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HARMONY IN TRANSITION: ASSESSING THE ENVIRONMENTAL LANDSCAPE OF ECONOMIC CHANGE IN CENTRAL ASIA

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Abstract
The transition from centrally planned economies to market-based systems in Central Asian countries during the 1990s had profound environmental implications. In 2021, these nations, including Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan, marked the 30th anniversary of their independence from the Soviet Union. This transition brought about significant political, social, and economic changes but also resulted in environmental challenges.
This study investigates the environmental consequences of Central Asia's shift from a command-based economy to a market-oriented one. Despite a notable decrease in carbon emissions since 1990, the region still contributes approximately 15 percent of global greenhouse gas emissions. The main drivers of increased CO_2 emissions include economic reforms, rising energy consumption, shifting consumption patterns, and environmental policies.
To mitigate CO_2 emissions, a transition away from solid fuels towards greater reliance on renewable energy sources is essential. This research employs various econometric methods, including unit root tests, cointegration analyses, and causality tests, to explore the relationship between economic reforms and CO_2 emissions in Central Asia. The findings reveal the complex dynamics at play and provide insights into policy measures needed to curb emissions and address environmental degradation in the region.

Keywords: Central Asia, market economy transition, environmental challenges, carbon emissions, renewable energy.

1. Introduction

The beginning of the 1990s marked the end of command-based policies in the former Soviet Union. In the 1990s, Central Asian countries, like the former communist countries, went through many difficult periods of economic transition, such as skyrocketing inflation, partial industrialization, and the collapse of the former Soviet welfare system. In 2021, five Central Asian countries - Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan - will celebrate the 30th anniversary of their independence after the collapse of the Soviet Union. These countries have entered an era of market economic reform, consisting of a wide range of political, social, and economic changes. The transition process in these countries led to the environmental degradation that occurred during the command-based regimes in these countries. We are pleased to examine the environmental challenges facing the Central Asian region as a result of the transition from a centrally planned economy to a market economy. Central Asia is a landlocked country with a 28-year history of historical heritage, including communist rule and central planning. Moreover, Central Asia remains a relatively underdeveloped topic compared to other regions. Turkmenistan and Uzbekistan have not yet completed their transition to a market economy. Kazakhstan and Turkmenistan are at the top of the list of middle-income countries, while Kyrgyzstan, Tajikistan, and Uzbekistan are in the category of low- and middle-income countries (Batsaikhan and Marek, 2017). Although carbon emissions have declined significantly since 1990, the transition to a transition economy in Central Asia still accounts for about 15 percent of global GHG emissions. For example, the region still includes Turkmenistan, Uzbekistan, and Kazakhstan, the world's most carbon-intensive countries, and has a wide range of environmental improvements. The increase in CO2 emissions is due to economic reforms in Central Asia, economic growth, changes in energy consumption patterns, and environmental policies (Pomfret, 2012). However, the impact of economic reforms and other underlying factors on CO2 emissions in Central Asia remains unclear in current studies. To reduce CO2 emissions, it is necessary to reduce the use of solid fuels, which are the primary emission factor. Therefore, increasing the share of renewable energy as part of the energy mix could reduce GHG emissions to some extent.

The following econometric methods were used in this study. An empirical analysis, Augmented DickyFuller (Fisher ADF), Philips Perron-Fischer Chi-square (Fisher PP), and Levin-Lin-Chu (LLC)methods were used to test unit root tests based on research data. In terms of static properties, the results of Cross-Sectional Augmented Dickey Fuller (CADF), Cross-Sectional Im, Pesaran and Shin (CIPS) were used to identify the primary differences between the variables, while Pedroni (2004) and Kao (1999) dynamic panel cointegration analyzes examined the equilibrium between the study variables in Central Asia. Also, a panel unit root test with an added structural break was performed to see the structure break. Panel non-stationary results show that the crosssections of the variables are correlated with the Breusch and Pagan (1980)Lagrange multiplier (LM) and Pesaran Scaled LM tests. The Pesaran cross-sectional dependence (CD) test shows strong CD in the variables of the models. The Pool Mean Group (PMG) Panel Autoregressive Distributive Lag(ARDL) and Robust least squares (MM-estimation) were used to calculate the longrun coefficient. Finally, the Dumitrescu and Hurlin (2012)Granger causality test was used to examine causality among variables.

The purpose of this article, then, is to study investigating the causal relationship between non-renewable and renewable energy consumption, CO2 emissions, economic growth, and population in Central Asia. Behind this, the study raises two policy questions. First, is the main cause of CO2 emissions in Central Asia due to the burning of solid fuels? Second, how is renewable energy contributing to environmental change in Central Asia? To answer these questions, the study examines whether the process of burning fossil fuels is the primary cause of global CO2 emissions. This study examines the relationships between non-renewable and renewable energy consumption, CO2 emissions, and economic growth in Central Asian countries, using 1992 to 2019 panel data from the WDI. The article is divided into six sections. Following this introduction in Section 1, there is a review of related literature in Section 2. Section 3 discusses the methodology and data. Section 4 examines the data analysis. Section 5 is the discussion of the findings, while Section 6 concludes with some recommendations and suggestions for future research.

2. Literature Review

The empirical literature on the relationship between CO2 emissions, economic growth, disaggregated energy (fossil fuel and renewable) consumption, and population economic growth is large and is beyond the scope of this paper to review extensively. Previous global panel studies on the relationship between energy consumption, energy growth, and environmental degradation such as Riti et al., (2017) examine the impacts of energy use and financial development indicators by the source in the environment-growth-energy model for 90 countries categorized based on income possession over the period 1980 to 2014. The study applies the panel analysis that accounts for cross-sectional dependence and heterogeneity of series used in the estimation. Results from panel Dynamic Ordinary Least Squares (DOLS) show that in all the categories of countries, fossil fuel energy use and gross domestic product (GDP) per capita are found to be the major drivers of CO2 emissions through fossil fuel energy use possesses the bigger elasticities. Population, however, displays a sign contrary to expectation regarding economic theory in high-income countries. Renewable energy and financial development on the other hand are capable of reducing CO_2 emissions. However, the magnitude of the longrun elasticity of CO_2 emissions concerning renewable energy use and financial development are much greater in the models with M2/GDP than the model with M2/Reserve, especially in the high-income countries. Also, Wan et al., (2018) showed the global energy interconnection (GEI) has more and more profound influence around the world, which is a highly practical way for humans to handle the energy crisis. In the studies of GEI, the economic dispatch is a basic and important content. In this paper, a model of dynamic economic dispatch of GEI is presented, which includes renewable energy generation. The objective function of this model is composed of the operating costs and the renewable energy curtailment.

In most of the regional panel analyses that examined the environment-growth-energy, their results indicate that energy consumption, particularly non-renewable energy consumption, contributes to CO_2 emissions (Amin et al., 2020;Bajra et al., 2020;Boubellouta and Sigrid, 2021;Cheng et al., 2021;Nepal et al.,2017;Pala, 2020;Pomfret, 2012;Taghizadeh-Hesary et al., 2020). For example, Nepal et al., (2017) examine the impacts of market-based economic reforms on per capita CO_2 emissions in the European and Central Asian transition economies where environmental degradation was pervasive prior reforms. A dynamic panel data model is employed for this purpose for 28 countries covering 22 years from 1990 to 2012. Their results suggest that reforms in competition policy and corporate governance are the significant driver of emissions reductions in the region. Therefore, advances in competition policy and governance reforms are desirable given the available scope to extend these reforms. Besides, Cheng et al., (2021) show first investigate the direct impacts and moderating effects of technological innovation, measured by the development of patents on CO_2 emissions by employing a balanced panel dataset for 35 Organization for Economic Co-operation and Development (OECD) countries covering 1996 to 2015. Also, to examine the potential heterogeneity and asymmetry, the panel quantile regression approach is utilized. The empirical results indicate that technological innovation directly reduces CO_2 emissions; however, this impact is significantly heterogeneous and asymmetric across quantiles. Furthermore, through analyzing the influencing mechanism, technological innovation affects the impacts of economic growth and renewable energy through its moderating effects.

Many studies have been conducted on the relationship between energy consumption, CO_2 emissions, and economic growth for different individual countries. The empirical literature abounds with studies that investigate the environmental effects of energy use and economic growth for both developed and developing countries using different datasets, model specifications, methodologies, and functional forms. Several of these panel studies inform this article's approach. For example, Corradini (2021) explored the relationship between institutional quality and economic growth across a panel of ItalianNomenclature of Territorial Units for Statistics(NUTS-3) regions. Estimates from panel vector autoregressions provide robust evidence in support of a causal effect of institutional quality on growth. This is found to be particularly important in areas characterized by lower levels of economic development. Conversely, no evidence is found of reverse dynamics of economic growth on institutional quality. The results cast doubts on the view that policies focusing on economic growth per se may lead to a strong institutional context, suggesting intervention aimed at improving formal institutions to be a prerequisite for sustained regional development. For China, Hao et al., (2021) showed the interrelationship between income inequality, fiscal decentralization, and public health is investigated within a comprehensive research framework for the first time. Using the panel data of 23 Chinese provinces for a period between 2002 to 2012, a carefully designed simultaneous equation model is used to control for potential endogeneity. The estimation results indicate that higher income inequality has a significant negative impact on public health performance. Interestingly, fiscal decentralization has negative direct and indirect effects on public health. For India, Tiwari et al., (2021) examine the direction of the Granger-causal relationship between electricity consumption and economic growth at the state and sectoral levels in India. In doing so, the panel cointegration tests with the structural break, the heterogeneous panel causality test, and the panel Vector Auto Regression (VAR) based impulse-response model are employed. The study covers overall economic growth and growth in agricultural and industrial sectors for eighteen major Indian states for the period 1960 to 2015. The results provide evidence in support of a longterm relationship between economic growth and electricity consumption only in the agriculture sector. Further, the results provide evidence for the presence of unidirectional Granger causality flowing in the direction of overall economic growth to electricity consumption at the aggregate state level.

An overview of the Central Asian countries (multi-country) literature on the Granger causality (Granger, 1969) and VAR methodology (Sims, 1972) that plethora of survey around (Ashurov et al., 2020;Batsaikhan and Marek, 2017;Bird et al., 2020;Nurseiit, 2020;Rosenbaum et al., 2012). For example, Ashurov et al., (2020) investigated and identified the determinants of foreign direct investment (FDI) in the Central Asian countries, specifically Tajikistan, Kazakhstan, Kyrgyzstan, Turkmenistan, and Uzbekistan, between 2000 to 2017. The methodology employed in the first part included a comparative analysis of the foreign investment trends and GDP, as well as an endogenous growth model. The result showed that five variables are robustly significant of FDI determinants: FDI, GDP, labor force, trade openness, and tax. Additionally, this paper demonstrates that among the most significant FDI contributors are China, Russia, and Japan as well as European countries because of the economic opportunities available; however, the USA is considered by Central Asian countries to offer the most opportunities for security control considerations rather than economic opportunities.

Only a few studies have included Kazakhstan in Central Asia in their CO_2 analysis. To the best of our knowledge, there has not been a time-series study investigating the causal relationship between energy consumption, CO_2 emissions, and economic growth in Central Asia. As a resource-rich country, Kazakhstan has been characterized by a considerable achievement in economic growth and it has been passed through different development stages (Azamat et al., 2018;Bolor-Erdene, 2020;Russell et al., 2018;Wang et al., 2019). For example, Wang et al., (2019) construct production-based CO_2 emission inventories for Kazakhstan from 2012 to 2016, and then further analyses the demand-driven emissions within the domestic market and international trade using environmentally extended input-output analysis. The production-based inventory includes 43 energy products and 30 sectors to provide detailed data for CO_2 emissions in Kazakhstan. The consumption-based accounting results showed that certain sectors like construction drive more emissions and that the fuel consumption in different sectors varies. Furthermore, Russia and China are major consumers of Kazakhstan's energy and associated emissions, with the construction sector playing the most important role in it. The results suggested that both technology and policy actions should be taken into account to reduce CO_2 emissions and that the Belt and Road Initiative is also a good chance for Kazakhstan to develop aGreen Economy.

3. Methodology and Data

The present article follows from this literature on energy consumption. It seeks to extend knowledge on this topic and underline the roles of renewable and non-renewable energy consumption on carbon emissions, using a broad range of the latest data. The key contribution of the present research to the existing literature will be to shed light on and quantify the impact of energy consumption, economic growth, and natural resources on carbon emissions in Central Asian countries.

3.1. Source of Model and Data

The purpose of this section is to examine the relationship between energy consumption (renewable and nonrenewable), CO_2 emissions, and economic growth in Central Asian countries between 1992 and 2019. It adopted the Panel Autoregressive Distributive Lag (ARDL), Panel Vector Auto Regression (PVAR), Vector Error Correction Model (VECM), and Panel Granger (1969) causality methodologies and reports some findings.

$$CO_{2t} = (REC, FEC, GDP, POP, \omega) \quad (1)$$

The model is then converted to a natural logarithm to bring the data to the same units, reduce the variance as well as interpret the coefficients in terms of elasticities.

$$lnCO_{2it} = \alpha_0 + \beta_1 lnREC_{it} + \beta_2 lnFEC_{it} + \beta_3 lnGDP_{it} + \beta_4 lnPOP_{it} + \omega_{it} \quad (2)$$

Where, ω and ω_{it} is the error term for Equation (1) and (2).

$q \quad q \quad q$

$$\Delta y = \alpha 0 + \beta 2xt-1 + \beta 3yt-1 + \beta 4zt-1 + \gamma i \Delta xt-1 + \delta i\, \Delta yt-j + s\Delta zt-k + \omega \quad (3)$$

$i=1 \quad j=0 \quad k=0$

Where t is time period, α_0 is constant, β_t is drift component x,y,z are the independent variables and ω_i represents white noise error processes. The parametersγ, and are short run dynamic coefficients. The ARDL approach estimates $(q+1)^k$ the number of regressions necessary in order to obtain optimal lag length for each variable, where q refers to the maximum number of lags used;and k to the number of variables in Equation (4). If cointegration exists among the variable, then the error correction model (ECM) can be represented by the following.

$$\Delta y_t = \sum_{i=1}^{q} \gamma_i \Delta x_{t-1} + \sum_{j=1}^{q} \delta_i \Delta y_{t-j} + \sum_{k=1}^{q} {}_k \Delta z_{t-k} + \omega_i \quad (4)$$

To study the impacts of non-renewable and renewable energy consumption, economic growth, and natural resource depletion in CO_2 emissions, panel data for Central Asian Countries was used, covering28 years. The data were retrieved from the World Development Indicators (WDI).

The study uses Carbon emissions (CO_2) as a dependent variable, measured by annual per capita carbon dioxide emissions in metric tons.

Renewable energy consumption (REC) is measured by annual per capita renewable energy consumption in kilograms of oil equivalent. The author hypothesizes that renewable energy consumption reduces carbon emissions.

For fossil fuels, energy consumption (FEC), annual per capita fossil fuels energy consumption in kilograms of oil equivalent per capita was used. The author hypothesizes that fossil fuel consumption contributes to carbon emissions.

Gross domestic product (GDP) per capita in constant 2010 US dollars is applied for economic growth. According to the hypothesis, economic growth contributes to carbon emissions in Central Asian countries.

Population (POP), a total of Central Asian population. As a result, the hypothesis is more people use more energy use and increases carbon emissions. For the estimates of the coefficient of the variables, the following empirical model is formulated. Stata 16.0 econometrics software was used for the analysis.

3.2 Unit Root Tests

The descriptive statistics and correlation matrix in Table 1 show the logarithmic variable data. The simplest study of data properties begins with a study of relative averages, variances, Jarque-Bera, Skewness, and Kurtosis of the data.

Table 2 presents the overall mean values and units of measure for the 28 years of the survey between 1992 to 2019. The author performed unit tests using the variables included in the regression section using FisherAugmented Dickey-Fuller (ADF), Philips Perron-Fischer Chi-square (Fisher PP), and Levin, Lin, and Chu (LLC) panel unit root tests at a significance level of 1%, 5%, and 10%.

3.3 Panel GrangerCausality Test

Although the Panel GrangerCausality test is preferable in verifying the existence of the long run among the variables, it does not explain the direction of a cause-effect relationship. Therefore, Panel VECM is used (Pesaran et al., 1999). The Vector Auto Regression (VAR) model is also available for this purpose.Granger (1969)noted that if a set of variables is co-integrated, there must be a short and long run causality that cannot be captured by the standard first difference VAR model. The VECM shows the reason within the sampleand does not explain the reason outside the sample. In this case, the author must implement the Granger causality test with the VECM framework as follows:

$$\Delta CO_{2_t} = \alpha_1 + \sum_{k=1}^{q} \gamma_{1k}\, \Delta CO_{2_{t-k}} + \sum_{k=1}^{q} \delta_{1k}\, \Delta REC_{t-k} + \sum_{k=1}^{q} {}_{1k}\, \Delta FEC_{t-k} + \sum_{k=1}^{q} \varphi_{1k}\, \Delta GDP_{t-k} + \sum_{k=1}^{q} \mu_{1k}\, \Delta POP_{t-k} + \omega_{1t} \quad (5)$$

$$\Delta REC_t = \alpha_2 + \sum_{k=1}^{q} \gamma_{2k}\, \Delta CO_{2_{t-k}} + \sum_{k=1}^{q} \delta_{2k}\, \Delta REC_{t-k} + \sum_{k=1}^{q} {}_{2k}\, \Delta FEC_{t-k} + \sum_{k=1}^{q} \varphi_{2k}\, \Delta GDP_{t-k} + \sum_{k=1}^{q} \mu_{2k}\, \Delta POP_{t-k} + \omega_{2t} \quad (6)$$

$$\Delta FEC_t = \alpha_3 + \sum_{k=1}^{q} \gamma_{3k}\, \Delta CO_{2_{t-k}} + \sum_{k=1}^{q} \delta_{3k}\, \Delta REC_{t-k} + \sum_{k=1}^{q} {}_{3k}\, \Delta FEC_{t-k} + \sum_{k=1}^{q} \varphi_{3k}\, \Delta GDP_{t-k} + \sum_{k=1}^{q} \mu_{3k}\, \Delta POP_{t-k} + \omega_{3t} \quad (7)$$

$$\Delta GDP_t = \alpha_4 + \sum_{k=1}^{q} \gamma_{4k}\, \Delta CO_{2_{t-k}} + \sum_{k=1}^{q} \delta_{4k}\, \Delta REC_{t-k} + \sum_{k=1}^{q} {}_{4k}\, \Delta FEC_{t-k} + \sum_{k=1}^{q} \varphi_{4k}\, \Delta GDP_{t-k} + \sum_{k=1}^{q} \mu_{4k}\, \Delta POP_{t-k} + \omega_{4t} \quad (8)$$

$$\Delta POP_t = \alpha_5 + \sum_{k=1}^{q} \gamma_{5k}\, \Delta CO_{2_{t-k}} + \sum_{k=1}^{q} \delta_{5k}\, \Delta REC_{t-k} + \sum_{k=1}^{q} {}_{5k}\, \Delta FEC_{t-k} + \sum_{k=1}^{q} \varphi_{5k}\, \Delta GDP_{t-k} + \sum_{k=1}^{q} \mu_{5k}\, \Delta POP_{t-k} + \omega_{5t} \quad (9)$$

The symbols, From Equations (5) – (9), where Δ is the first difference operator and ln is the natural logarithm. Where, α_1 to α_5 is the value of the model at its mathematical origin known as the constant. k to q is the lag length estimated on the basis of likelihood ratio analysis. The parameters γ,,,φ and μ are short run dynamic coefficients while the parameters β_1 to β_5 function as the long run multipliers of the underlying panel ARDL model. The residuals ω_{it} assumed to be normally distributed, are white noise. It shows model convergence to long run equilibrium path in case of disturbance in the short run.

3.4 Panel Cointegration Test

In this section, Given the fact that the individual variables are integrated of the first order, the divergent panel cointegration analysis set-forth by
(Pedroni, 2004) possibly takes into account the profile mutual dependence with separate individual effects. Therefore, the Pedroni cointegration test is used for comparison purposes and thus robustness, and the Kao (1999) cointegration test is also employed. The Pedroni cointegration test suggests seven statistics, divided into two categories: panel test statistics and group test statistics. The first category is based on the 'within dimension method' and consists of four test statistics, namely panel v-statistic, panel-rho, panel PP-statistic, and panel ADF-statistic. The second category is based on the 'between dimension method' and includes three test statistics, namely group rho-statistic, group PP-statistic, and group ADF statistic. For all these statistics, the null hypothesis assumes there exists no cointegration relationship among the variables, while the alternative hypothesis assumes there is a cointegration relationship.

3.5 Panel Non-Stationarity Test

The Cross-Sectional Augmented Dickey-Fuller (CADF), Cross-Sectional Im, Pesaran and Shin (CIPS) tests, as proposed by Pesaran (2007) LM panel unit root test, are used for checking the stationary properties of the variables. Both of the tests incorporate a cross-sectional dependence assumption. So, the information regarding the stationary properties given by these tests is robust. The CADF and CIPS test mechanisms are also similar; however, the only exception is that CIPS considers the cross-sectional average of the CADF test. The following equation can be written in reflecting the standard ADF framework.

$$\Delta\chi_{it} = \alpha_i + \beta_i\chi_{i,t-1} + \rho_i T + \sum_{k=1}^{q} \vartheta_{ij}\chi_{i,k-1} + \omega_{it} \tag{10}$$

Δ T

Where, indicates the first differenced operator. χ_{it} is the objective variable; α_i and are the constant and time trend. ω_{it} is the error term. The null hypothesis is that individuals in the panel dataset are not stationary. An alternative for both tests is that at least one individual within the dataset is stationary.Since the variable's stationary properties may change in the presence of structural breaks, the author checks the stationary properties in the presence of structural breaks to ensure the previous stationary test results' robustness. The Author uses that the variables are inter-related within the cross-sections, as shown in the Breusch and Pagan (1980) LM, Pesaran Scaled LM, and Pesaran (2004) CD test. The test depends on a transformation procedure, which makes it invariant to the nuisance parameters. Therefore, it is more statistically robust than the conventional panel unit root tests when dealing with breaks in cross-sections.

3.6 Pool Mean Group Panel ARDL

The author uses the Pool Mean Group (PMG) panel ARDL model to investigate the relationships among the variables in a heterogeneous panel environment where the cross-sectional dependency issue is present. By keeping the longrun parameters constant across the countries and allowing the shortrun parameters to vary, this test provides a consistent longrun estimation of the variables than the traditional panel estimators (Pesaran et al., 1999). Furthermore, the capacity for incorporating the mixed order of integration makes this test stronger than the other estimation methods.

$$\chi_{it} = \sum_{j=1}^{p} \lambda_{ij} \chi_{i,t-1} + \sum_{j=0}^{q} \vartheta_{ij} \chi_{i,t-j} \mu_i + \omega_{it} \quad (10)$$

The model p and q can be specified by the following equation. χ_{it} is the objective variable; ω_{it} is the error term. The parameters λ_{ij} and ϑ_{ij} are long run dynamic coefficients. Where, $\mu_i$needs to be large enough to be utilized for each group. Therefore, in this study, the author will only look at the longrun estimation results.

3.7 Dumitrescu and Hurlin Granger Causality Test

The author uses the Dumitrescu and Hurlin (2012) causality test to check the concerned variables' causality. Therefore, to verify the direction of causality, the author employed the Dumitrescu and Hurlin heterogeneous panel causality test that takes into account the heterogeneity of both the regression model and the causal relationship. In other words, this test allows for the alternative hypothesis that a subgroup of individuals may have a causal relationship while other sub-groups may not have it. Essentially, acceptance of the null hypothesis will imply that a variable does not Granger causality another variable for all the panel units while the rejection of the null will imply that a variable Granger causality another variable for all the panel units. This test explores the short-term dynamic bivariate panel causalities among study variables. Across the cross-sectional units, the test accommodates a dissimilar lag structure and unrestricted heterogeneous coefficients.

4. Result and Discussion

4.1 Unit Root Tests Result

The descriptive statistics and the correlation matrix of the variables are provided in Table 1, respectively. A look at the descriptive analysis shows that the investigated variables display some insignificant variances in the statistics. The average and standard deviation values of CO_2 emissions are 1.1463 and 1.2693 respectively. The average and standard deviation values of REC stand at 0.9910 and 2.7212 respectively. FEC, GDP, and POP use have mean values of 4.3484, 23.5343, and 16.0636 respectively, while the respective standard deviations are 0.3525, 1.3393, and 0.6847 respectively. The large standard deviations of the variables are indications of large variations of the values around their averages, hence, large disparities. To test the distribution properties of these variables, the study uses Jarque-Bera, Skewness, and Kurtosis as indicators. In a normal distribution Kurtosis is 3, and skewness is 0. In what follows, more properties of these variables are presented. The correlation coefficient between CO_2 emissions and REC is 0.7970, implying that the relationship between CO_2 emissions and REC is 79.7% in a positive direction. The relationship between CO_2 emissions and FEC is approximately strongly by 92.09%, while the relationship between CO2 emissions and GDP and POP are approximately 80.01% and 31.55%. The correlation coefficient of FEC and GDP by 0.6866 (68.66%). The results show that CO_2 emissions are weakly correlated with REC, FEC, GDP, and POP.

Table 1: Descriptive statistics and correlation matrix

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Variable	$lnCO_2$	$lnREC$	$lnFEC$	$lnGDP$	$lnPOP$
Mean	1.1463	0.9910	4.3484	23.5343	16.0636
Std. Dev.	1.2693	2.7212	0.3525	1.3393	0.6847
Minimum	-1.2286	-6.3200	3.5246	21.4874	15.1765
Maximum	2.7689	4.1683	4.6051	26.0857	17.3295
Variance	1.6112	7.4048	0.1242	1.7936	0.4687
Skewness	-0.4210	-0.8108	-1.1483	0.2330	0.4548
Kurtosis	1.8110	2.0624	2.8063	1.8224	1.6342
Jarque-Bera	12.38	15.36	30.99	9.355	15.71
$lnCO_2$	1.0000				
$lnREC$	-0.7970	1.0000			
$lnFEC$	0.9209	-0.7349	1.0000		
$lnGDP$	0.8001	-0.4458	0.6866	1.0000	
$lnPOP$	0.3155	0.0278	0.3699	0.7140	1.0000

Notes: All variables are expressed in their logarithms, Std. Dev.=standard deviation. Source: Compiled by the author based on World Bank data (1992-2019).

The results of the unit root tests are reported in Table 2. Given that author is considering a relatively long panel, the stationarity of the variables needs to be assessed. Toward this end, we performed a panel unit root test, namely the Fisher-Augmented Dickey-Fuller (Fisher ADF) test. Two additional tests were performed for robustness, namely, the Philips Perron-Fischer Chi-square (Fisher PP) and Levin, Lin, and Chu (LLC) panel unit root tests. Also, the results of the Fisher ADF test and robustness checks are presented in Table 2. Each test was performed on variables at levels and first differences.

Table 2: Unit root tests

Variable	Fisher ADF	Prob.	Fisher PP	Prob.	LLC	Prob.	Stationarity
$lnCO_2$	11.3950	0.3276	4.3901	0.0000	0.6361	0.7376	NO
$\Delta lnCO_2$	113.327	0.0000	19.0971	0.0000	-6.2869	0.0000	YES
$lnREC$	25.8615	0.0039	0.7176	0.7635	-1.2659	0.1028	NO
$\Delta lnREC$	114.343	0.0000	23.3879	0.0000	-6.6692	0.0000	YES
$lnREC$	27.2933	0.0023	7.4753	0.0000	-1.5834	0.0567	YES
$\Delta lnREC$	139.212	0.0000	23.9918	0.0000	-4.9822	0.0000	YES
$lnGDP$	0.0464	1.0000	1.5849	0.0565	0.2948	0.6159	NO
$\Delta lnGDP$	29.505	0.0010	7.6215	0.0000	-8.3847	0.0000	YES
$lnPOP$	0.4795	1.0000	15.8998	0.0000	5.38	1.0000	NO
$\Delta lnPOP$	20.843	0.0222	0.4659	0.3206	-5.9494	0.0000	YES

Source: Compiled by the author based on World Bank data (1992-2019).

4.2 Panel GrangerCausality Rest Result

Table 3 shows the significance levels for FEC, REC, GDP, and POP for short and longrun analyzes. Coefficient integration of FEC, REC, GDP, and POP expressed in CO_2 emissions is based on cointegration among variables. The sign of the coefficient of FEC is negative in the short run but turns out to be positive in the long run. A 1% increase in FEC contributes 10.16% to CO_2 emissions in a positive direction. The longrun analysis shows that a 1% increase in FEC contributes to a 2.226% rise in CO_2 emissions. The longrun analysis shows that a 1% increase in fossil fuel energy consumption contributes to a 0.276% rise in CO_2 emissions. This notion shows efficiency and technological change in the process of production and consumption in the long run. REC impacts are negative by reducing emissions and ensuring environmental quality. A 1% increase in renewable energy consumption decreases emissions by 0.172 and 0.104% in the short and long run, respectively. The plausibility of the findings lies with the sign and significance of the coefficient of renewable energy consumption both in the short and long runs. The negative and statistical reliability of the renewable energy factor has shown that it contributes to the reduction of GHG emissions and, consequently, to climate change. The finding that renewable energy reduces GHG emissions is in line with the efforts by each countries Ministry of Environment and Water Resources of the Central Asian governments to reduce the incidence of climate change impacts in the country. This effort gave rise to the renewable energy program initiated in the country. A 1% increase in POP contributes 3.321% to CO_2 emissions in the negative direction. The longrun analysis shows that a 1% increase in POP leads to a 3.905% rise in CO_2 emissions. A has a negative sign and is statistically reliable, but the short circuit current equals 16.02%. Economic growth (GDP) effects on the environment (CO_2 emissions) on the other hand show a diminishing trend from the short run to the long run. In the short run, a 1% increase in GDP will result in a 0.0409% increase in CO_2 emissions. However, in the long run, the effect of GDP increased from 0.0409 to 2.382 percent. Overall, the analyses of the short and long run confirm the dynamic interaction of the variables and agreed with the energy-growth-environment-led thesis where FEC, GDP, and POP lead to environmental degradation while REC ensures environmental quality. Higher energy consumption tends to increase emissions from non-renewable sources, while renewable energy and clean energy can reduce emissions.

Table 3: Panel GrangerCausality test result

Dependent variable: $lnCO_2$				
Variables	Coefficient	Standard error	z	Probability
Long run elasticities				
$lnREC$	0.104*	0.0434604	2.39	0.017
$lnFEC$	2.226***	0.5635583	3.95	0.000
$lnGDP$	2.382***	0.307141	-1.63	0.103
$lnPOP$	3.905**	1.436103	2.72	0.007
Short run elasticities				
Constant	-0.276*	0.1238026	-2.23	0.026
$\Delta lnREC$	-0.172*	0.0774787	-2.22	0.026
$\Delta lnFEC$	10.16	10.88702	0.93	0.351
$\Delta lnGDP$	-0.0409	0.2567712	-0.16	0.873
$\Delta lnPOP$	3.321	5.625534	0.59	0.555
$ECT_{(-1)}$	-16.02*	7.074501	-2.26	0.024

*, ** and *** indicate significant of the variables at 1, 5 and 10% significance level. Source: Compiled by the author based on World Bank data (1992-2019).

4.3 Panel Cointegration Test Result

The results of both the Pedroni (2004) and Kao (1999) Residual Cointegration Test are presented in Table 4. Regarding the Pedroni test, the results indicate that for both models, statistic and weighted statistics from Panel PP Statistic, Panel ADF statistic, Group PP statistic, and Group ADF statistic tests are statistically significant at 1%. Since at least four statistics reject the null hypothesis of no cointegration, the Pedroni cointegration test supports the existence of longrun cointegration relationships between the variables under study. Likewise, the Kao Residual cointegration test also shows that for every case of opportunity cost at the significance level of 1%, the hypothesis of no difference in the absence of a longrun relationship is rejected. And for every case p-value of 0.451 for Central Asian countries respectively which are highly significant, they provide firm information that the factors have a longrun relationship, hence, cointegrated. Therefore, overall evidence from the Pedroni and Kao tests for cointegration show that cointegration exists between the explained variable and the explanatory variables in the selected countries based on income possession.

Table 4: Result of Kao and Pedroni cointegration tests.

	Statistic	Prob.
Kao test	0.1212*	0.451
Within-Dimension		
Panel v-statistic	-0.6394	0.386
Panel rho-statistic	-0.1246	0.478
Panel PP Statistic	-1.1524*	0.021
Panel ADF statistic	-0.7488*	0.070
Panel v-statistic (weighted statistic)	0.2878	0.995

Panel rho-statistic (weighted statistic)	0.0529	0.873
Panel PP-statistic (weighted statistic)	-2.0258	0.489
Panel ADF-statistic (weighted statistic)	-1.4746	0.868
Between- Dimension		
Group rho-statistic	0.6647	0.411
Group PP statistic	-0.6826*	0.025
Group ADF statistic	-0.3075*	0.007

*indicate significant of the variables at 1% significance level, respectively.Source: Compiled by the author based on World Bank data (1992-2019).

4.4 Panel Non-Stationarity Test Result

This study uses the panel non-stationary tests is important to note that the CADF and the CIPS analyses generate consistent outcomes in the absence of independence of cross-sections and heterogeneity across Central Asian countries in the panel. Likewise, these results also endorse the use of Pesaran (2007) CIPS and CADF unit root tests. Both CIPS and CADF have been run using only intercept as well as constant and trend. This test has the advantage of incorporating the smooth structural break as well as endogenous sharp structural breaks. The evidence from the CIPS tests reported in Table 5 shows that all variables have a unit root, while results from the CADF test show that all variables are stationary.

Table 5: CADF and CIPS panel unit root test

		CADF		CIPS	
VAR	Deterministic	$I(0)$	$I(1)$	$I(0)$	$I(1)$
$lnCO_2$	Trend &Cons	-0.112	0.0824*	-3.3232	-5.2022*
$lnREC$	Trend &Cons	0.00359	-0.430**	-3.0691	-5.1721*
$lnFEC$	Trend &Cons	0.00326	0.0633***	-2.7646	-5.7069*
$lnGDP$	Trend &Cons	0.101	0.0424*	-6.0489	-2.5422*
$lnPOP$	Trend &Cons	0.127	0.000476*	-0.9403	-2.9503*

I(0) and I(1) stands for order of integration at level and on first difference.* and ** represent 1% and 5% levels of significance. Source: Compiled by the author based on World Bank data (1992-2019).

Table 6 shows that the variables are inter-related within the cross-sections, as shown in the Breusch and Pagan (1980)LM, Pesaran Scaled LM tests. Finally, Pesaran (2004) CD test shows strong cross-sectional dependence in the variables of the models. They strongly reject the null hypothesis of cross-section independence in the data series at a 1% significance level, thereby indicating that all the study variables are cross-sectionally dependent. The energy consumption across central Asian countries can respond to similar factors, like weather and macroeconomic growth-related shocks, a policy of subsidized energy supply in one country (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan) that is emulated by other countries, and global energy prices.

Table 6: Tests for CD for individual Variables.

	Breusch-Pagan LM	Pesaran Scaled LM	Pesaran CD
$lnCO_2$	1.6112***	170.68***	1.597***
$lnREC$	7.4048***	2.36***	2.861***
$lnFEC$	0.1242***	4.23***	0.422***
$lnGDP$	1.7936***	61.00***	16.293***
$lnPOP$	0.4687***	33.41***	14.956***

*** indicate significant of the variables at10% significance level, respectively.Source: Compiled by the author based on World Bank data (1992-2019).

4.5 Specification and Estimation (LongRun)

The results of the static specification (robustness check) using Pooled Ordinary Least Squares (POLS) and Robust least squares (MM-estimation) are presented in Table 7. The F-statistics over a short period show that there are one-way factors to the change in CO_2 emissions, FEC, and CO2 emissions to REC. In the case of shortrun distortion, the rate of longrun calibration of the CO_2 emissions equation is 0.0334%. The FEC equation, on the other hand, is speed setting, fluctuating around 0.000897% if the system shakes briefly. REC has a long consolidation rate of 0.0423%. POP and GDP impact rates are relatively low at 0.0221% and 0.0221%. The shortrun Granger presents the results of causation. Even FEC to CO_2 emissions is unidirectional. GDP and CO_2 emissions are bidirectional in the short run. Concerning the robustness checks, for all models, the panel POLS methods produce similar results, economically and statistically, compared to those obtained from MM-estimation, and all coefficients are statistically significant at 1% level. Specifically, the coefficients of GDP per capita and its square are positive and negative respectively in Central Asian countries. Furthermore, the same results regarding the credit to the private sector and population density in terms of the sign and the magnitudes of the estimated coefficients are found; this is another evidence of robust results. Also, the turning points are very similar to the points calculated with POLD and MM estimation. The turning points for all models and across all four estimators were within the GDP range of the sample. Renewable energy produces shortrun CO_2 emissions from renewable energy within a short run of time, showing growth forecasts. This means that renewable energy ensures environmental quality in favor of growth while fossil fuel energy ensures growth at the expense of the environment. Besides, with the increase in GDP, there is a tendency to increase energy consumption. Increasing energy consumption, furthering longrun economic growth in Central Asian nations, is increasing emissions.

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Table 7: Results of Pooled Mean Group Regression and MM estimation

PMG						
VAR	$lnCO_2$	$\Delta lnREC$	$\Delta lnFEC$	$\Delta lnGDP$	$\Delta lnPOP$	ECT_{t-1}
$lnCO_2$	-	-0.409	0.246***	0.176***	0.00875	-0.0334*
		(0.319)	(0.0306)	(0.0523)	(0.00731)	[-0.0168]
$lnREC$	-0.0306	-	-0.00766	0.00687	-0.00074	0.0423
	(0.0238)		(0.0102)	(0.0149)	(0.00201)	[-0.0623]
$lnFEC$	1.350***	-0.563	-	0.168	-0.0195	0.000897
	(0.168)	(0.75)		(0.127)	(0.0172)	[-0.00728]
$lnGDP$	0.455***	0.237	0.0788	-	0.0238*	0.0221***
	(0.135)	(0.515)	(0.0597)		(0.0116)	[-0.00087]
$lnPOP$	1.245	-1.412	-0.506	1.309*	-	0.0221*
	(1.04)	(3.823)	(0.444)	(0.641)		[-0.0104]
MM estimation						
$lnCO_2$	-	-0.897***	0.0351*	-0.203	0.0516**	3.593
		(-0.143)	(-0.0137)	(-0.119)	(-0.0177)	[-25.5]
$lnREC$	-0.550***	-	0.000682	-0.528***	-0.0341*	-22.94**
	(-0.0793)		(-0.00445)	(-0.0542)	(-0.0161)	[-1.697]
$lnFEC$	0.926***	-0.0844	-	-0.378**	-0.152***	14.92***
	(-0.114)	(-0.292)		(-0.118)	(-0.0169)	[-0.00728]
$lnGDP$	0.347	0.097	0.0902***	-	0.346***	-69.08***
	(-0.403)	(-0.159)	(-0.0123)		(-0.00838)	[-6.549]
$lnPOP$	-0.724	-0.985**	-0.0561**	1.721***	-	14.34***
	(-0.867)	(-0.335)	(-0.0174)	(-0.082)		[-1.94]

*, ** and *** indicate significant of the variables at 1, 5 and 10% significance level, respectively.Source: Compiled by the author based on World Bank data (1992-2019).

Dumitrescu and Hurlin Panel Causality Test Results

The study tests the causality between the variables. Since the relationship between the variables has been confirmed by using different panel data techniques. Now to determine the direction of the relationship, the causality test is essential. Dumitrescu and Hurlin (2012) Granger causality test is applied to test the causality among the observed variables. The empirical results of the test are reported in Table 8. Results reveal a strong feedback link between CO_2 and FEC. This indicates that the feedback hypothesis exists between CO_2 and FEC in Central Asian countries. On the other hand, in the energy sector, there is a one-way causal relationship between CO_2 grangercausality FEC and vice versa, implying that economic growth in the industrial sector increases electricity demand. They indicate the presence of a unidirectional causality between CO_2 and POP. Moreover, the results also provide a two-way causal relationship is found between CO_2 and GDP of Central Asian nations. It means CO_2 and GDP both affect each other.

Table 8: Dumitrescu and Hurlin Granger panel causality test results

	Wald-Stat.	Zbar-Stat.	Prob.
CO_2 does not cause REC	0.565***	8.2802	0.0000
REC does not	0.485*	2.2423	0.0249

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causeCO_2			
CO_2 does not cause FEC	0.731***	2.1468	0.0318
FEC does not causeCO_2	0.181	4.0741	0.0000
CO_2 does not cause GDP	0.589***	2.8551	0.0000
GDP does not cause CO_2	1.082***	2.5558	0.0000
CO_2 does not cause POP	0.752***	8.8164	0.0000
POP does not cause CO_2	0.959***	5.8838	0.0000

*, ** and *** indicate significant of the variables at 1, 5 and 10% significance level, respectively.Source: Compiled by the author based on World Bank data (1992-2019).

4. Discussions

In Central Asia, with a transition economy, market reforms have been successful for the past 30 years. The reform has successfully implemented the country's policy reforms but has not done enough to reduce CO_2 emissions per capita. Market reforms require higher energy consumption than in the previous planned economy. Therefore, the goal is to further reduce CO_2 emissions per capita. Kazakhstan, a leading Central Asian country, sees per capita CO_2 emissions that need to be reformed. As energy consumption in Central Asia remains mixed, central planning shows that the old polluting legacy of the economy is widespread. It is noteworthy that the use of raw coal is increasing. Kazakhstan, Turkmenistan, and Uzbekistan are rich in solid fuels, while the Kyrgyz Republic and Tajikistan are rich in hydropower. However, during the winter months, countries with abundant hydropower resources face energy shortages due to reduced water flow and increased heat demand. The system was originally designed to balance the uneven distribution of solid fuel resources in Kazakhstan, Turkmenistan, and Uzbekistan, and water resources in the Kyrgyz Republic and Tajikistan through electricity exchanges, but to move to a country that can more efficiently regulate carbon emissions. There is a need for coordination throughout Central Asia. This could reduce the use of energy resources that emit large amounts of carbon dioxide and further shift to a green energy system. With such an integrated system, water-rich countries can buy electricity from neighboring countries, which are rich in solid fuels in the winter, and exchange excess energy in the opposite direction in the summer. To implement this solution, these countries need physical infrastructures, such as a bulk transmission network and an administrative structure to streamline the market. In the case of the Central Asian Power Grid, the power grid, built during the former Soviet Union, can serve as an important basis for expanding energy trade and increasing regional energy security. However, the exchange of energy through the system, which was built in the 1970s, has gradually declined over the past few decades. However, the system, which connects Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan, can be used as a ready-made platform for regional energy security.

The Central Asian Energy Grid will help increase the share of renewable energy in the region's energy structure. Therefore, investing in renewable energy capacity could be an important option in reducing CO_2 emissions, especially among developing countries. To achieve the goal of reducing CO_2 emissions and mitigating climate change, policies should be pursued to encourage investment in renewable energy technologies. Likewise, reducing energy consumption through improved energy efficiency means reducing energy consumption per capita and emissions associated with its production. Therefore, it is necessary to implement policies aimed at reducing CO_2 emissions per capita over time, emissions taxes, and support for advanced technology to reduce emissions.

5. Conclusion and Recommendations

This study used annual panel data of Central Asian countries from the World Bank's World Development Indicators (WDI) for the period from 1992 to 2019. The carbon dioxide (CO_2) emissions in Central Asian countries are based on the longrun and shortrun relationship between renewable energy consumption, fossil fuels energy consumption, economic growth, and population with the Panel Granger Causality, Panel Cointegration, and Panel non-stationarity tried to explain using the causality test. The correlation matrix and descriptive statistics revealed that the panel data series lack the property of cross-sectional independence and homogeneity. An empirical analysis uses the Augmented Dicky-Fuller (Fisher ADF), Philips Perron-Fischer Chi-square (Fisher PP), and Levin-Lin-Chu (LLC) method to test the basics of the panel data unit based on this information. Longrun and shortrun causal relationships between the variables were performed in the error correction term augmented Granger causality experiment, which revealed longrun causality only during regression of CO_2 emissions. The increase in fossil fuel use in Central Asia is the main cause of CO_2 emissions. Our research hypothesis is therefore confirmed. Kazakhstan is a relatively large economy in the Central Asian region. Especially during the transition period, its economic growth has increased relatively rapidly and so have GHG emissions. The results of the analysis show that this use of fossil fuels has been harmful to the environment. The results from Cross-Sectional Augmented Dickey-Fuller (CADF), Cross-Sectional Im, Pesaran and Shin (CIPS)in Central Asian countries indicate stationarity of variables at first difference while Pedroni's and Kao's dynamic panel cointegration analyses reveal co-integrating equilibrium among the variables of interest in Central Asian countries. Panel non-stationarity result shows that the variables are inter-related within the cross-sections, as shown in the Breusch-Pagan Lagrange multiplier (LM), Pesaran Scaled LM tests. The Pesaran CD test shows strong cross-sectional dependence in the variables of the models. Pool Mean Group (PMG) panel Autoregressive Distributive Lag (ARDL) results concerning the robustness checks, for all models, the panel Pooled Ordinary Least Squares (POLS) methods produce similar results, economically and statistically, compared to those obtained from MM-estimation. Finally, Dumitrescu and Hurlin's Granger causality test is applied to test the causality among the observed variables. Results reveal a strong feedback link between CO_2 and FEC. This indicates that the feedback hypothesis exists between CO_2 and FEC in Central Asian countries. Central Asian region's economy has been growing rapidly, and as energy consumption has increased, so have GHG emissions, especially from fossil fuels. Power plants use much fossil fuel. Central Asia is rich in natural resources such as coal, oil, natural gas and, uranium, and has significant renewable energy resources from wind, solar, hydro, and biomass. It is possible to change the total energy mix by replacing renewable energy sources with the wind, hydropower, and solar energy. Central Asia has significant reserves of wind power, small, medium, and large hydropower and solar power plants. Almost half of the population lives in rural areas, and it is possible to create a small centralized renewable energy system.

References

Amin, Sakib, Tooraj Jamasb, and Rabindra Nepal.(2020). "Regulatory reform and the relative efficacy of government versus private investment on energy consumption in South Asia." Economic Analysis and Policy.421-433.https://doi.org/10.1016/j.eap.2020.12.019

Ashurov, Sharofiddin, Anwar Hasan Abdullah Othman, Romzie Bin Rosman, and Razali Bin Haron.(2020). "The determinants of foreign direct investment in Central Asian region: A case study of Tajikistan, Kazakhstan, Kyrgyzstan, Turkmenistan and Uzbekistan (A quantitative analysis using GMM)." Russian Journal of Economics 6, 162-176.https://doi.org/10.32609/j.ruje.6.48556 Azamat Amirov, Madina Kozhukhova, Gaukhar Koshebaeva, Valeryi Biryukov, Miras Zhiyenbayev. (2018).

"Economic and energy security of the Republic of Kazakhstan." International Journal of Energy Economics and Policy, 8(6), 16-21.https://doi.org/10.32479/ijeep.6935

Bajra, Ujkan Q., Zenun Halili, and Nimete Berisha.(2020). "Frontier Economies and Economic Growth: Evidence from European and Central Asian Countries." BorsaIstanbul Review.279-291, https://doi.org/10.1016/j.bir.2020.04.002

Batsaikhan, Uuriintuya, and Marek Dabrowski.(2017). "Central Asia—twenty-five years after the breakup of the USSR." Russian Journal of Economics 3, no. 3: 296-320.http://dx.doi.org/10.1016/j.ruje.2017.09.005

Bird, Julia Helen, Mathilde Sylvie Maria Lebrand, and Anthony J (2020). Venables. The Belt and Road Initiative: Reshaping Economic Geography in Central Asia? The World Bank,102441. https://doi.org/10.1016/j.jdeveco.2020.102441

Bolor-Erdene Turmunkh. (2020). Renewable and Non-Renewable Energy Consumption, CO2 Emissions and Economic Growth in a Developing Country: Empirical Evidence from Kazakhstan,Asian Development Perspectives, 11(2), 106-121.https://doi.org/10.22681/ADP.2020.11.2.106

Boubellouta, Bilal, and Sigrid Kusch-Brandt. (2021). "Relationship between economic growth and mismanaged e-waste: Panel data evidence from 27 EU countries analyzed under the Kuznets curve hypothesis." Waste Management 120, 85-97.https://doi.org/10.1016/j.wasman.2020.11.032

Breusch, Trevor S., and Adrian R. Pagan. (1980). "The Lagrange multiplier test and its applications to model specification in econometrics." The review of economic studies 47(1),239-253. https://doi.org/10.2307/2297111

Cheng, Cheng, Xiaohang Ren, Kangyin Dong, Xiucheng Dong, and Zhen Wang.(2021) "How does technological innovation mitigate CO2 emissions in OECD countries? Heterogeneous analysis using panel quantile regression." Journal of Environmental Management 280, 111818. https://doi.org/10.1016/j.jenvman.2020.111818

Corradini, Carlo.(2021). "Local institutional quality and economic growth: A panel-VAR analysis of Italian NUTS-3 regions." Economics Letters 198: 109659.https://doi.org/10.1016/j.econlet.2020.109659

Dumitrescu, Elena-Ivona, and Christophe Hurlin. (2012). "Testing for Granger non-causality in heterogeneous panels." Economic modelling 29(4),1450-1460.https://doi.org/10.1016/j.econmod.2012.02.014

Granger, Clive WJ.(1969). "Investigating causal relations by econometric models and cross-spectral methods." Econometrica: journal of the Econometric Society, 424-438.https://doi.org/10.2307/1912791

Hao, Yu, Jiahui Liu, Zhi-Nan Lu, Ruijie Shi, and Haitao Wu.(2021). "Impact of income inequality and fiscal decentralization on public health: Evidence from China." Economic Modelling 94, 934-944. https://doi.org/10.1016/j.econmod.2020.02.034

Kao, Chihwa.(1999). "Spurious regression and residual-based tests for cointegration in panel data." Journal of econometrics 90(1) 1-44.https://doi.org/10.1016/S0304-4076(98)00023-2

Nepal, Rabindra, Tooraj Jamasb, and Clement Allan Tisdell.(2017). "On environmental impacts of market-based reforms: Evidence from the European and Central Asian transition economies." Renewable and Sustainable Energy Reviews 73, 44-52.http://dx.doi.org/10.1016/j.rser.2017.01.078

Nurseiit, Nurlan Aitkaliuly.(2020). "Prospects for the Regional Cooperation in Central Asia." Eurasian Journal of Business and Economics 13, no. 26, 1-22.https://doi.org/10.17015/ejbe.2020.026.01

Pala, Aynur. (2020). "Energy and economic growth in G20 countries: Panel cointegration analysis." Economics and Business Letters 9, no. 2, 56-72.https://doi.org/10.17811/ebl.9.2.2020.56-72

Pedroni, Peter.(2004). "Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis." Econometric theory, 597-625. http://www.jstor.org/stable/3533533

Pesaran, M. Hashem, Yongcheol Shin, and Ron P. Smith. (1999). "Pooled mean group estimation of dynamic heterogeneous panels." Journal of the American statistical Association 94, no. 446, 621-634. https://doi.org/10.1080/01621459.1999.10474156

Pesaran, M. Hashem.(2007). "A simple panel unit root test in the presence of cross‐section dependence." Journal of applied econometrics 22, no. 2, 265-312.https://doi.org/10.1002/jae.951

Pesaran, M. Hashem.(2004). "General diagnostic tests for cross-sectional dependence in panels." Empirical Economics, 1-38.https://doi.org/10.1007/s00181-020-01875-7

Pomfret, Richard.(2012). "Resource management and transition in Central Asia, Azerbaijan and Mongolia." Journal of Asian Economics 23, no. 2, 146-156.https://doi.org/10.1016/j.asieco.2011.08.004

Riti, J.S., Shu, Y., Song, D. and Kamah, M., (2017). The contribution of energy use and financial development by source in climate change mitigation process: a global empirical perspective. Journal of Cleaner Production, 148,882-894.https://doi.org/10.1016/j.jclepro.2017.02.037

Rosenbaum, Stephen M., Stephan Billinger, Nils Stieglitz, Abdumalik Djumanov, and Yerlan Atykhanov.(2012). "Market economies and pro-social behavior: Experimental evidence from Central Asia." The Journal of Socio-Economics 41, no. 1, 64-71.https://doi.org/10.1016/j.socec.2011.10.010

Russell, Andrew, Mohamed Ghalaieny, Bella Gazdiyeva, Sara Zhumabayeva, Aygul Kurmanbayeva, Kanat Kambarovich Akhmetov, Yelzhas Mukanov.(2018). "A spatial survey of environmental indicators forKazakhstan: an examination of current conditions and future needs." International Journal of Environmental Research 12, no. 5, 735-748.https://doi.org/10.1007/s41742-018-0134-7

Sims, Christopher A., (1972). "Money, income, and causality." The American economic review 62, no. 4, 540 552.https://www.jstor.org/stable/1806097

Taghizadeh-Hesary, Farhad, Tapan Sarker, Naoyuki Yoshino, Aline Mortha, and Xuan Vinh Vo.(2020). "Quality infrastructure and natural disaster resiliency: A panel analysis of Asia and the Pacific." Economic Analysis and Policy.394-406. https://doi.org/10.1016/j.eap.2020.12.021

Tiwari, Aviral Kumar, Leena Mary Eapen, and Sthanu R. Nair. (2021). "Electricity consumption and economic growth at the state and sectoral level in India: Evidence using heterogeneous panel data methods." Energy Economics 94, 105064.https://doi.org/10.1016/j.eneco.2020.105064

Wan, Haibin, Yang Cao, Wei Wang, Qingrun Yang, Dongil Lee, Tao Ding, and Huiming Zhang.(2018). "Economic dispatch constrained by central multi-period security for Global Energy Interconnection and itsapplication in the Northeast Asia." Global Energy Interconnection 1, no. 2, 108-114. https://doi.org/10.14171/j.2096-5117.gei.2018.02.001

Wang, Xingyu, Heran Zheng, Zhenyu Wang, Yuli Shan, Jing Meng, Xi Liang, Kuishuang Feng, and Dabo Guan. (2019). "Kazakhstan's CO2 emissions in the post-Kyoto Protocol era: Production-and consumption- basedanalysis." Journal of environmental management 249, 109393. https://doi.org/10.1016/j.jenvman.2019.109393