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Article

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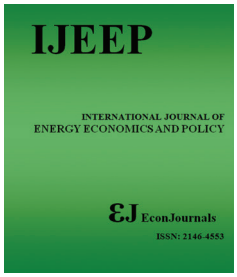

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Determinants of Energy Consumption in MIST Countries

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ABSTRACT

In this study, the factors that determine energy consumption are tried to be explained. For this purpose, the factors determining energy consumption are analyzed specifically for Mexico, Indonesia, South Korea and Turkey countries, for a period covering the years 2000-2022. In the study, population growth rate, balance of trade in goods and services, gross domestic product (GDP), foreign direct investments (FDIs) and energy prices are used as factors determining energy consumption. The results show that the total population growth rate and GDP tend to have a positive impact on energy consumption at the 99% confidence level, while trade openness and FDIs variables affect energy consumption at the 90% confidence level, and this balance exhibits a positive interaction. No significant effect of energy prices on energy consumption was detected.

Keywords: Mexico, Indonesia, South Korea and Turkey Countries, Energy Consumption, Gross Domestic Product, Foreign Direct İnvestment, Population Growth Rate
JEL Classifications: O40, Q43, Q40

1. INTRODUCTION

According to the 2021 report published by BP, global energy demand is increasing every year. Approximately 28% of the total energy demand is made up of coal, 34% of oil and 24% of natural gas, respectively. For this reason, the majority of global energy demand consists of non-renewable energy sources that we call fossil fuels. According to the energy scenarios made by the IEA, even if it is predicted that the share of fossil fuels in energy resources will decrease relatively in the 2040s, fossil fuels will maintain their dominant position among energy resources. On the other hand, the share of renewable energy sources is expected to be approximately 16.1% in the 2040s and the share of these energy sources in energy is expected to increase. Especially emerging economies such as Mexico, Indonesia, South Africa and Turkey, called Mexico, Indonesia, South Korea and Turkey (MIST) countries, are constantly increasing their energy needs with rapid industrialization and population growth. The energy consumption of these countries plays an important role not only within their own borders, but also in the global energy market. In this context, understanding and analyzing the energy consumption of MIST countries is of great importance not only in economic terms, but also in terms of financial stability and global energy supply security.

This article aims to understand the energy strategies and future energy demands of these countries by addressing the determinants of energy consumption in MIST countries. MIST countries use energy as a key driver in their efforts to achieve economic growth and industrialization goals. However, the determinants of this energy consumption have a rather complex structure. On the one hand, rapid population growth and urbanization processes increase energy demands, on the other hand, factors such as economic structure, technological developments and energy efficiency are important factors affecting energy consumption. This article aims to provide a comprehensive basis for establishing energy policies and developing sustainable energy strategies of these countries by systematically examining the determinants of energy consumption in MIST countries.

2. LITERATURE REVIEW

Although there are many reasons why energy consumption is increasing intensively today, the most important ones are; The rapid increase in the world population, industrialization activities, technological innovations, increase in living standards and rapidly increasing consumption expenditures can be counted as follows. In this context, there are many studies in the literature that examine energy consumption directly or indirectly. Asafu-Adjaye (2000), Wolde-Rufael (2005), Lee (2006), Lee and Chien (2010), Baek (2016), Paramati et al. (2018), Syzdykova et al. (2020), and Syzdykova et al. (2021) examine the relationship between energy consumption and economic growth. Omri and Kahouli (2014), Sbia et al. (2014), Leitão (2015), Doytch and Narayan (2016), Amri (2016), and Paramati et al. (2018) are studies that explain the relationship between energy consumption and foreign direct investments (FDIs). In addition, Yuan et al. (2010), He et al. (2014), Osigwe and Arawomo (2015), Chen et al. (2016), and Brini et al. (2017) versus in the studies conducted, the relationship between energy consumption and energy prices is investigated. All these studies confirm the relationship of these variables with energy consumption.

The relationship between economic growth and energy consumption is very important both theoretically, empirically and politically (Odhiambo, 2009). This relationship was first discussed by Kraft and Kraft (1978) using data on the United States economy for the period 1947-1974. In this study, it was concluded that the relationship in question is towards energy consumption through economic growth. The study concluded that increases in economic growth increase energy consumption. With the development and change of world conditions, energy consumption and demand for energy types have increased and this issue has become important for economists.

Asafu-Adjaye (2000) examined the causality relationships between energy consumption, energy prices and gross domestic product (GDP) for India, Indonesia, Thailand and the Philippines. While he found a causality relationship running from energy consumption to GDP for India and Indonesia, between energy and GDP for Thailand and the Philippines. He concluded that there is a two-way causality relationship. Masih and Masih (1997) concluded that there is a mutual causality relationship between energy consumption, energy prices and income for South Korea and Taiwan. Hondroyiannis et al. (2002) used data from the Greek economy for the period 1960-1996 to reveal the relationship between economic growth and energy consumption. In this study, they used the vector error correction model. According to the results obtained, a long-term and positive relationship was determined between economic growth and energy consumption. It has been concluded that the increase in energy consumption increases economic growth.

Paul and Bhattacharya (2004) carried out their studies using data from the Indian economy for the period 1950-1996 in order to reveal the relationship between economic growth and energy consumption. They used the Engle-Granger cointegration test. According to the results obtained, a positive relationship was determined between economic growth and energy consumption. It has been concluded that the increase in energy consumption increases economic growth. In Green (2004) study, factors affecting energy consumption include economic development, ecological factors (such as climate, geographical distribution and population density), political factors, technological factors and regional differences. In his study on 19 African countries between 1971 and 2001, Wolde-Rufael (2005) found a unidirectional causality relationship from GDP to energy consumption in some African countries, and from energy consumption to GDP in others. According to the findings obtained in the same study, it was observed that there was a bidirectional relationship between energy consumption and GDP among some countries.

Lee and Chang (2008) examined the relationship between energy consumption and economic growth for 16 Asian countries using data for the period 1971-2002. In the study using panel cointegration and causality analysis, it is seen that real GDP and energy consumption are cointegrated in the long term, but no causality relationship can be detected in the short term. However, there is a one-way causality relationship from energy consumption to economic growth in the long run.

Ciarreta and Zarraga (2010) carried out their study using data from the economies of 12 European Union member countries for the period 1970-2007 in order to reveal the relationship between economic growth and electrical energy consumption. They used panel cointegration and panel causality tests. According to the results obtained, a unidirectional and positive relationship was determined between economic growth and electrical energy consumption. It has been concluded that artisanal consumption of electrical energy increases economic growth. In the study by Hossain (2011) examining the relationships between carbon dioxide emissions, energy consumption, economic growth, trade openness and urbanization, it was concluded that there is a short-term causality relationship from economic growth to energy consumption and from trade openness to economic growth. Sadorsky (2012) pointed out that there is a short-term unidirectional relationship between energy consumption and exports in South American countries, and that there is a mutual causality relationship between imports, exports and energy consumption in the long term. According to Jia et al. (2011), the factors affecting energy consumption on a global scale are transportation and information industry activities, medical industry activities, other economic activities, R&D and agricultural activities.

Omri and Kahouli (2014) used energy consumption data instead of CO_2 emissions and investigated the causality relationships between energy consumption, FDI and economic growth for 65 countries with a dynamic panel simultaneous equation system. In the study, data from the period 1990 to 2011 were used. The results of the analysis conducted separately for high income, middle income and low income groups reveal a two-way causality relationship between all variables in high income countries. In middle-income countries, a bidirectional causality relationship has been detected between energy consumption and economic growth, a bidirectional causality relationship between FDI and

economic growth, and a unidirectional causality relationship from FDI to energy consumption. In the low country group, there is a one-way causality relationship from energy consumption to economic growth and from FDI to energy consumption. It was concluded that there is a two-way causality relationship between FDI and economic growth.

Nasreen and Anwar (2014), a study on Asian economies, stated that economic growth and trade openness have positive effects on energy consumption, and revealed that there is a two-way causality relationship between the variables of energy consumption and trade openness. Shahbaz et al. (2014), in their study involving 91 countries, found that there is cointegration between trade openness and energy consumption variables, and that there is an inverted U-shaped relationship between these two variables in high-income countries and a U-shaped relationship in middle and low-income countries. The study also suggests that there is a unidirectional causality relationship between trade openness and energy consumption. Sbia et al. (2014) study found findings that trade openness reduces energy demand.

According to Kapusuzoglu and Karan (2013), factors affecting energy consumption in developing countries include rural population, total population, GDP, consumer price index and carbon dioxide emissions. In the study of Samuel et al. (2013), variables such as real GDP per capita, real electricity price, replacement price, population, air temperature, financial development variables, capital stock, industrial development and productivity variables were defined as variables that affect energy demand. In their study, Paytakhti Oskooe and Tabaghchi Akbari (2014) identified the factors affecting energy consumption as foreign trade, population, income, added value of economic sectors and oil prices. Azam et al. (2016), factors affecting energy consumption in Greece are urbanization, infrastructure, trade, income, population growth and FDI.

Bekhet et al. (2017) discussed the relationship between energy consumption, economic growth, financial development and CO_2 emissions. Dynamic panel simultaneous equation system was used in the study covering the member countries of the Gulf Cooperation Council. Findings for the period 1980-2011 reveal the long-term relationship between CO_2 emissions, real per capita income, energy consumption and financial development in all countries except the United Arab Emirates.

Tiba and Frikha (2018) examined the relationship between income, trade openness and energy consumption, again using the panel simultaneous equation system, using data from the 1990 to 2011 period. Data from 24 middle and high income countries were used in the study. According to the findings, there is a two-way causality relationship between energy consumption-income and trade openness-income in both high-income and middle-income countries. In addition, a unidirectional causality relationship was determined from trade openness to energy consumption in high-income countries, and from energy consumption to trade openness in middle-income countries. In the study of Senjawati et al. (2018), the factors affecting energy consumption, especially the factors affecting home electrical energy consumption, are psychological factors and regulation factors. These factors have a significant and positive impact on behavior, with men having a higher impact on psychological factors and women having a higher impact on behavior. In the study of Adjei Mensah et al. (2020), factors affecting energy consumption in African countries include economic growth, urbanization, population growth, oil price, labor and capital stock.

According to Ogunsola and Tipoy, (2022), the factors affecting energy consumption in African oil-exporting countries are trade openness and economic structure. In their study, Fernandes and Reddy (2021) identified the factors affecting energy consumption in the newly industrialized countries of Asia as GDP, exchange rate, industrialization, urbanization and trade openness. Sami and Acar (2022) state the factors affecting energy consumption as FDIs, energy prices and economic growth. Dokas et al. (2022) argue that the factors affecting energy consumption are economic growth, investment, winter temperature, trade openness, corruption and innovation. Wahyudi and Palupi, (2023) investigated the causal relationship between total energy consumption, FDI and labor force participation rates in OECD countries from 1994 to 2019. In the study, the authors determined that energy consumption and FDI have a two-way causality relationship, and energy consumption and labor force participation rate have a bidirectional causality relationship. In the long run, FDI has a significant positive impact on energy consumption, while labor force participation has an insignificant negative impact on energy consumption.

3. DATA SET, MODEL AND ECONOMETRIC METHOD

Data from MIST countriesfor the period 2000-2022 were used in the study. It is possible to see the energy consumption of MIST countries in the period 2000-2022 from the Graph 1.

The model of the study was established as follows:

$$enc_{it} = \beta_0 + \beta_1 pop_{it} + \beta_2 trade_{it} + \beta_3 gdp_{it} + \beta_4 fdi_{it} + \beta_5 ep_{it} + \varepsilon_{it} \quad (1)$$

The variables in the equality 1 model are defined as follows: *enc* primary energy consumption (gigajoules per capita), *pop* total population growth rate, *trade* ratio of goods and services exports and imports to GDP, *gdp* atio of GDP of the country, *fdi* FDI s in the country, *ep* energy prices are defined as. In the econometric analysis of the study, panel data analysis tests are applied to the panel data set created from MIST country data. In practice, cross-sectional dependence in panel variables, the existence of unit root with 1st and 2nd generation stationarity tests, the existence of cointegration with tests that take into account structural breaks, and long-term coefficients with panel autoregressive distributed lag (ARDL) tests that include lags in the regression were investigated, respectively.

4. ANALYSIS FINDINGS

Within the methods used to test the cross-sectional dependence in the panel data set, Pesaran et al. (2004)CD_{LM} test, Breusch-

Pagan (1980) CD_{LM1} test, Pesaran et al. (2004) *2* and Pesaran, Ullah and Yamagata (2008) are the CD_{LMADJ} tests. The CD_{LM1} and CD_{LM2} tests are estimators that test whether there is cross-sectional dependence under the condition T > N. The CD_{LM} test under the N > T condition and the CD_{LMADJ} test are estimators that test whether there is cross-sectional dependence under both conditions. Since the T > N condition is provided in the panel data set, appropriate CD tests are estimated. The test results related to cross-sectional dependence are given below (Table 1).

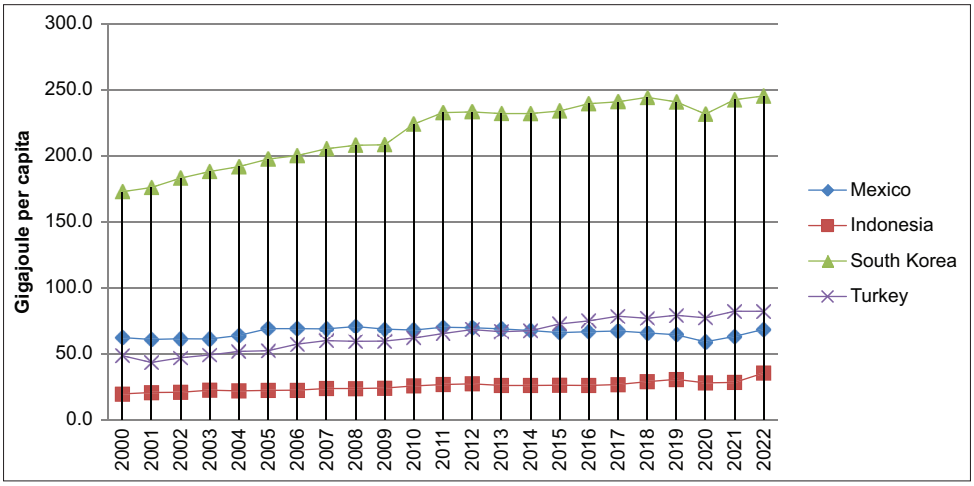
The results of CD_{LM1}, CD_{LM2} and CD_{LMADJ} tests show that the null hypothesis is rejected statistically significantly in country panel data sets and the existence of cross-sectional dependence is proven. After the cross-section dependence tests, LevinLin and Chu (LLC), Im-Pesaran and Shin (IPS) from the 1st generation unit root tests, and CrossSectionally Augmented IPS (CIPS) and Hadri-Kurozumi (2012) unit root estimators from the 2nd generation unit root tests used. In practice, LLC and IPS, which are 1st generation unit root tests, are used respectively by Levin et al. (2002) and Im et al. (2003). Among the second generation unit root tests, Im et al. tested the stationarity of the panel countries as a whole. CIPS developed by (2003) and HK estimator developed by Hadri-Kurozumi (2012) are used. Panel unit root test results are presented in Table 2.

As can be seen in Table 2, all variables included in the model in the panel data sets have stationary process characteristics at first differences. As a result of econometric analysis, it is concluded that the panel data set has cross-sectional dependence and consists of mixed series that are stationary at both levels and first differences. For this reason, Westerlund (2006) test is applied to test whether there is a cointegrated relationship in the model. Westerlund (2006) cointegration test is an LM statistical test, it is a test that takes into account structural breaks and cross-sectional dependence and can also be applied to non-linear series. In the application of the test, the assumption of case = 4 (takes into account structural break when there is individual constant and trend) was estimated. The results obtained by taking the maximum number of delays as 3 and the number of cycles as 1000 are given in Table 3.

According to the Probability[2] result in the Westerlund (2006) cointegration test, where cross-sectional dependence is taken into account, the null hypothesis of cointegration in the panel data set in the model is accepted as statistically significant. Once the existence of cointegration is accepted in the tested model, the long-term coefficient equation can be estimated. Pooled mean group estimation (PMGE) and mean group estimation (MGE) estimators, developed by Pesaran et al. (1999) and based on the panel ARDL model, are used to estimate the long-term equation. While estimating the model, the Hausman test was applied to test the consistency of the PMG or MGE (Table 4).

As a result of the Hausman test, the consistency of the null hypothesis and PMG, MGE is accepted in both panel data sets, but only PMG is the effective estimator (Baltagi, 2008: 72). The negative and statistically significant error correction coefficient (Ø = −0.802; −0.756) shows that there is a long-term relationship between the dependent and independent variables and that even if the balance deviates, it converges to the balance again. According to the results obtained from the diagnostic tests shown in the table above, there is no autocorrelation and heteroscedasticity problem in the model. All long-term coefficients reached in the model are statistically significant. In the long-term equation estimated for the 2000-2022 period, MIST country coefficients show parallel results. As a result of the tests, it was determined that energy

Graph 1: Energy consumption of Mexico, Indonesia, South Korea and TurkeyMIST countries



Source: Created by the authors from BP data

Table 1: Cross-section dependency test results

Test	*enc*	*pop*	*trade*	*gdp*	*fdi*	*ep*
CD_{LM1}	156.27*	208.30*	192.35*	110.32	106.80*	133.11*
CD_{LM2}	29.31	11.28	16.34*	16.50*	25.47*	21.56*
CD_{LMADJ}	40.10	30.53*	28.30	34.54*	40.56*	40.64*

* indicates cross-sectional dependence

Table 2: Panel unit root test results

Test	*enc*	*pop*	*trade*	*gdp*	*fdi*	*ep*
LLCt-stat						
Level	−2.35	−7.95*	−7.24*	−2.70	−4.52	−8.03*
1st difference	−8.03*	−9.18*	−8.48*	−3.20	−9.79*	−7.76*
IPSW-stat						
Level	−2.13	−6.07*	−5.09*	−8.06*	−7.26*	−2.51
1st difference	−5.09*	−8.33*	−6.73*	−7.87*	−8.49*	−6.29*
CIPSstat						
Level	−7.09*	6.90*	8.51*	6.73*	−8.08*	7.03*
1st difference	−8.36*	8.40*	9.24*	8.84*	−9.56*	10.90*
HK						
Level	8.16	10.88*	9.61*	7.10	9.93*	8.96
1st difference	10.08*	11.76*	11.02*	11.54*	10.60*	11.40*

LLC: LevinLin and Chu, IPS: Im-Pesaran and Shin, AIC: Akaike information criterion, CIPS: CrossSectionally Augmented IPS. GDP: Gross domestic product, FDI: Foreign direct investments. Notes: *indicates that the null hypothesis was rejected at the 5% significance level. Lag lengths for LLC and IPS tests were calculated using AIC. Critical values for the CIPS test were obtained from Pesaran (2007)

Table 3: Cointegration test results

Break	Test	Cointegration test
Non break test	Value	4.408
	Probability[1]	0.009*
	Probability[2]	0.304
Break test	Value	11.509
	Probability[1]	0.001*
	Probability[2]	0.318

Probability[1] estimates based on asymptotic normal distribution. Probability[2] makes predictions based on the bootstrapped distribution. *indicates the presence of statistically significant cointegration

Table 4: PMG and MG test results

Variables	Long-term coefficients		Hausman
	PMG	MG	
Y	0.042*	0.008	0.35
pop	0.036**	0.036**	0.22
trade	0.090*	0.198	0.35
gdp	0.021***	0.040**	0.50
fdi	0.018*	0.023*	0.56
ep	0.123	0.008	0.79
Error correction coefficient			
Ø	−0.802	−0.756	
Short-run coefficient			
ΔY	0.032**	0.054*	
Δpop	0.019*	0.062**	
Δtrade	0.064	0.385	
Δgdp	0.032**	0.032	
Δfdi	0.030	0.012	
Δep	0.016*	0.025	
Diagnostic tests			
Log-likelihood	204.72	308.47	
χ^2 *SC*	0.18	0.31	
χ^2 *HE*	0.22	0.36	

PMGE: Pooled mean group estimation, MGE: Mean group estimation. GDP: Gross domestic product, FDI: Foreign direct investments. Notes: Akaike information criterion (AIC) was used to determine the optimal lag length. χ^2SC, χ^2HE show the Chi-square statistics for the Breusch-Godfrey serial correlation test and the White heteroscedasticity test. *, **, and *** indicate 1%, 5%, and 10% significance levels, respectively

consumption was positively affected by the GDP rate (at the 1% level of significance) and the total population growth rate (at the 5% level of significance). Trade openness and FDIs variables positively affect energy consumption at a 90% reliability level.

5. CONCLUSION

This research investigated the determining factors affecting energy consumption in MIST countries. By focusing on five main variables such as total population growth rate, balance of trade in goods and services, GDP, FDIs and energy prices, the effects of these factors on energy consumption were examined. The results show that the total population growth rate and GDP tend to have a positive impact on energy consumption at the 99% confidence level, while trade openness and FDIs variables affect energy consumption at the 90% confidence level, and this balance exhibits a positive interaction. No significant effect of energy prices on energy consumption was detected. Cointegration test results reveal the existence of long-term relationships between the specified variables. In this context, it is important to take into account factors such as total population growth, economic growth, trade openness and FDIs in establishing energy policies and developing sustainable energy strategies. While this study provides a comprehensive understanding of the energy consumption dynamics of MIST countries, it also highlights the need to examine more variables and different methodologies in future research.

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