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Research Article

Energy consumption and economic growth: the case of post-Soviet era Central Asian Countries

Enerji tüketimi, altyapı yatırımları ve ekonomik büyüme: Sovyetler Birliği sonrası Orta Asya Ülkeleri

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Öz

Bu çalışmanın amacı, dört Orta Asya ülkesi için enerji kullanımı, istihdam ve altyapı yatırımlarının reel Gayri Safi Yurtiçi Hasıla (GSYİH) üzerindeki etkilerini belirlemektir. Kazakistan, Kırgızistan, Tacikistan ve Özbekistan için 1990-2018 dönemi panel veri analizini kullanarak Otoregressive Dağıtılmış Gecikme modeli (ARDL) ile reel GSYİH, enerji kullanımı, altyapı yatırımları ve istihdam arasındaki uzun vadeli ilişkiyi araştırmak için kullanılmıştır. Sonuçlar, reel GSYİH ile enerji kullanımı arasında ters bir ilişki olduğunu, ancak istihdam ve altyapı yatırımları ile reel GSYİH arasında pozitif bir ilişki olduğunu göstermektedir. Değişkenler arasındaki nedenselliğin belirlenmesi için Dolado-Lütkepohl Nedensellik Testi uygulanmıştır. Dolado-Lütkepohl test sonuçları, elektrik tüketiminden reel GSYİH'ya doğru bir nedensellik olduğunu göstermektedir. Altyapı yatırımları ile reel GSYİH arasında da tek yönlü bir nedensellik bulunmuştur. Sonuçlar ayrıca altyapı yatırımlarının ile istihdam arasında tek yönlü bir nedensellik olduğunu göstermektedir. Sonuçlar, bu ülkeler için altyapı yatırımlarının ülkelerin ekonomik büyümesi ve gelişmesinde önemli bir faktör olduğunu doğrulamaktadır.

Anahtar Kelimeler: *Enerji Tüketimi, altyapı yatırımları, ekonomik büyüme, ARDL*

Abstract

The aim of this study is to estimate the impact of energy use, employment, and capital formation on real GDP for four Central Asian countries: Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan using panel data analysis between 1990 to 2018. This study uses ARDL[1] *approach to investigate the long-run relationship among real GDP and energy use, employment, and capital formation. The results show an*

[1] The Autoregressive Distributed Lag

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inverse relationship between real GDP and energy use, but a positive relationship real GDP and other independent variables, employment and capital formation. The Dolado-Lütkepohl Causality Test has been applied to determine the causality among the variables. Test results show that electric consumption increases real GDP. A unidirectional causality has been found between capital formation and real GDP. The results also show a unidirectional causality between capital and employment, confirming capital accumulation is a vital factor in economic growth.

Keywords: *Economic development, regional economics, energy use, capital formation*

JEL Classification: *E00, K32, F43*

Introduction

Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan, landlocked countries in Central Asia, faced significant economic hardship since the disintegration of the Soviet Union in 1991. These countries show a similar pattern of Gross Domestic Product (GNP) growth in real terms. All of the countries under study experienced a steady decline in their national incomes for several years after the independence followed by a gradual but sustained increase in overall economic activity. Kazakhstan, however, experienced slightly higher economic growth than the other countries.

Energy consumption per capita showed a steady decline after the independence of these states from the Soviet Union. However, it started to recover in the late 1990's as economic conditions started to improve. Figure 1 summarizes the electricity consumption for four of the countries under study.

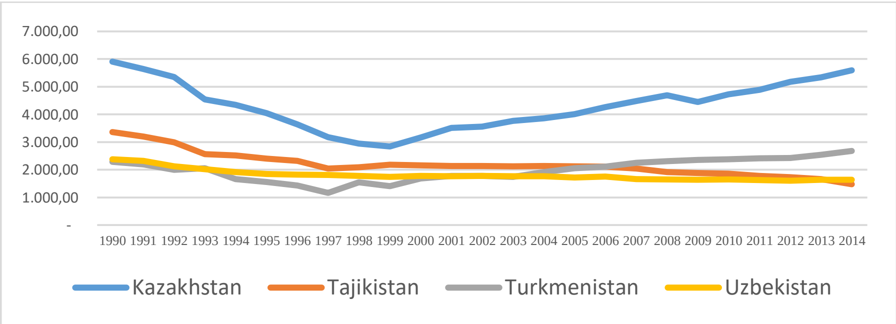

Fig. 1: Electricity Consumption (kWh per capita)

Source: World Bank Open Data

The most dramatic decline in per capita energy consumption was experienced by Kazakhstan after gaining its independence from the Soviet Union. Uzbekistan also experienced a steady decline in per capita energy consumption in the first decade of their independence. Tajikistan, however, is still in a slow decline stage.

Kazakhstan has experienced strong economic growth over the past two decades. The driving force behind such a development was natural resource extraction and export-oriented policies. During the global economic crisis of 2008-2009, however, Kazakhstan's economic growth slowed down. A sharp drop in oil, natural gas and commodity prices in 2009 caused a recession in Kazakhstan. Oil, natural gas, and emtia prices recovered soon after the great global recession and growth in the oil industry have stimulated the Kazakh economy. Another big drop in oil prices in 2014 and commodity price fluctuations over the recent years subjected the economy to uncertainties, impacting its steady growth. Sectors other than natural resource extraction are on a very slow growth path and exhibit low productivity and low international competitiveness (U.S. Energy Information Administration [EIA] 2017).

Uzbekistan is energy self-reliant. Uzbekistan electricity infrastructure and distribution network is in very poor condition, causing electricity shortages, low efficiency, high losses and low reliability. A growing economy and more demand for gas and oil force Uzbekistan to increase production and infrastructure investment in distribution pipelines. The need for finding funds, through foreign direct investment has been increasing. Uzbekistan eased up the processes domestic private and foreign direct investment. The government provides advantages, financial encouragements and assurances to attract international investors, and creates special investment zones and provides tax discounts. Some of the difficulties for investor include slow bureaucratic processes, restrictive currency regulation, excessive state involvement and corruption.

Kyrgyzstan has limited amounts of coal, natural gas and oil, but is abundant in water resources and uses its hydro power for electricity generation. Kyrgyzstan imports natural gas, oil and coal for more than 65% of its energy requirements. The country meets all of the demand for natural gas and oil with imports from neighboring countries. About 50% of the total coal supply imported for energy consumption (IEA, 2015).

Tajikistan has plentiful water resources and hydropower is being used as the principal source of energy. Nurek HPP is the largest hydropower plant (HPP) in the Central Asia. The country uses hydropower for electricity generation. Imported oil and gas are being used for residential heating and lighting and industrial production. The coal production is also growing slowly.

Tajikistan experienced a civil war until 1997. The economy slowly recovered after 1997. The agricultural sector employs more than 65% of the labor force and is the largest sector of the economy. Cotton and aluminum exports accelerated the economic growth of the country. Unilateral transfers from Tajik laborers working abroad, mainly in Russia, also contributed to economic growth. The global economic recession impacted Tajikistan because of reduced exports and unilateral transfers. (EIA, 2017).

Tajikistan’s energy sector is open to supply shocks. The seasonal changes of water resources cause electricity blackouts during the winter months. The country is not part the Central Asia Power Grid since 2009 and gas supplies from Uzbekistan also stopped in 2013, creating some concerns for the energy supply.

The oil and gas reserves require significant domestic private and foreign direct investment for all these countries. The governments have instituted reforms to reduce attract more investment in the recent years. These countries, however, do not attract enough foreign investment, due to corruption and political instability, (EIA, 2013).

Kazakhstan generates more than 80% of its total electricity from coal power plants. There was a significant growth in energy demand and it is estimated to reach 120-180 TWh by 2030. The industrial sector uses approximately 70% of the electricity, the residential sector accounts to 10%, the commercial and service sectors account to 9%, transportation 6% and agriculture sector 2% (Karatayev & Clarke, 2014).

The primary source of power generation in Uzbekistan is natural gas, which accounts for about 90% of the total power generation. The remaining 10% of the energy comes from hydropower. In addition to meeting its own energy demand, Uzbekistan supplies a significant portion of the energy generating capacity of the Central Asia Power System (CAPS). Uzbekistan is also supplies electricity to Afghanistan (US Energy Information Agency, 2016).

Autoregressive distributed lag (ARDL), bound tests, and an error correction model (ECM) are used to investigate the relationship among the variables.

Section 2 of this study summarizes the relevant literature; section 3 discusses data and econometric methodology; section 4 includes econometric tests and results; and, section 5 presents the conclusion and recommendations.

1. Literature review

Electricity is a form of energy which is becoming more and more important in our lives because of our dependency on it from performing our daily work, communication, education, healthcare to entertainment related activities. We also need electricity to heat, our homes, light up our schools, empower our computers at offices, and power water pumps and machinery at factories. Energy powers cars, planes, trains, buses and motorcycles. Electricity powers all of our modern conveniences such as our laptops, air conditioners, smart phones and refrigerators. For the developing countries energy shortages cause severe healthcare problems such as high infant mortality, maternal death and shorter life expectancy, social problems like poverty, illiteracy, and migration to urban centers (IEA, 2000).

Having affordable energy for industrial production and household use helps bring about economic development. The World Bank Annual Report (2018) points out that while poverty continues to decline, millions remains economically insecure. Lack of access to power, physical and broadband infrastructure and connectivity slows down economic development, resulting in poverty characterized by severe lack of basic human necessities, including food, drinking water, health, housing, and education, causing high infant mortality, illiteracy, and rapid urbanization.

Many studies have looked into the relationship between energy consumption and economic growth for both advanced countries and for the developing countries. These studies have resulted with varying results due to data including different groups of countries at different economic development levels, with different dependent and independent variables used, and different study methodologies.

Paul and Bhattacharya (2004) studied the causal relationship between energy consumption and economic growth in India between 1950 and 1996. They found that both energy consumption and economic growth impact each other. Energy increases the return on labor, capital and other factors of production, hence, fuels economic growth and, in turn, economic growth brings about higher demand for production and consumption. Cheng (1999) found that energy consumption and economic growth are cointegrated and economic growth drives energy consumption in both the short-run and long-run. Asafu-Adjaye (2000) found that energy consumption drives economic growth in India and Indonesia, while bidirectional Granger causality exists between energy consumption and economic growth in Thailand and the Philippines.

Ozturk, Aslan, & Kalyoncu (2010) have studied 51 countries, arranged as low-income, lower-middle-income and upper-middle-income countries, covering years between 1971 and 2005. They found that there is a cointegration between energy consumption and economic growth cointegrated for all groups. Their results indicate that there is long-run Granger causality running from economic growth to energy consumption for low income countries and bi-directional causality for middle income countries. Stern (2000) found cointegration in a relationship including GDP, energy, capital, and labor. He concludes that energy is an essential driver for economic growth.

Karagol, Erbaykal & Murat Ertuğrul (2007) examined the relationship between economic growth and electricity consumption in Turkey between 1974 and 2004. They found cointegration between economic development and electricity use. Their results indicate a positive relationship in short-run, but, an inverse relationship in long-run between the variables.

Gross fixed capital formation provides a basic foundation for economic activity. The location and level of public investments can change both the well-being of the community as a whole and the income distribution within a community. Infrastructure contributes to economic growth by acting through both supply and demand. Gokirmak (2019) looked into the relationship between public infrastructure investments and GDP in The United States for the period of 1960-2013. His results suggest a positive relationship between public capital and industrial output. Results of this analysis also shows some evidence of reverse causality--the argument that economic trends also invite public investment. The results also support the argument that public capital actually stimulates private investment.

2. Data and econometric methodology

This study uses annual data from the World Bank database for Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan from 1990 to 2018 to test causality among real output (GDP, constant 2010 US$), electric power consumption (*Elect*), employment in industry (*Emp*), and capital formation (*Cap*) in the long-run. The model can be illustrated as follows:

LGDP=$\beta_{0+}\beta_1 Elect + \beta_2 Emp + \beta_3 Cap + u$ (1)

The Autoregressive Distributed Lag (ARDL) model is used as the econometric methodology (Pesaran et al., 2001). The generalized ARDL (p, q) model is specified as follows:

$$y_{it} = \sum_{j=1}^{p} \delta y_{i,t-j} + \sum_{j=0}^{q} \beta_{ij}^{s} X_{i,t-j} + \varphi_i + e_{it} \qquad (2)$$

where y_{it} is the dependent variable, (X_{it}) is a $k \times 1$ vector that are I(0) or I(1) or cointegrated: δ_{ij} is the coefficient of the lagged dependent variable called scalars; β_{ij} are $k \times 1$ coefficient vector; φ_i is the unit-specific fixed effects; $i = 1,...,N$; $t = 1,2,...,T$; p, q are optimal lag orders; e_{it} is the error term.

For the purpose of the estimation, the ARDL model can be shown as follows:

LGDP=$\beta_0 + \beta_1 Elect_{t-1} + \beta_2 Emp_{t-1} + \beta_3 Cap_{t-1} + \sum ai\,\Delta GDP_{t-1} + \sum biEmp + \sum ciCap_{t-1} + u_t$ (3)

The statistical properties of the data under study should be determined in order to show and explain the characteristics of each variable in the model. For this purpose, the descriptive statistics is presented in the Table 1.

The stationarity levels of the variables were tested by using Im, Pesaran, and Shin panel unit root tests. Although Pesaran et al. (2001) suggest that ARDL model is admissible even when the variables are *I(0)* or *I(1)*.

2.1. Unit root test results and optimum lag selection

Table 1 shows unit root test results for the variables used in this study.

Table 1. Results of the panel unit root test.

Series	Im, Pesaran and Shin W-stat	
	Level	First Differences
LGDP	0.92099 (082159	-1.89918 (0.0288)**
Electric use	-2.97342 (0.0015)*	
Employment	0.19535 (0.5774)	-64.7218 (0.0000)*
Capital formation	5.20151 (1.0000)	-4.40804 (0.0000)*

Note: Numbers in the parenthesis show the *p*-values.

*Significant at the 1% level.

**Significant at the 5% level.

An optimal lag length is estimated, based on the appropriate and consistent information criteria, the Optimized Loglikelihood (LogL), the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), or Hannan-Quinn Information Criterion (HQ), in the ARDL model. As it is seen in the Table 2, the most appropriate specification is ARDL (3, 3, 3, 3) since all criteria have the least value in this case.

Table 2: Model Selection Criteria

Model	LogL	AIC*	BIC	HQ	Specification
9	271.450133	-4.975865	-3.416958	-4.348141	ARDL(3, 3, 3, 3)
3	264.252360	-4.580514	-3.248357	-4.044095	ARDL(1, 3, 3, 3)
6	250.030187	-4.575407	-3.129874	-3.993335	ARDL(2, 3, 3, 3)
8	237.574454	-4.472976	-3.25494	-3.982210	ARDL(3, 2, 2, 2)
5	229.992343	-4.390629	-3.285221	-3.945515	ARDL(2, 2, 2, 2)
2	219.780335	-4.247824	-3.255792	-3.848363	ARDL(1, 2, 2, 2)
7	212.128659	-4.163877	-3.285220	-3.810069	ARDL(3, 1, 1, 1)
4	203.361794	-4.054294	-3.289012	-3.746139	ARDL(2, 1, 1, 1)
1	191.586630	-3.875555	-3.223648	-3.613052	ARDL(1, 1, 1, 1)

2.2. Econometric tests and results

2.2.1. Panel ARDL results

ARDL method is used for the regression analysis even though unit root test showed stationarity properties for the variables at *I(0)* and *I(1).* Table 3 shows ARDL results for long-run equation. The Table 3 shows that all independent variables, which are employment, electricity consumption, and capital formation, affect GDP significantly. However, the coefficient of electricity consumption has been found to be negative; this result is consistent with Karagol et al. (2007) findings. Karagol et al. stated that there is a positive relationship between economic growth and electricity consumption in the short-term; but there is an inverse relationship between the variables in the long term. The electricity consumption is the main input in the development of industry, but also a key factor in improving the life standards of individuals. The coefficients of employment and capital formation are positive as expected; this means that increase in employment and investment cause GDP to increase as predicted.

The short-term dynamics of the models in the ARDL method are represented by the error correction mechanism. The coefficient of the error correction term is negative and significant; this means that the short-run imbalances or shocks are eliminated in the long-run and the system is converging to the long-run equilibrium. According to the ARDL results, only 34% of the short-term imbalances are eliminated in each year.

Table 3. Panel ARDL Results: Dependent Variable D(LGDP)

Variable	**Coefficient**	**Std. Error**	**t-Statistics**	**Prob.**
		Long Run Equation		
EMP	4.53E.07	2.43E-08	18.67894	0.0000
ELECT	-0.000196	6.45E-05	-3.038058	0.0040
CAP	1.98E-11	3.08E-12	6.438339	0.0000
ECM_{t-1}	-0.344161	0.135483	-2.540257	0.0147

where EMP, ELECT, CAP, and ECM_{t-1} s how employment, electricity consumption, capital formation, and error correction mechanism respectively.

2.2.2. Dolado-Lütkepohl Causality Test Results

The Dolado-Lütkepohl causality test is based on Toda and Yamamoto's (1995) methodology, which is augmented VAR $(p+d_{\max})$. In the Toda-Yamamoto (TY) causality test, the analysis cannot be affected by the occurrence of unit root and cointegration relationship of the series. In the TY model, after the optimal lag length (m) of the VAR model and the maximum stationary degree are determined, a VAR (p + dmax) model is estimated.

To test the causality between two variables, the following bivariate VAR (k) model is constructed:

$$LGDP = \alpha_1 + \sum_{i=1}^{h+d} \beta_{1i} LGDP_{t-i} + \sum_{j=1}^{I+d} \delta_{1j} Elect_{t-j} + e_{1t} \qquad (4)$$

$$Elect = \alpha_1 + \sum_{i=1}^{h+d} \beta_{2i} Elect_{t-i} + \sum_{j=1}^{I+d} \delta_{2j} LGDP_{t-j} + e_{2t} \qquad (5)$$

Where d is the maximum order of integration, h and d are the optimal lag length, e_{1t} and e_{2t} are the error terms. For the bivariate VAR equation 4 (above), the null (H_0) and alternative (H_1) hypothesis can be specified as follows:

H_0: LGDP does not Granger cause Elect, if $\sum_{j=1}^{I} \delta_{1j} = 0$

H_1: LGD does Granger cause Elect, if $\sum_{j=1}^{I} \delta_{1j} \neq 0$

The first step is to determine the estimation of the maximum order of integration $(d_{\max})$ in the system. The results of the unit root test in the Table 2 indicate that the order of integration for all variables, except elect, is one *I (1)*. Dolado and Lütkepohl (1996) state that the causality test can be utilized which is based on VAR analysis. Similar to the TY model, a VAR (p) model is determined according to the criteria for the optimal length of selection. Then, the model is estimated by adding an external lag VAR $(p+1)$ and the WALD test is applied. Like all causality tests, in this approach, it is very important to determine the optimal length. The lag length of the VAR model has been determined as 2 by Akaike Information Criterion (AIC) and all other information criteria support this lag length.

Table 4: VAR Length Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-3204.287	NA	4.60e+36	95.769	95.90	95.821
1	-2500.595	1302.356	5.59e+27	75.241	**75.899***	75.5020
2	-2469.539	**53.768***	**3.59e+27***	**74.792***	75.976	**75.260***
3	-2460.679	14.281	4.50e+27	75.005	76.716	75.682
4	-2445.459	22.717	4.72e+27	75.028	77.266	75.914
5	-2437.012	11.597	6.17e+27	75.254	78.018	76.347
6	-2420.379	20.853	6.46e+27	75.235	78.525	76.537

7	-2405.067	17.368	7.23e+27	75.255	79.072	76.766
8	-2385.178	20.185	7.34e+27	75.139	79.483	76.858

*indicates lag order selection by the criterion

LR: sequential modified LR test statistic (at 5% level),

FPE: final prediction error,

After VAR (2) model is predicted, the model is estimated by adding an external lag VAR (3) and causality test is performed.

Table 5: Dolado-Lütkepohl Causality Test Results

Causality	**Chi-Square**	**Probability**
Elect → *LGDP*	15.18365	0.0005
Cap → *LGDP*	7.383836	0.00249
Cap → *Emp*	4.981015	0.0829

Table 5 shows that there is a causality running from electric consumption to real GDP since the probability is lower than 5%, meaning that null hypothesis can be rejected. Another causality test is performed between capital formation and real GDP and a unidirectional causality result has been found. There is also a unidirectional causality between capital and employment. This result confirms that capital accumulation is an important factor in countries' GDP growth and development.

Conclusion

This study examined electricity consumption, which was taken as a proxy of energy, employment, and capital formation in determining real GDP for four Central Asian countries, Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan using panel data analysis over the period 1990 to 2018. The ARDL model was used to examine the long-run relationship among real GDP and energy use, employment, and capital formation. According to the results, there is an inverse relationship between real GDP and energy use, but there is a positive relationship between real GDP and other independent variables, which are employment and capital formation in the long-run.

This study used the Dolado-Lütkepohl causality approach to observe the causality between variables. The findings show that there is a unidirectional causality between energy use and real GDP, meaning that there is a causality running from energy use to real GDP. Another causality test was performed between capital formation and real GDP and a unidirectional causality result also has been found. This result confirms that capital accumulation is an important factor in countries' GDP growth and development.

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Araştırma Makalesi

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Enerji tüketimi, altyapı yatırımları ve ekonomik büyüme: Sovyetler Birliği sonrası Orta Asya Ülkeleri

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Genişletilmiş Özet

Özet

Bu çalışmanın amacı, dört Orta Asya ülkesi için enerji kullanımı, istihdam ve altyapı yatırımlarının reel Gayri Safi Yurtiçi Hasıla (GSYİH) üzerindeki etkilerini belirlemektir. Kazakistan, Kırgızistan, Tacikistan ve Özbekistan için 1990-2018 dönemi panel veri analizini kullanarak Otoregressive Dağıtılmış Gecikme modeli (ARDL) ile reel GSYİH, enerji kullanımı, altyapı yatırımları ve istihdam arasındaki uzun vadeli ilişkiyi araştırmak için kullanılmıştır. Sonuçlar, reel GSYİH ile enerji kullanımı arasında ters bir ilişki olduğunu, ancak istihdam ve altyapı yatırımları ile reel GSYİH arasında pozitif bir ilişki olduğunu göstermektedir. Değişkenler arasındaki nedenselliğin belirlenmesi için Dolado-Lütkepohl Nedensellik Testi uygulanmıştır. Dolado-Lütkepohl test sonuçları, elektrik tüketiminden reel GSYİH'ya doğru bir nedensellik olduğunu göstermektedir. Altyapı yatırımları ile reel GSYİH arasında da tek yönlü bir nedensellik bulunmuştur. Sonuçlar ayrıca altyapı yatırımlarının ile istihdam arasında tek yönlü bir nedensellik olduğunu göstermektedir. Sonuçlar, bu ülkeler için altyapı yatırımlarının ülkelerin ekonomik büyümesi ve gelişmesinde önemli bir faktör olduğunu doğrulamaktadır.

Giriş

Kazakistan, Kırgızistan, Tacikistan ve Özbekistan, Orta Asya'da bağımsızlığını son dönemde ilan etmiş devletlerdir. Deniz ve okyanuslara bağlantısı olmayan bu ülkeler, 1991'de Sovyetler Birliği'nin dağılmasından sonra ciddi ekonomik sıkıntı yaşamışlardır. Bu Orta Asya ülkeleri, reel olarak birbirlerine benzer bir Gayri Safi Milli Hasıla büyümesi eğilimi göstermektedirler. İncelenen ülkelerin tümü, bağımsızlıktan sonraki birkaç yıl boyunca ulusal gelirlerinde istikrarlı bir düşüş yaşamış, ardından genel ekonomik faaliyetlerde kademeli ancak sürekli bir artış olmuştur. Ancak Kazakistan, diğer ülkelere göre biraz daha yüksek bir ekonomik büyüme yaşamıştır.

Bu devletlerin Sovyetler Birliği'nden ayrılmasının ardından kişi başına düşen enerji tüketimi, istikrarlı bir düşüş göstermiştir. Ancak, 1990'ların sonlarında da ekonomik koşulların iyileşmesiyle enerji tüketiminde artma başlamıştır. Kişi başına enerji tüketimindeki en çarpıcı düşüş, Sovyetler Birliği'nden bağımsızlığını kazandıktan sonra Kazakistan'da yaşanmıştır., Bağımsızlığının ilk on yılında Özbekistan'da da kişi başına düşen enerji tüketiminde istikrarlı bir düşüş yaşanmıştır. Ancak Tacikistan hala yavaş bir düşüş aşamasındadır.

Veri ve ekonometrik metodoloji

Bu çalışmada, uzun dönemde reel GSYİH ile elektrik tüketimi (*Elect*), sanayide istihdam (Emp) ve altyapı yatırımları (Cap) arasındaki nedenselliği test etmek için, Kazakistan, Kırgızistan, Tacikistan ve Özbekistan için Dünya Bankası veri bankasından alınan ve Dünya Kalkınma Göstergelerinden elde edilen 1990-2018 yılları arasındaki dönemi kapsayan yıllık veriler kullanılmıştır. Bu çalışmada Otoregressif Dağılımlı Gecikme Modeli (ARDL), sınır testleri ve bağımlı ve bağımsız değişkenler arasındaki ilişkiyi araştırmak için bir Hata Düzeltme Modeli (Error Correction Model [ECM]) kullanılmaktadır. Model aşağıdaki gibi gösterilebilir:

$$\text{LGDP}=\beta_{0+}\beta_1 Elect+\beta_2 Emp+\beta_3 Cap+u \qquad (1)$$

Çalışmada kullanılan ekonometrik metodoloji, Pesaran ve diğerleri (2001) tarafından sunulan Otoregressif Dağılımlı Gecikme Modeli'nden (ARDL) türetilmiştir. Genelleştirilmiş ARDL (p, q) modeli aşağıdaki gibi tanımlanmıştır:

$$y_{it}=\sum_{j=1}^{p}\delta y_{i,t-j}+\sum_{j=0}^{q}\beta_{ij}^{s}X_{i,t-j}+\varphi_i+e_{it} \qquad (2)$$

Modeldeki bağımlı değişken y_{it}, (X_{it}) I (0) veya I (1) veya eşbütünleşik bir $k\times 1$ vektördür: δ_{ij} skalar olarak adlandırılan gecikmeli bağımlı değişkenin katsayısıdır;, β_{ij} $k\times 1$ katsayı vektörüdür; φ_i üniteye özgü sabit etkiler; $i=1,...,N$; $t=1,2,...,T$; p,q optimal gecikme terimleri; e_{it} ise hata terimidir.

ARDL modeli aşağıdaki gibi gösterilebilir:

$$\text{LGDP}=\beta_0+\beta_1 Elect_{t-1}+\beta_2 Emp_{t-1}+\beta_3 Cap_{t-1}+\sum ai\,\Delta GDP_{t-1}+\sum biEmp+\sum ciCap_{t-1}+u_t \qquad (3)$$

Bu aşamada, incelenen verilerin istatistiksel özellikleri, modeldeki her bir değişkenin özelliklerini göstermek ve açıklamak için belirlenmelidir.

Ekonometrik Testler ve Sonuçlar

Panel ARDL Sonuçları

Birim kök testi değişkenlerin durağanlık özellikleri *I(0)* ve *I(1)* olsa bile ARDL testi regresyon analizi için kullanılır. Uzun süreli denklem için ARDL sonuçlarının özetlendiği. Tablo 3, istihdam, elektrik tüketimi ve sermaye oluşumu olan tüm bağımsız değişkenlerin GSYH'yi önemli ölçüde etkilediğini göstermektedir. Ancak, elektrik tüketim katsayısı negatif olarak gözükmektedir; bu sonuç Karagöl ve diğerleri (2007) bulguları ile uyumludur. Karagol ve diğerleri kısa vadede ekonomik büyüme ile elektrik tüketimi arasında pozitif bir ilişki olduğu halde; uzun vadede değişkenler arasında negatif bir ilişki olduğunu göstermişlerdir. Elektrik tüketimi, sanayinin gelişmesinde ana girdi olmakla birlikte, aynı zamanda bireylerin yaşam standartlarının iyileştirilmesinde de önemli bir faktördür. İstihdam ve sermaye oluşumu katsayıları beklendiği gibi pozitiftir; bu da istihdam ve altyapı yatırımlarındaki artışın GSYİH'nın artmasına neden olduğu anlamına gelir.

ARDL yöntemindeki modellerin kısa vadeli dinamikleri, hata düzeltme mekanizması ile gösterilir. Hata düzeltme teriminin katsayısı negatif ve anlamlıdır; kısa vadede oluşan dengesizliklerin veya şokların uzun vadede ortadan kaldırıldığı ve sistemin dengeye yakınlaştığı anlamına gelir. ARDL sonuçlarına göre, kısa vadeli dengesizliklerin sadece %34'ü her yıl elimine edilmektedir.

Panel ARDL Sonuçları: Bağımlı Değişken D(LGDP)

Değişken	**Katsayı**	**Std. Hata**	**t-İstatistik**	**Olasılık**
Uzun Vade Denklemi				
EMP	4.53E.07	2.43E-08	18.67894	0.0000
ELECT	-0.000196	6.45E-05	-3.038058	0.0040
CAP	1.98E-11	3.08E-12	6.438339	0.0000
ECM_{t-1}	-0.344161	0.135483	-2.540257	0.0147

EMP, ELECT, CAP ve ECM_{t-1} sırasıyla istihdam, elektrik tüketimi, sermaye oluşumu ve hata düzeltme mekanizmaları.

Dolado-Lütkepohl Nedensellik Test Sonuçları

Dolado-Lütkepohl nedensellik testi, Toda ve Yamamoto'nun (1995) metodolojisine dayanmaktadır ve VAR$(p+d_{max})$. artırılmıştır. Toda-Yamamoto (TY) nedensellik testinde analiz, serinin birim kökü ve eşbütünleşme ilişkisinin varlığından etkilenemez. TY modelinde, VAR modelinin optimal gecikme uzunluğu (m) ve maksimum durağanlık derecesi belirlendikten sonra, bir VAR (p+dmax) model tahmin edilir.

H_0: LGDP Granger'e neden olmaz, eğer $\sum_{j=1}^{I} \delta_{1j} = 0$

H_1: LGDP Granger'e neden olur, eğer $\sum_{j=1}^{I} \delta_{1j} \neq 0$

İlk adım, sisteme maksimum entegrasyon büyüklüğü (d_{max}) tahminini belirlemektir. Aşağıdaki tablodaki birim kök testinin sonuçları, elektrik tüketimi hariç, tüm değişkenler için entegrasyon sırasının *I(1)* olduğunu göstermektedir. Dolado ve Lütkepohl (1996), VAR analizine dayanan nedensellik testinin kullanılabileceğini belirtmektedir. TY modeline benzer şekilde, en uygun seçim uzunluğu kriterlerine göre bir VAR(p) modeli belirlenir. Daha sonra, model harici bir gecikme VAR$(p+1)$ eklenerek tahmin edilir ve WALD testi uygulanır. Tüm nedensellik testlerinde olduğu gibi, bu yaklaşımda en uygun uzunluğu belirlemek çok önemlidir. VAR modelinin gecikme uzunluğu Akaike Bilgi Kriteri (AIC) tarafından 2 olarak belirlenmiştir ve diğer tüm bilgi kriterleri bu gecikme uzunluğunu desteklemektedir.

VAR Uzunluk Seçim Kriterleri

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-3204.287	NA	4.60e+36	95.769	95.90	95.821
1	-2500.595	1302.356	5.59e+27	75.241	**75.899***	75.5020
2	-2469.539	**53.768***	**3.59e+27***	**74.792***	75.976	**75.260***
3	-2460.679	14.281	4.50e+27	75.005	76.716	75.682

4	-2445.459	22.717	4.72e+27	75.028	77.266	75.914
5	-2437.012	11.597	6.17e+27	75.254	78.018	76.347
6	-2420.379	20.853	6.46e+27	75.235	78.525	76.537
7	-2405.067	17.368	7.23e+27	75.255	79.072	76.766
8	-2385.178	20.185	7.34e+27	75.139	79.483	76.858

* kriterlere göre gecikme sırası seçimini gösterir.

LR sıralı olarak değiştirilmiş LR test istatistiğidir (her test %5 seviyesinde), FPE nihai tahmin hatasıdır, *AIC* Akaike bilgi kriteri, *SC* Schwarz bilgi kriterid ve *HQ* Hannan-Quinn bilgi kriteridir.

VAR (2) modeli tahmin edildikten sonra, bir dış gecikme VAR (3) eklenerek model tahmin edilir ve nedensellik testi yapılır.

Dolado-Lütkepohl Nedensellik Test Sonuçları

Nedensellik	Chi-Square	Olasılık
$Elect \rightarrow LGDP$	15.18365	0.0005
$Cap \rightarrow LGDP$	7.383836	0.00249
$Cap \rightarrow Emp$	4.981015	0.0829

Yukarıdaki tablo elektrik tüketiminden gerçek GSYİH'ya uzanan bir nedensellik olduğunu göstermektedir, çünkü olasılık %5'ten düşüktür, yani null hipotezin reddedilebileceği anlamına gelir. Sermaye oluşumu ile reel GSYİH arasında da nedensellik testi gerçekleştirilmiş ve tek yönlü bir nedensellik sonucu bulunmuştur. Sermaye ile istihdam arasında da tek yönlü bir nedensellik vardır. Bu sonuç, sermaye birikiminin ülkelerin GSYİH büyüme ve gelişmesinde önemli bir faktör olduğunu doğrulamaktadır.

Sonuç

Bu çalışma, 1990-1998 döneminde ARDL modeli panel veri analizini kullanarak dört Orta Asya ülkesi, Kazakistan, Kırgızistan, Tacikistan ve Özbekistan, için reel GSYİH'nın belirlenmesinde enerji, istihdam ve altyapı yatırımlarının etkisini incelemiştir. Test sonuçlarından, reel GSYİH ile enerji kullanımı arasında ters bir ilişkinin var olduğu, ancak reel GSYİH ile istihdam ve altyapı yatırımları arasında pozitif bir ilişkinin var olduğu gözlemlenmiştir.

Bu çalışmada Dolado-Lütkepohl nedensellik yaklaşımı, değişkenler arasındaki nedenselliği gözlemlemek için, kullanmıştır. Bulgular, enerji kullanımı ile reel GSYİH arasında tek yönlü bir nedensellik olduğunu, yani enerji kullanımından gerçek GSYİH'ya giden bir nedensellik olduğunu göstermektedir. Altyapı yatırımları ile reel GSYİH arasında da başka bir nedensellik testi yapılmış ve tek yönlü bir nedensellik sonucu bulunmuştur. Bu sonuç, altyapı yatırımlarının, ülkelerin GSYİH büyüme ve gelişmesinde önemli bir faktör olduğunu doğrulamaktadır.