.028)		
LNTR			0.048 (0.026)*								
LTCH							0.050 (0.028)*				
LIND			-0.172 (0.044)**			-0.176 (0.056)***					
LSRV	-0.228 (0.066)***							-0.364 (0.053)***	-0.229 (0.069)***	-0.269 (0.073)***	
LAGR	-0.084 (0.022)			-0.011 (0.007)*	0.009 (0.018)						-0.027 (0.027)
LURB			-0.242 (0.763)		-1.946 (0.719)***				-1.333 (0.957)		-1.257 (1.047)
LFOS		-0.646 (0.039)***		-0.630 (0.041)***	-0.563 (0.066)***		-0.681 (0.036)***				-0.567 (0.059)***
LREN	-0.03 (0.024)					0.030 (0.025)				0.008 (0.044)	
LGDP	0.533 (0.117)***	0.790 (0.057)***	0.538 (0.068)***	0.770 (0.050)***			0.821 (0.079)***	0.514 (0.177)***			
LECI					0.029 (0.066)		-0.045 (0.028)		0.068 (0.063)		
LCOR									0.026 (0.020)		
LGOV						0.074 (0.043)		0.026 (0.028)		0.077 (0.049)	
LLAW					0.077 (0.048)						0.148 (0.064)***

LTFP										0.511 (0.188)***	0.289 (0.190)
Sabit	-0.439 (1.836)	0.349 (1.704)	-0.464 (3.650)	0.048 (1.284)	3.439 (4.693)	1.160 (1.294)	1.445 (1.586)	-1.191 (2.170)	-0.220 (7.528)	0.152 (2.470)	5.728 (5.258)
$Wald_{ist}$	47.24***	376.05***	100.75***	477.32***	171.70***	16.64**	438.27***	58.83***	22.58***	67.63***	335.96***
RMSE	0.0084	0.0053	0.0093	0.0049	0.0033	0.0056	0.0031	0.0067	0.0088	0.0069	0.0042
Mean VIF	1.92	1.25	2.95	1.91	3.18	1.75	1.66	1.31	3.27	3.32	3.84

Notes: $***$, $**$ and $*$ denote significance at the 1%, 5%, and 10% levels, respectively. The expressions in parentheses show "estimated $z_{\boldsymbol{\beta}}$" values. RMSE is Root Mean Square Error. Waldist indicates the general significance of the estimated models. For each variable, the first line contains the estimator coefficient, and the second row contains the standard error values of the estimators. Where is Ho: $\beta_k = 0$, Ha: $\beta_k \neq 0$.

Table 7. AMG long-term coefficient estimation results of the models

LEE	Model1	Model2	Model3	Model4	Model5	Model6	Model7	Model8	Model9	Model10	Model11
LECO	0.075 (0.056)					0.029 (0.076)	-0.005 (0.023)	0.115 (0.054)**		0.149 (0.080)*	
LSOC				0.080 (0.045)*	0.147 (0.075)**	-0.083 (0.202)					
LPOL		0.082 (0.071)								0.483 (0.413)	
LNRR	-0.017 (0.009)*	-0.014 (0.008)*	-0.011 (0.013)		-0.031 (0.013)**	-0.039 (0.021)*		-0.023 (0.011)**		-0.055 (0.014)***	-0.027 (0.012)**
LCOA				0.032 (0.014)**		0.015 (0.047)		0.051 (0.026)**			0.058 (0.023)**
LOIL		0.033 (0.010)***			-0.028 (0.018)		0.019 (0.009)**		0.023 (0.022)		
LNTR			0.022 (0.011)*								
LTCH							0.044 (0.027)**				
LIND			-0.189 (0.042)***			-0.170 (0.040)***					
LSRV	-0.335 (0.043)***							-0.425 (0.054)***	-0.109 (0.084)	-0.299 (0.070)***	
LAGR	-0.076 (0.024)***			-0.028 (0.021)	-0.036 (0.020)*						-0.049 (0.024)**
LURB			-0.065 (0.244)***		-0.827 (0.392)**				-1.178 (0.556)**		-0.438 (0.437)
LFOS		-0.594 (0.047)***		-0.598 (0.053)***	-0.483 (0.052)**		-0.696 (0.031)***				-0.562 (0.066)***
LREN	0.038 (0.023)*					0.032 (0.027)				0.053 (0.025)**	
LGDP	0.611 (0.067)***	0.770 (0.062)***	0.614 (0.086)***	0.784 (0.061)***			0.857 (0.046)***	0.660 (0.062)***			

LECI					0.103 (0.055)*		-0.050 (0.023)**		-0.051 (0.054)		
LCOR									0.032 (0.016)*		
LGOV						0.097 (0.045)**		0.029 (0.027)		0.052 (0.030)*	
LLAW					0.061 (0.034)*						0.087 (0.040)**
LTFP										0.412 (0.187)**	0.477 (0.118)***
Sabit	5.743 (0.294)***	6.288 (0.196)***	10.025 (1.768)***	6.369 (0.190)***	14.518 (2.789)***	7.156 (0.434)***	6.620 (0.184)***	5.635 (0.331)***	15.564 (4.016)***	6.501 (0.913)***	12.430 (3.162)***
Wald$_{ist}$	166.59***	205.57***	65.84***	246.01***	180.19***	36.10***	872.86***	231.76***	17.31***	63.26***	259.82***
RMSE	0.0121	0.0076	0.0126	0.0073	0.007	0.0113	0.0045	0.0104	0.0121	0.0132	0.0076

Notes: $***$, $**$ and $*$ denote significance at the 1%, 5%, and 10% levels, respectively. The expressions in parentheses show "estimated $z_{\boldsymbol{\beta}}$" values. RMSE is Root Mean Square Error. Waldist indicates the general significance of the estimated models. For each variable, the first line contains the estimator coefficient, and the second row contains the standard error values of the estimators. Where is Ho: $\beta_k = 0$, Ha: $\beta_k \neq 0$.

5. DISCUSSION

For all models, CCEMG estimation results are included in Table 6, and AMG estimation results are included in Table 7. The RMSE value, which is used as a comparison and preference criterion between models, is close to 0 (zero) and the value of R2 to 1 (one) indicates that the explanation power and preference among the compared models with the same dependent variable will be more compatible (Wang et al., 2021). Indeed, the RMSE compatibility criterion is preferred for model comparisons. As both CCEMG and AMG generally give similar results, RMSE values between models also show similar results. Therefore, Model 4 among the first 4 models created in the 1990-2018 period for 23 emerging economies where 15 variables are considered in both CCEMG and AMG types models, Model 7 from the next 5 models created during 1996-2018 for 23 emerging economies in which 19 variables were considered, and Model 11 from the last two models created during 1996-2018 for 21 emerging economies by considering 20 variables will be firstly preferred for evaluations because Model 4, Model 7 and Model 11 have the closest RMSE value to zero.

According to Model 4, CCEMG and AMG results generally gave similar results regarding both in sign and magnitude of elasticities belonging to related variables. Considering both CCEMG and AMG results, increases in social globalization, coal price and GDP per capita increase energy efficiency. On the other hand, the increase in agricultural sector energy use and fossil fuel consumption decreases energy efficiency. In addition to CCEMG Model 4, the estimated AMG Models; 1, 5, and 11 indicated significant agricultural sector energy use ratios.

According to Model 7, considering both CCEMG and AMG results, increases in the oil price, technology export and GDP per capita increase energy efficiency. On the other hand, increases in economic globalization, fossil fuel consumption and economic complexity index reduce energy efficiency. However, economic globalization was found to be statistically insignificant in Model 7. The estimated AMG type Model 8 and 10 indicated significant economic globalization ratios.

According to Model 11, considering the results of both CCEMG and AMG, increases in the rule of law, total factor efficiency and coal price increase energy efficiency, while fossil fuel consumption, urbanization, agricultural sector energy use and natural resource rents decrease energy efficiency. However, urbanization was found to be statistically insignificant. When the coefficients are examined, 1% increase in GDP per capita increases the energy efficiency by approximately 0.78%, 0.86% in Model 4 and Model 7, respectively, and 1% increase in total factor productivity increases the energy efficiency by 0.48% in Model 11, while a 1% increase in fossil fuel use decreases the energy efficiency by 0.60%, 0.70% and 0.56% in Model 4, 7, and 11 respectively.

When all significant variables in all models are considered, the ones that increase energy efficiency the most, in general, are GDP per capita social globalization, government efficiency, corruption control and total factor productivity. The most reducers were found to be overall service sector energy use, industrial sector energy use, urbanization and fossil fuel consumption. Moreover;

- The increase in the control of corruption indicates that taking and giving bribes decreased, the institutional quality increased, fair and effective markets developed in the markets to compete, investment security in foreign capital inflows increased. Therefore, it shows that the effective use of energy used in production will increase.
- The increase in the rule of law shows that the legal structure in the host country is solid, and the institutional quality has improved in terms of domestic and foreign investors. Therefore, in investments made by domestic and foreign investors, the fact that the investment regulations and the established procedures of the companies are transparent and fast will cause many negativities to disappear.
- It will provide information about the quality, knowledge and experience of the human capital of the exporting country with the increase in technology embodied exports. It is thought that the increase in technology embodied exports in a country signals the increases the quality of human capital, and this increase will also be reflected in the efficient use of energy in production.
- The increases in natural resource rents will cause an increase in costs for domestic and foreign investors who will operate in the host country. Because it is easily accessible and does not require high technology to reduce energy costs in production, it will affect energy efficiency negatively by increasing the use of fossil fuels such as coal.

- Since the increase in the income of economies will bring technological developments along with it, an increase in per capita production increase, like the findings in Akal (2016) 's study, will increase energy efficiency.
- The increase in energy prices brings some options in imported energy dependent countries such as using energy more efficiently and turn towards alternative energy sources such as renewable energy, which will reduce foreign dependency.
- Renewable energy offers many opportunities to emerging economies to improve energy efficiency. Countries that increase energy efficiency by increasing the share of renewable energy while maintaining or increasing the level of economic activity, at the same time increase overall sustainability and reduce the energy bill. In addition, it reduces energy imports and helps to realize many goals such as reducing greenhouse gas and greenhouse gas emissions.
- In 2018, the share of fossil fuels among energy resources was 59% in the industrial sector (coal 40%, natural gas 12%, petroleum 8%), 62% in the service sector (petroleum 46%, natural gas 12%, coal 4%) and 62% in the agricultural sector (49% petroleum, 12% coal, 2% natural gas). This situation will lead to a decrease in energy efficiency since intense fossil fuels are used in these sectors, and the increasing use of energy in these sectors will increase the use of imported fossil fuels.
- As the government's efficiency increases, it will positively affect the implementation of energy policies that will increase the environmental quality. There will be a decrease in the use of fossil fuels and an increase in environmentally friendly renewable energy.
- As the total factor productivity is used as a technology variable, technological development will reduce the energy density; thus, there will be an increase in energy efficiency.
- The population density experienced in urbanization will cause an increase in the general energy density, especially in the housing sector, as the technology infrastructure is not at an advanced level in emerging economies, thus reducing energy efficiency.
- Since high globalization will increase economic activity in economies, it will also increase energy consumption. As the increasing globalization demonstrates that trade and foreign capital inflows have increased, it will increase energy efficiency by transferring technology, knowledge and experience.
- Increasing economic complexity is expected to increase energy efficiency. However, as emerging economies increase the use of fossil fuels in response to their increased production, and they still do not have sufficient technological infrastructure for renewable energy, economic complexity in emerging economies decreases energy efficiency.

6. CONCLUSION AND POLICY IMPLICATIONS

In this study, energy efficiency for 23 emerging economies has been investigated multidimensionally. Due to the deficiencies in the data set, the effect of 21 variables on energy efficiency was investigated with 3 separate data sets. By avoiding the multicollinearity problem, different models were created with fewer variables to measure the potentially significant effect of each proposed variable on energy efficiency. For 23 emerging economies in which 15 variables are used, Model 4 was chosen from the first four models created during 1990-2018. For 23 emerging economies where 19 variables were used, Model 7 was chosen from the next five models created in the 1996-2018 period. And finally, Model 11 was chosen from the last two models created in the 1996-2018 period for 21 emerging economies where 20 variables were used.

As a method, before testing whether the variables contain unit root or not, the correlation between units was tested, and as a result, the stationarity of the series was tested with the second generation unit root tests. Models have been created by preventing the multicollinearity problem and matching econometric criteria. The estimates are that all models have a cointegration relationship, and therefore, the homogeneity of the slope parameters of the models and the cross-section dependence were tested to investigate the long-term relationship. Later, CCEMG and AMG long-term coefficients were estimated since all models had cross-sectional dependency and heterogeneous slope. CCEMG and AMG results in generally gave similar results, and models with values closest to 0 (zero) among RMSE model preference and compatibility criteria were preferred.

According to the preferred Model 4, Model 7 and Model 11, while GDP per capita and total factor productivity have the most positive effects on energy efficiency, fossil fuel use has most negative effect in energy efficiency in elasticity magnitudes. When the coefficients are examined, 1% increase in GDP per capita in Model 4 and Model 7 and in total factor productivity in Model 11 increases the energy efficiency by %0.78, %0.86 and %0.48, respectively, while a 1% increase in fossil fuel use decreases the energy efficiency by %0.60, %0.70 and %0.56, respectively.

For emerging economies, GDP per capita, social globalization, government efficiency, corruption control and total factor productivity positively affect energy efficiency in the long-term. On the other hand, it was found that sectoral energy use, urbanization and fossil fuel consumption negatively affected energy efficiency the most. When the models in which these variables are examined, 1% increase in GDP per capita, total factor productivity, social globalization, government efficiency and control of corruption increases the energy efficiency by 0.48, 0.15%, 0.10% and 0.03% respectively, while a 1% increase in urbanization, fossil fuel use, service sector and industrial sector energy use decreases the energy efficiency by approximately 1.18%, 0.70%, 0.43% and %0.17, respectively.

Along with globalization, the liberalization of capital mobility in the world and the increasing competition between countries, and as a result, increased production and consequently energy use increased. An economy that increases its production has reduced dependence on the domestic market and increased its sales, profits and competition in the foreign market by producing technological goods. As a result, their income increased; this is reflected in the growth figures. The highest growth figures were found in emerging economies. These economies, on the other hand, made their exports with the energy they imported.

In emerging economies, the increase in the figures reflected positively on macro indicators due to technology, knowledge, and human capital transfer has increased countries' research on the determinants of these transfers. For this reason, the way to successfully differentiate emerging economies from the competition they embark on and to direct their future will be to improve the quality of the administration as well as economic policies, to increase the rule of law with judicial reforms, to implement anti-corruption policies and to supervise them in order to make investments in a reliable and fair market. Also, it is to increase the share of R&D in technological developments, to avoid wastage while using natural resources by seeking to extract them at a low cost, to give importance to human capital with educational reforms even if it is not rich in natural resources.

All these findings may be evaluated further as above examples given in determining energy policies toward using it more efficiently in these countries as needed urgently.

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