RESEARCH ARTICLE | ARAŞTIRMA MAKALESİ

Analyzing the Relationship Between Migration, Economic Growth and Energy Consumption: Evidence from EU Countries

Ali İslamoğlu[1], Serap Çoban[2]

[1] Nevşehir Hacı Bektaş Veli University, Nevşehir, Türkiye.
ali.islamoglu@nevsehir.edu.tr

[2] **Correspondent Author (Sorumlu Yazar)**
Nevşehir Hacı Bektaş Veli University, Faculty of Economics and Administrative Sciences, Department of Economics, Nevşehir, Türkiye.
seraps@nevsehir.edu.tr

Abstract

In this paper, the relation between migration, economic growth and energy consumption of 20 European Union countries between 2008-2021 is analyzed by panel data analysis method. Dumitrescu & Hurlin (2012) panel granger causality test is used to determine the direction of the relationships between variables. As a result of the analysis, it is determined that there is causality from migration to economic growth, causality from energy consumption to economic growth and causality from energy consumption to migration. In this context, it is concluded that migration is not the cause of energy consumption, but energy consumption causes migration. Countries with high energy consumption are countries with high capital power and high labor demand and therefore are the target of migration movements. In this case, it can be said that energy consumption will cause migration movements until the labor market reaches equilibrium between migration receiving and sending countries. It is also found that economic growth is not the cause of migration in these countries, but migration causes economic growth. As a result of migration movements, economic growth is positively affected as a result of the meeting of capital power and labor supply.

Keywords: Migration, economic growth, energy consumption, causality

Göç, Ekonomik Büyüme ve Enerji Tüketimi Arasındaki İlişkinin Analizi: AB Ülkelerinden Kanıtlar

Öz

Bu çalışmada, 20 Avrupa Birliği ülkesinin 2008-2021 yılları arasındaki göç, ekonomik büyüme ve enerji tüketimi arasındaki ilişki panel veri analizi yöntemiyle analiz edilmektedir. Değişkenler arasındaki ilişkilerin yönünü belirlemek için Dumitrescu ve Hurlin (2012) panel granger nedensellik testi kullanılmaktadır. Analiz sonucunda göçten ekonomik büyümeye, enerji tüketiminden ekonomik büyümeye ve enerji tüketiminden göçe doğru nedensellik olduğu tespit edilmiştir. Bu bağlamda göçün enerji tüketiminin nedeni olmadığı, enerji tüketiminin göçe neden olduğu sonucuna varılmıştır. Enerji tüketimi yüksek olan ülkeler, sermaye gücü yüksek, iş gücü talebi yüksek olan ve bu nedenle göç hareketlerinin hedefi olan ülkelerdir. Bu durumda göç alan ve gönderen ülkeler arasındaki işgücü piyasası dengeye gelinceye kadar enerji tüketiminin göç hareketlerine neden olacağı söylenebilir. Ayrıca bu ülkelerde göçün nedeninin ekonomik büyüme olmadığı, göçün ekonomik büyümeye neden olduğu tespit edilmiştir. Göç hareketleri sonucunda sermaye gücü ile işgücü arzının buluşması sonucunda ekonomik büyüme olumlu yönde etkilenmektedir.

Anahtar Kelimeler: Göç, ekonomik büyüme, enerji tüketimi, nedensellik

Jel Codes (Jel Kodları)
F22, Q43, C23

Recieved Date (Gönderilme)
29.05.2024

Accepted Date (Kabul)
11.09.2024

1. Introduction

People have moved for many reasons, such as climate, geography, job opportunities, wars, natural disasters, economic reasons, and family reunification. Some of the migration movements in history have been quite large. For example, the Great Migrations from Central Asia to Europe, the Hun invasions, the conquests of the Mongol Empire, Alexander's campaigns, the expansion of the Spanish Empire and the Atlantic slave trade have all had a major impact on the intercontinental movement of people. In the last century, especially after World War II, factors such as globalization and economic diversification have led to a rapid increase in migration movements. Today, there are around 280 million international migrants and more than 750 million internal migrants worldwide. The economic, social, and political dimensions of migration have been extensively addressed in the literature. For example, the impact of migration on economic growth has been examined in various studies, demonstrating that migrant labor contributes to economic growth in host countries (Borjas, 1995; Dustmann et al., 2016).

The European Union (EU) has historically been a significant destination for migration, deeply influencing the region's economic and social dynamics. Migration has been a crucial factor in shaping labor markets and economic growth in EU countries. Also, energy consumption, one of the production inputs and perhaps the most important one today, has become one of the most important indicators of economic growth (Kraft and Kraft, 1978; Soytaş and Sarı, 2006). Efficient use of energy resources and sustainable energy policies are at the heart of economic development strategies (Stern, 2004). Numerous studies in the literature examine the relationship between energy consumption and economic growth, demonstrating that energy consumption positively impacts economic growth (Apergis and Payne, 2009; Ozturk, 2010).

However, studies on the impact of migration on a country's labor markets or economic growth, migration and the energy nexus remain limited, although most of the research in the literature has focused on this topic. The literature emphasizes the role of migration in areas such as environmental degradation, water consumption, ecosystem violation and land use allocation (Alshoubaki and Harris, 2018; Sato et al. 2000; Jacobsen, 1997; Jaafar et al. 2019). While the focus is predominantly on the potential negative impacts of refugee migration, there is a lack of an integrated approach to migration and energy consumption in the literature. In this context, this study on European Union (EU) countries aims to provide a significant contribution to understanding the dynamics between migration, economic growth, and energy consumption.

In this study, the causality relationship between migration, economic growth, and energy consumption will be examined using a panel data set for 20 EU countries from 2008-2021. The findings of this study will provide important insights into the impacts of migration on economic growth and energy consumption, filling gaps in the literature. In this context, the study will contribute to the literature and provide valuable information to policymakers regarding the integration of migration and energy policies.

2. Literature Review on Migration, Economic Growth and Energy Consumption

Many studies have paid attention to economic growth, and energy consumption in the literature. Although numerous studies analysed the interaction between migration and economic growth, some studies examined the relationship between migration and energy consumption.

2.1. Migration and Economic Growth

In general, most studies pinpoint how migrants with access to highly skilled jobs impact economic development. For instance, Wadhwa et al. (2008) suggest that skilled immigrants have a pivotal role in improving entrepreneurship and innovation in the U.S. STEM (science, technology, engineering, and mathematics) sectors that lead to economic growth. Likewise, Engin and Konuk (2020) show that migrants might support productivity leading to a diminish in unemployment in the labor market. Hence, migrants might enhance economic growth.

Moreover, to comprehend the dynamics between migration and economic development, theories of migration are pivotal. In this context, Aksoy (2012) looks into many drivers of migration, such as climate change, political uncertainties, and economic challenges. The author also highlights cultural adaptation and ethnocentrism. Güllüpınar (2012) reviews different migration theories and adds the impact of communication technologies and globalization as a factor in migration. These theoretical perspectives provide a foundation for analyzing how migration affects economic conditions in different regions.

On a regional level, socioeconomic factors often drive migration. According to Dücan (2016), unemployment and terrorism are key drivers of internal migration in Turkey, adversely impacting education and employment. Similarly, Göv and Dürrü (2017) find that there is unidirectional causality from migration to GDP and show that migration has a positive effect on economic growth in OECD countries. On the other hand, Şimşek (2018), suggests that unskilled immigration negatively impacts inflation and GDP in countries like the U.S., Germany, and France as the type of migration—skilled versus unskilled—matters.

Regarding Turkey, Meçik and Koyuncu (2020) examine the interaction between migration and economic growth and find a positive correlation between migration and GDP. In addition, Borjas (2019) claims that the skill composition of migrants is a key factor in economic growth. Accordingly, high-skilled workers contribute more substantially to long-term growth. Briefly, the studies above suggest that while migration can drive economic growth in general, the effects depend on the type of migrants, skill levels, and regions.

2.2. Migration and Energy Consumption

Migration affects population growth and energy consumption. Hence, the relationship between migration and energy consumption is complex. Many studies investigate the impact of migration on energy consumption by paying attention to factors such as urbanization and environmental sustainability. For instance, Komatsu et al. (2013) analyze migration and CO2 emissions in Hanoi. He finds that rural-to-urban migration reduces residential energy consumption and emissions, whereas urban-to-urban migration has no significant impact on energy use. Furthermore, migration has a significant role in electricity consumption. Feridun and Shahbaz (2015) indicate that there is a long-run equilibrium relationship between migration, economic growth, and electricity consumption in Northern Cyprus. The authors find that migration, coupled with economic growth, leads to an increase in electricity demand over time.

Moreover, the environmental implications of migration are emphasized in many studies. Aslan and Altınöz (2018) look into 35 OECD countries and find a positive correlation between migration and carbon emission. As a result, the authors claim that increasing the migrant population may contribute to environmental degradation. In a similar manner, Alola et al. (2019) depict that while renewable energy consumption reduces CO2 emissions, migration has a slightly increasing effect in the European Union.

Regarding refugee migration, Kirikkaleli and Doğan (2021) suggest that a rise in refugee population diminishes per capita energy consumption in Turkey. Yet, total energy demand increases. Therefore, the authors highlight the importance of environmental and energy-related consequences of migration. Moreover, urbanization and industrialization influence energy consumption. Torasa et al. (2020) examine the effects of urban sprawl and migration on energy use in Thailand. The authors claim that urbanization and migration have a significant and positive effect on energy consumption. However, the study also notes that population growth has a negligible impact on energy demand. This result suggests that the process of migration and industrial expansion drives higher energy consumption. Koyuncu (2019) broadens the scope and focuses on the interaction among renewable and non-renewable energy consumption, migration, and economic growth across countries with different income levels. The study finds that environment-friendly practices, including renewable energy consumption, positively affect economic growth and sustainable development in high-income countries. Still, non-renewable energy use and CO2 emissions have a central role in driving growth in lower-middle and low-income countries.

In short, the literature above suggests that migration has significant and complicated impacts on economic growth and energy consumption. Whereas skilled migration—is likely to improve economic growth through entrepreneurship, innovation, and increased labor market participation, unskilled migration has a negative effect on inflation and GDP. Furthermore, studies on the interaction between migration and energy consumption suggest both positive and negative effects depending on the type of migration, urbanization patterns, and the use of renewable versus non-renewable energy sources. Hence, future research should consider the diverse socioeconomic and environmental factors shaping the migration's implications.

3. Empirical Analysis

This study uses panel data analysis to examine the relationship between migration, economic growth, and energy consumption. The Dumitrescu & Hurlin (2012) panel Granger causality test is applied to determine the directional relationships between these variables. Alternative methodologies such as Vector Autoregression (VAR) and Cointegration tests were considered, but panel data analysis was chosen for its robustness in handling cross-sectional and time-series data simultaneously. This method is particularly suitable for the dataset comprising 20 European Union countries over a 13-year period, providing reliable insights into the causality relationships among the variables.

3.1. Data and Model

The study econometrically analyzes the effects of migration on energy consumption and economic growth in EU countries using annual data for the period 2008-2021. The sample of the study includes a total of 20 EU countries, namely Germany, Austria, Belgium, Czech Republic, Denmark, Finland, France, Croatia, Croatia, Ireland, Italy, Cyprus, Luxembourg, Hungary, Malta, Portugal, Portugal, Slovenia, Slovenia, Greece, Spain, Sweden and Sweden. Our focus on European Union (EU) countries is motivated by several reasons. Firstly, the high levels of economic opportunities and welfare in EU countries have led to significant migration inflows. Secondly, the EU is a major consumer of energy on a global scale, allowing for a comprehensive analysis of how energy consumption affects migration and economic growth. Lastly, the availability of high-quality, consistent data for EU countries during the specified period is another key reason for their selection.

Table 1. Definition of Variables Used and Data Sources

Variable	Definition	Data Source
imm	Migration rate (percentage of total population)	EUROSTAT
gdp	Economic growth (constant prices)	EUROSTAT
encon	Energy consumption (million tons of oil)	EUROSTAT

The natural logarithms of energy consumption and economic growth variables are used and econometric findings are derived with the help of STATA package program. Data were obtained from EUROSTAT database. The abbreviations of the variables to be used in the analysis, variable definitions, data sources and analysis are given in Table 5.

$$imm=f(encon) \quad \text{and} \quad imm=f(gdp) \qquad (1)$$

Models in the above are constructed to reveal the causality relationship between migration, economic growth and energy consumption.

3.2. Econometric Method and Findings

Before analyzing the relationship between migration, economic growth and energy consumption variables, some preliminary tests are needed, such as investigating whether there is dependence between cross-sections.

In panel data analyses, determining whether the series are stationary or not is necessary to avoid the problem of spurious regression. However, unlike time series analysis, before deciding which of the panel unit root tests to conduct, factors such as whether the series are homogeneous and whether there is dependence between the cross-sections should be tested.

First, it is important to decide whether the coefficients are homogeneous. Global economic trends such as the expansion of international trade relations, financial liberalization and globalization lead to the fact that an economic crisis in one country may spread to other countries. In this context, cross-sectional dependence tests are used to determine whether a crisis in one country affects other countries. Among these tests, methods such as Breusch and Pagan (1980) LM (Lagrange Multiplier) test, CD (Cross Section Dependency) test and CDLM test (Pesaran (2004)) are widely used to determine whether there is cross-sectional dependence in variables and models. The main hypothesis of these tests is that there is no cross-sectional dependence. However, empirical evidence shows that when the null hypothesis is rejected, an economic crisis in one country affects other countries. Therefore, cross-sectional dependence is a common phenomenon in global economic conditions. In this case, first generation panel unit root tests should be applied to the model. However, when the null hypothesis is rejected and cross-sectional dependence is detected, second generation panel unit root tests should be applied to the model (Baltagi, 2008: 284; Nazlıoğlu, 2010: 142). The detection of cross-sectional dependence can significantly affect the results of the analysis. Therefore, it is of great importance to take this result into account when conducting the analysis (Breusch and Pagan, 1980).

According to the empirical findings, the failure to reject the null hypothesis (H0: "There is no cross-sectional dependence") indicates that there is no cross-sectional dependence between countries, that is, an economic crisis in one country does not affect other countries. Table 2 presents the results of the cross-sectional dependence test.

Table 2. Cross-Sectional Dependence: Pesaran (2004) Test Results

Variables	**Statistic Value**	**Probability Value**	**corr**	**abs(corr)**
imm	-0.32	0.752	-0.006	0.434
encon	25.65	0.000	0.497	0,569
gdp	38.35	0.000	0.744	0,865

Note: Significance level is taken as 5%.

The Peseran (2004) test results in Table 2 reveal that there is cross-sectional dependence at the 5% significance level. This indicates that a macroeconomic shock in one country may affect other countries as well. The results of the analysis require the application of second-generation panel unit root tests.

The homogeneity test tests whether a change occurring in one country affects other countries at the same level. Therefore, coefficients are expected to be heterogeneous in models constructed for countries with different economic structures, whereas coefficients are expected to be homogeneous in models constructed for country groups with similar economic structures. In this study, the Delta Test (Slope Homogeneity Test) developed by Pesaran and Yagamata (2008) is used to test homogeneity. The Delta test is a valid test for large samples. The null hypothesis in the homogeneity test is as follows. Table 3 presents the homogeneity test results.

Table 3. Slope Homogeneity Test Results

Test	**Test statistic**	**Prob**	**Test statistic (adj.)**	**Prob**
Delta	9.054	0.000	10.712	0.000

Note: Significance level is taken as 5%.

According to results, the null hypothesis H_0 based on the homogeneity of the coefficients in Delta tests is rejected at 5% significance level and it is concluded that the coefficients are heterogeneous. This reveals that the effect of a change in energy consumption on migration differs across countries. Similarly, the effect of a change in economic growth on migration varies across countries.

Since cross-sectional dependence is detected among the series, it is recommended to use second generation panel unit root tests to analyze the stationarity of the series. Therefore, second generation unit root tests such as CADF unit root test developed by Pesaran in 2007 are used in the analysis.

The CADF unit root test was developed by Pesaran in 2007. In this test, first, the CADF test statistic is calculated for all units in the panel. Then, the Cross Sectionally Augmented IPS (CIPS) test statistic is calculated for the panel using the arithmetic mean of the CADF test statistics. In this way, the CADF test is used for unit-level stationarity, while the CIPS test is used to investigate the stationarity of the panel. The CADF statistic is calculated using equations 2 and 3 (Pesaran, 2007: 269-271).

$$\Delta_{yit} = a_i + b_i y_{i,t-1} + c_i \overline{y}_{t-1} + d_i \Delta \overline{y}_t + e_{it} \tag{2}$$

$$\Delta_{yi} = (\Delta_{yi1}, \Delta_{yi2}, ..., \Delta_{yiT})', y_i, -1 = (y_{i0}, y_{i1}, ..., y_i, T-1)' \tag{3}$$

The hypotheses of the CADF unit root test are as follows (Güloğlu and İvrendi, 2008: 2):

$H_0: b_i = 0,$ series is non-stationary (for all variables)

$H_1: b_i < 0,$ series is stationary (for at least one variable)

The CADF unit root test can be used when the time dimension (T) of the series is both larger and smaller than the cross-sectional dimension (N) (Güloğlu and İvrendi, 2008: 3). Accordingly, the CADF test statistic is calculated using the following equation (Pesaran, 2007: 269-271).

$$t_i(N,T) = \frac{\Delta y_i' \overline{M}_w y_{i,-1}}{\sqrt{\hat{\sigma}_i (y'_{i,-1} \overline{M}_w y_{i,-1})}} \tag{4}$$

It's here;

$$\Delta_{yi} = (\Delta_{yi1}, \Delta_{yi2}, ..., \Delta_{yit})', y_{i,-1} = (y_{i0}, y_{i1}, ..., y_{i,T-1})' \tag{5}$$

$$\overline{M}_W = I_T - \overline{W}(\overline{W}'\overline{W})^{-1}\overline{W}', \overline{W} = (\tau, \Delta \overline{y}, \overline{y}_{-1}) \tag{6}$$

$$\tau = (1,1,...,1)', \Delta \overline{y} = (\Delta \overline{y}_1, \Delta \overline{y}_2, ..., \Delta \overline{y}_T)', \overline{y}_{-1} = (\overline{y}_0, \overline{y}_1, ..., \overline{y}_{T-1})' \tag{7}$$

$$\hat{\sigma}_i^2 = \frac{\Delta y_i' M_{i,w} \Delta y_i}{T-4} \tag{8}$$

The CIPS test statistic equation, which is calculated by averaging the t statistic values calculated for the cross-section, is given below (Pesaran, 2007: 288),

$$CIPS(N,T) = N^{-1} \sum_{i=1}^{N} t_i(N,T) \tag{9}$$

The above-mentioned CADF and CIPS test statistic values are compared with the critical table values calculated by Pesaran's Monte Carlo simulation to test the stationarity hypotheses. H_0 As a result of the comparison of test statistics and table values; if the CADF and CIPS test statistic values are greater than the critical table values in absolute value, the null hypothesis is rejected. That is, the null hypothesis H_1 stating that the series is stationary is accepted (Pesaran, 2007: 265-312). In this study, CADF and CIPS statistics were calculated for migration rate, energy consumption and economic growth series of 20 EU countries for the period 2008-2021. The results are presented in the table below along with the Pesaran (2007) critical table values.

Table 4. Pesaran Panel Unit Root Test Results

Migration Rate		**Level**	
		Constant	**Constant+trend**
Critical Values	1%	-2.45	-3
	5%	-2.22	-2.77
	10%	-2.11	-2.65
CIPS		**-1.58**	**-1.652**
Energy Consumption		**Level**	
		Constant	**Constant+trend**
Critical Values	1%	-2.45	-3
	5%	-2.22	-2.77
	10%	-2.11	-2.65
CIPS		**-1.884**	**-2.690**
Economic Growth		**Level**	
		Constant	**Constant+trend**
Critical Values	1%	-2.45	-2.98
	5%	-2.22	-2.76
	10%	-2.11	-2.64
CIPS		**-1.239**	**-2.700**

The existence of cross-sectional information requires the consideration of heterogeneity across units in panel causality analysis. Hoaltz-Eakin et al. (1988) tested the null hypothesis that there is no causal relationship between the variables of all units against the alternative hypothesis that there is a causal relationship between the variables of all units. In other words, the null hypothesis of no homogeneous Granger causality was tested against the alternative hypothesis of homogeneous Granger causality. Due to these homogeneous hypotheses, the hypothesis that Granger causality is not valid for all cross-sections can be rejected and the hypothesis that this relationship exists in all cross-sections can be accepted, while in reality there is a causality relationship in only a subgroup of the sample.

The panel Granger causality test introduced by Dumitrescu and Hurlin (2012) overcomes the heterogeneity problem. In the Dumitrescu-Hurlin panel Granger causality test, the absence of a homogeneous Granger causality relationship under the null hypothesis is tested against the alternative hypothesis that this relationship exists in at least one cross-section. In the Dumitrescu-Hurlin panel Granger causality test, when X and Y denote two stationary processes observed over period T for N number of units, the following linear heterogeneous model is considered for each unit (i) at time *t*:

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_i^{(k)} y_{i,t-k} + \sum_{k=1}^{K} \beta_i^{(k)} x_{i,t-k} + \varepsilon_{i,t} \tag{10}$$

It is $\beta_i = (\beta_i^{(1)}, \beta_i^{(2)}, \beta_i^{(3)}, \dots, \beta_i^{(K)})$ in equation (10). Individual effects (α_i) are assumed to be fixed, lag parameters $\gamma_i^{(k)}$ and regression slope coefficients $\beta_i^{(k)}$ are assumed to vary across units. Therefore, a fixed effects model is established for the causality test. The lag length K is assumed to be the same across cross-sections. The main and alternative hypotheses tested using equation (9) are as follows:

$$H_0 = \beta_i = 0 \qquad \forall i = 1,\ldots,N$$

$$H_1 = \beta_i = 0 \ \forall i = 1,....,N_1$$
$$\beta_i \neq 0 \qquad \forall_i = N_1 + 1,....,N \quad 0 \leq N_1 / N < 1 \tag{11}$$

The null hypothesis states that there is no Granger causality relationship between the variables analyzed in all units; the alternative hypothesis states that there is a relationship between these two variables in at least one unit. Although the model used is heterogeneous, the null hypothesis leads to a homogeneous result and the alternative hypothesis leads to a heterogeneous result.

The test statistic used to test the null hypothesis is the simple average of the individual Wald statistics:

$$W_{N,T}^{Hnc} = \frac{1}{N}\sum_{i=1}^{N} W_{i,T} \tag{12}$$

In equation (12), $W_{i,T}$, denotes the Wald test statistic used to test Granger causality for country i. Since individual Wald statistics for small values of T do not converge to the same chi-squared distribution, Dumitrescu and Hurlin (2012) propose to use the estimated standardized test statistic for $W_{N,T}^{Hnc}$ using the estimated values of the mean and variance of this unknown distribution:

$$\tilde{Z}_{N,T}^{HNC} = \frac{\sqrt{N}\left[W_{N,T}^{Hnc} - \sum_{i=1}^{N} E(\tilde{W}_{i,T})\right]}{\sqrt{\sum_{i=1}^{N} Var(\tilde{W}_{i,T})}} \tag{13}$$

The mean and variance in equation (12) are calculated as shown in (14), where T$\geq$ is 6+2K.

$$E(\tilde{W}_{i,T}) = N^{-1}\sum_{i=1}^{N} E(W_{i,T}) = K \times \frac{(T-2K-1)}{(T-2K-3)}$$

$$Var(\tilde{W}_{i,T}) = N^{-1}\sum_{i=1}^{N} Var(W_{i,T}) = 2K \times \frac{(T-2K-1)^2 \times (T-K-3)}{(T-2K-3)^2 \times (T-2K-5)} \tag{14}$$

Dumitrescu and Hurlin (2012) show through simulations that the test statistic $\tilde{Z}_{N,T}^{HNC}$ has good size and power properties even in panels with a small number of units and that this test statistic is quite robust even in the case of an incorrect lag length. This panel Granger causality test, introduced to the literature by Dumitrescu and Hurlin (2012), can also be applied to unbalanced panels and panels with heterogeneous lag lengths. In this case, instead of the test statistic in equation (13), the test statistic shown in equation (15) should be used:

$$\tilde{Z}_{N,t}^{HNC} = \frac{\sqrt{N}\left[W_{N,T}^{Hnc} - N^{-1}\sum_{i=1}^{N} E(\tilde{W}_{i,T})\right]}{\sqrt{N^{-1}\sum_{i=1}^{N} Var(\tilde{W}_{i,T})}} = \frac{\sqrt{N}\left[W_{N,T}^{HNC} - N^{-1}\sum_{i=1}^{N} K_i \times \frac{(T_i - 2K_i - 1)}{(T_i - 2K_i - 3)}\right]}{\sqrt{N^{-1}\sum_{i=1}^{n} 2K_i \times \frac{(T_i - 2K_i - 1)^2 \times (T_i - K_i - 3)}{(T_i - 2K_i - 3)^2 \times (T_i - 2K_i - 5)}}} \tag{15}$$

The testing procedure has a number of advantages and also takes into account cross-sectional dependence. First, the tests have very good properties even for samples with very small T and N values.

Second, test statistics based on the cross-sectional average of individual Wald statistics can be used without estimating any specific panel regression. Third, the method can be used in unbalanced panels and/or panels with different lag order K for each individual.

Table 5. Causality Test Results for Migration and Energy Consumption

$\tilde{Z}_{N,T}^{HNC}$ Test Statistic Results (Number of Lags: 1)			
H0 Hypothesis	**W-bar**	**Z-bar**	**Z-bar tilde**
Energy Consumption ⇨ Migration	3.2043	6.9705 (0.030)	4.0367 (0.030)
Migration ⇨ Energy Consumption	1.6343	2.0059 (0.3750)	0.7938 (0.500)

Note: Values in parentheses indicate p values. p values are calculated using 200 bootstrap iterations. The optimal number of lags is determined according to AIC.

According to the empirical results in Table 5, the hypothesis that " H_0 **:** Energy consumption is not the Granger cause of migration rate" is rejected. Therefore, it is understood that energy consumption is the cause of migration. On the other hand, the null hypothesis that " H_0 : Migration rate is not a Granger cause of energy consumption" is accepted. This shows that there is no causality relationship from migration variable to energy consumption. As a result, it is understood that there is a unidirectional causality relationship from energy consumption to migration.

Table 6. Causality Test Results for Migration and Economic Growth

$\tilde{Z}_{N,T}^{HNC}$ Test Statistic Results (Number of Lags: 2)			
H0 Hypothesis	W-bar	Z-bar	Z-bar tilde
Economic Growth ⇨ Migration	5.3119	7.4055 (0.2600)	2.6264 (0.2600)
Migration ⇨ Economic Growth	5.8821	8.6806 (0.0650)	3.2227 (0.0650)

Note: Values in parentheses indicate p values. p values are calculated using 200 bootstrap iterations. The optimal number of lags is determined according to AIC.

According to the empirical results in Table 6, the hypothesis that "Economic growth is not the Granger cause of migration rate." hypothesis is accepted. Therefore, it is understood that economic growth is not the cause of migration. However, null hypothesis "Migration rate is not a Granger cause of economic growth" is rejected. This shows that there is a causality relationship from migration variable to economic growth. As a result, it is understood that there is a unidirectional causality relationship from migration variable to economic growth.

Table 7. Causality Test Results for Energy Consumption and Economic Growth

$\tilde{Z}_{N,T}^{HNC}$ Test Statistic Results (Number of Lags: 1)			
H0 Hypothesis	**W-bar**	**Z-bar**	**Z-bar tilde**
Economic Growth ⇨Energy Consumption	2.5974	5.0513 (0.1750)	2.7831 (0.1750)
Energy Consumption ⇨ Economic Growth	3.4943	7.8875 (0.0350)	4.6357 (0.0350)

Note: Values in parentheses indicate p values. p values are calculated using 200 bootstrap iterations. The optimal number of lags is determined according to AIC.

According to the empirical results in Table 7, the null hypothesis that "Economic growth is not the Granger cause of energy consumption" is accepted. Therefore, it is understood that economic growth is not the cause of energy consumption. However, the null hypothesis "Energy consumption is not a Granger cause of economic growth" is rejected. This shows that there is a causality relationship from energy consumption to economic growth. As a result, it is understood that there is a unidirectional causality relationship from energy consumption to economic growth.

4. Conclusion

Many people around the world migrate on the basis of necessity or voluntariness. The migration journey that starts for different reasons stems from people's desire to reach better. Causes such as wars, natural disasters, social events, famine have caused people to migrate compulsorily. In addition, there are voluntary migration movements, whether by individual or family decisions. Migration flows accelerate when labor and capital are imbalanced. Countries where labor wages are low emigrate, while labor wages are high in countries where capital power and labor demand are high. For this reason, migration movements continue until the labor market reaches equilibrium.

In this paper, the causality relationship between migration, energy consumption and economic growth data of 20 EU member states is analyzed. In this context, data for the years 2008-2021 are obtained from the website of the EU Statistical Office (Eurostat). First, the homogeneity of the variables in the panel data set is analyzed using the Delta homogeneity test. As a result of this analysis, the coefficients of the variables that make up the panel data set are heterogeneous. These results suggest that the impact of changes in energy consumption on migration differs across countries. In addition, the effect of other variables such as economic growth on migration also varies across countries.

Energy consumption causes migration, but migration is not found to cause energy consumption. Increased energy consumption, especially increased use of fossil fuels such as oil, natural gas and coal, may cause migration due to climate change and environmental factors. For example, an increase in droughts, floods and other natural disasters due to climate change may affect food production and cause migration. In addition, increased energy consumption may require the opening of industrial plants and mines and increased production capacity, leading to reduced unemployment and increased economic opportunities. These factors may cause some people to leave their neighborhoods in search of a better life. Energy consumption is a major input to the production of goods and services. For this reason, societies with high energy consumption have higher labor demands than other countries. In countries with high energy consumption, the price of labor will be higher than in other countries.

Migration causes economic growth, but it is not found that economic growth causes migration. Developed countries with surplus capital want to maintain their advantage by combining this advantage with labor. In the labor market, unskilled labor is needed as much as skilled labor. In developed societies, locals do not want to work in unskilled jobs. Migrants who will do these jobs migrate to obtain high labor wages within the scope of the migration policies of developed countries. With the migration movement, the labor needed by capital enters the market. As a result, economic growth is inevitable with the resulting production and employment.

There are different theoretical explanations for why migration increases economic growth. These explanations approach the effects of migration on economic growth and the economic activities of migrants from different perspectives. By increasing labor supply, migration reduces labor costs, which in turn allows firms to produce at lower costs. Lower production costs increase the competitiveness of firms and thus support economic growth. As migrants tend to be educated and skilled, they can command higher wages in the labor market. This can lead to an increase in the economic value added of migrants and thus contribute to economic growth. Migrants come from different cultures and experiences and therefore have the potential for innovation and entrepreneurship. Innovation and entrepreneurship can contribute to economic growth through the creation of new firms and job opportunities. Migrants enable resources to be used more efficiently between different countries. This can support economic growth by increasing trade between different countries. However, for migration to increase economic growth, factors such as migrants having appropriate skills and education, sufficient job opportunities in the labor market, innovation and entrepreneurship potential, and efficient use of resources need to be ensured.

A theoretical explanation that economic growth does not cause migration is based on the fact that economic growth affects the population structure of a country and migration changes this structure. This explanation is based on the idea that economic growth does not cause migration and may even reduce it. First, economic growth can prevent the local population from migrating by increasing job opportunities in a country. That is, economic growth can reduce migration by reducing unemployment. This means that migration will be favored by those with job opportunities instead. Second, economic growth can improve the welfare of the local population by increasing the level of income in a country. Thus, people may not feel the need to migrate because they have better living conditions. Also, a higher level of income can include other social services, such as better education and health care, so people may have less reason to pursue a better life in their home country. Finally, economic growth can increase the education level of the local population by investing more in a country's human capital. This can result in the labor force in the country becoming more highly qualified and more competitive. In this case, employers will not need foreign labor as they will be able to find more qualified labor among the local workforce. Given all these reasons, economic growth may reduce migration or may not affect migration at all. Therefore, the relationship between economic growth and migration is very complex and may vary according to country characteristics. However, it can be said that there is a theoretical basis that economic growth does not cause migration.

Energy consumption is the cause of economic growth, but it is not established that economic growth causes energy consumption. Energy is one of the most important production inputs in today's economies. Countries with energy resources have a great advantage in economic activities. Realization of production together with energy consumption will increase employment. With increasing employment, economic growth will gain a positive momentum. Energy consumption is a critical factor for economic growth because energy used in production processes and the provision of services is the main driver of economic activity. Energy consumption is associated with several ways to boost economic growth. *(i) Efficiency:* Increasing energy consumption can increase efficiency in production processes. This means producing more goods and services using less energy. This can result in lower costs and higher profitability. *(ii) Technological Progress:* Energy consumption can be a driver for technological progress. An increase in energy consumption can lead to the development and implementation of new technologies to improve energy efficiency. This can lead to a more efficient economy, using less energy to produce more goods and services. Energy production and consumption creates many jobs, directly and indirectly. Employment in the energy sector can boost economic growth and at the same time the products and services provided by these sectors can provide inputs to other sectors. Energy is a basic need for households as well as for production processes. As energy consumption increases, the amount households spend on goods and services increases. This in turn can boost economic growth. For these reasons, there is a positive relationship between energy consumption and economic growth. However, an increase in energy consumption can also lead to negative effects such as environmental problems. Therefore, increasing energy efficiency and promoting the use of environmentally friendly energy sources are important for the sustainability of economic growth.

The findings indicate that migration influences economic growth by balancing labor supply and capital power. Energy consumption drives migration, suggesting that countries with high energy consumption attract more migrants due to better economic opportunities. These results align with previous studies but also highlight unique aspects of the European Union context. The conclusions emphasize the policy implications, suggesting that European Union countries should consider the dual impact of energy policies on migration and economic growth.

Ethics Declaration

In this study, there is no conflict of interest and no situation requiring ethics committee approval.

References

Aksoy, Zeynep (2012). International Migration and Intercultural Communication, International Journal of Social Research, Volume:5, Issue:20.

Alola, A. A., Yalciner, K., Alola, U. V., & Saint Akadiri, S. (2019). The role of renewable energy, immigration and real income in environmental sustainability target. Evidence from Europe largest states. Science of The Total Environment, 674, 307-315.

Ari Y. O (2018) , Economic determinants of circular migration: The case of Georgia-Turkey / Economic determinants of circular migration: The case of Georgia-Turkey

Aslan, A., & Altınöz, Buket. (2018). Exploring The Nexus Between International Migration, Renewable Energy Consumption And Climate Change: Evidence From OECD Countries. International Energy Economy And Security Congress.

Baltagi, B. H. (2008). Forecasting with panel data. Journal of forecasting, 27(2), 153-173.

Birinci A (2010), Economic growth, energy consumption and environmental pollution long run relationship for Turkey. Master's Thesis, Karadeniz Technical University, University of Social Sciences, Department of Econometrics, Trabzon.

Borjas, G. J. (2019). Immigration and Economic Growth, NBER Working Paper No: w25836.

Breusch, T. S., & Pagan, A. R. (1980). The lagrange multiplier test and its applications to model specification in econometrics. The review of economic studies, 47(1), 239-253.

Dumitrescu, E. I. and Christophe Hurlin (2012), "Testing for Granger noncausality". Economic Modelling, 2012, vol. 29, issue 4, 1450-1460.

Dücan, E. (2016). Regional analysis of socio-economic causes of internal migration in Turkey. Journal of Economic and Social Research, 12(2), 167-183.

Engin, C. and Konuk, T. (2020). The Effect of International Migration on Unemployment and Economic Growth in the Turkish Economy: An Econometric Analysis. Journal of Kahramanmaraş Sütçü İmam University Faculty of Economics and Administrative Sciences, 10 (1), 103-123 . Retrieved from http://iibfdergisi.ksu.edu.tr/tr/pub/issue/55534/706758

Feridun, M., & Shahbaz, M. (2015). Immigration and electricity consumption: The case of Northern Cyprus. International Journal of Green Energy. https://doi.org/10.1080/15435075.2014.912654

Güllüpınar, (2012). "An Evaluation on the Political Economy of Migration and International Migration Theories", Yalova Journal of Social Sciences, Issue 4: 53-85.

Güloğlu, B., & İvrendi, M. (2008). Output fluctuations: Transitory or permanent? The case of Latin America. Applied Economics Letters, 1-6.

Harris, R. D., & Tzavalis, E. (1999). Inference for unit roots in dynamic panels where the time dimension is fixed. Journal of econometrics, 91(2), 201-226.

Holtz-Eakin, D., Newey, W. and Rosen, S. (1988). "Estimating Vector Autoregression With Panel Data". Econometrica. 56. pp. 1371-1395.

Kirikkaleli, D., & Dogan, N. (2021). Energy consumption and refugee migration in Turkey. Utilities Policy. https://doi.org/10.1016/j.jup.2020.101144

Knight, M., Loayza, N., & Villanueva, D. (1993). Testing the neoclassical theory of economic growth: A panel data approach. Staff papers, 40(3), 512-541.

Komatsu, S., Ha, H. D., & Kaneko, S. (2013). The effects of internal migration on residential energy consumption and CO2 emissions: A case study in Hanoi. Energy for Sustainable Development, 17(6), 572-580.

Koyuncu T. (2019), Doğrudan Yabancı Yatırımlar, Enerji Tüketimi, Göç ve Karbondioksit Salınımı ile Ekonomik Büyüme Arasındaki İlişkilerin Analizi, Basılmamış Yüksek Lisans Tezi.

Kraft J, Kraft A (1978), On the relationship between energy and GNP. Journal Energy Development 3: 401-403.

Meçik, O. & Koyuncu, T. (2020). The Relationship between Migration and Economic Growth in Turkey: Toda-Yamamoto Causality Test. Journal of Human and Social Sciences Research, 9 (3) , 2618-2635. DOI: 10.15869/itobiad.748770.

Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. Journal of applied econometrics, 22(2), 265-312.

Pesaran, M. H., & Yamagata, T. (2008). Testing slope homogeneity in large panels. Journal of econometrics, 142(1), 50-93.

Pesaran, M. H., Schuermann, T., & Weiner, S. M. (2004). Modeling regional interdependencies using a global error-correcting macroeconometric model. Journal of Business & Economic Statistics, 22(2), 129-162.

Pesaran, M. H., Ullah, A., & Yamagata, T. (2008). A bias-adjusted LM test of error cross-section independence. The econometrics journal, 11(1), 105-127.

Pesaran, M.H. (2004), "General Diagnostic Tests for Cross Section Dependence in Panels", Unpublished manuscript, Cambridge University.

Soytas, U. and Sari, R. (2006). "Energy Consumption and Income in G-7 Countries", Journal of Policy Modeling, 28(7), 739-750.

Şimsek D., (2018). Göç Hızı-Enflasyon-Ekonomik Büyüme İlişkisi: En Yüksek Göç Oranına Sahip Sekiz Ülkenin İncelenmesi, Basılmamış Yüksek Lisans Tezi.

Torasa, C., Sittisom, W., & Mekhum, W. (2020). What Difference Urban Sprawl Industrialization and Migration Can Make in Energy Consumption? A Time-series Analysis of Thailand. International Journal of Energy Economics and Policy.

Wadhwa, V., Saxenian, A., Rissing, B. A., & Gereffi, G. (2008). Skilled immigration and economic growth. Applied Research in Economic Development, 5(1), 6-14.

Yılmaz A. (2014). International Migration: Types, Causes and Effects, International Periodical for the Languages, Literature and History of Turkish or Turkic, Turkish Studies, Volume 9/2, p. 1685-1704.