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THE ASSOCIATION BETWEEN CO2 AND ECONOMIC GROWTH IN CENTRAL ASIAN COUNTRIES: PANEL DATA APPROACH

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Abstract

The purpose of this paper is to investigate the relationship between CO2, Economic growth and FDI in Central Asian countries including Uzbekistan, Kazakhstan, Kyrgyzstan, and Tajikistan, collecting the secondary data from 2000 to 2020 by utilize panel regression, namely Pooled OLS, Random Effect and Fixed Effect Models, furthermore, panel causality test was utilized to see the causal relationship between variables of our interest. Ultimately, this paper adds to the existing literature by revealing the following primary findings by showing the correlation between carbon dioxide emissions, economic development, and foreign direct investment in Central Asian nations. The paper's primary empirical findings indicate that there is a unidirectional link between GDP and CO2 emissions, GDP and energy consumption, and energy consumption and CO2. In Central Asia, meanwhile, we found no indication of a significant link between FDI and GDP or between CO2 and FDI.

Keywords: CO2, Economic growth, Foreign Direct Investments, Panel Data Models, Panel causality test.

INTRODUCTION

Numerous scholars have looked at the underlying link between energy usage, CO2, FDI, trade openness and economic development in emerging countries throughout the last two decades (Bakirtas & Akpolat, 2018; Fodha & Zaghdoud, 2010; Kahia, Aïssa, & Lanouar, 2017). Various research have looked at the causal link between energy consumption and a variety of independent factors such economic growth, financial development, employment, and population (Jamel & Derbali, 2016). The relationship between GDP and energy consumption has been extensively studied by several key academic works throughout the last few decades in this alignment. Using a variety of econometric methodologies and different proxy indicators, various researchers have been interested in yearly data for multiple nations in order to determine the causal link between CO2, energy consumption, and GDP (Baranzini, Weber, Bareit, & Mathys, 2013; Ghosh, 2010). However, these empirical studies have shown inconsistent results, indicating the need for further research to elucidate this causal relationship. A number of recent researches have confirmed the existence of a link between economic growth, carbon dioxide emissions, energy consumption, FDI, and trade openness by using a variety of econometric methods such as: (1) Unit root tests with Structural Breaks; (2) the co-integration test to see if the variables are linked in the long term; (3) for long-run and short-run impacts, the ordinary least squares (OLS) approach and the error–correction model; (4) For causal connection, the VECM with Granger causality approach is utilized; (5) To investigate the robustness of causality analysis, an innovative accounting approach is used.

As well as, any country's key policy mission is to deliver targeted economic and social development. This is also very meaningful for Central Asian emerging countries, which more than 30% population of the region live below the poverty line (Margatova, Kudebayeva, & Naqvi). The per capita GDP of the region accounts for about $4000 which means that is lower than that of the middle and low income countries and the world which are US$ 10,636 and US$ 4,497 respectively (Alacevich, 2020). Nevertheless, the fact that these nations in Central Asia have had significant growth in recent years is optimistic. According to the statistics given by World Bank, only Uzbekistan and Tajikistan had 1.6% and 4.5% change respectively in GDP growth whilst Kazakhstan, Kyrgyzstan and Afghanistan had small decline accounts for about -2.6%, -8.6%, and -1.9% because of the COVID-19 pandemic (2021). Considering the existing level of poverty and economic situation in these nations, continued and enhanced growth in the economy is vital. Numerous socioeconomic variables impact economic growth, including population increase, energy consumption, trade openness, infrastructure development, financial sector development, a corruption-free society, and effective governance and policy, and many others according to the views of Rehman (2020). Furthermore, environmental pollution is also caused by major elements such as industrial growth, transportation, population, deprivation, soil erosion, overcrowding and traffic, exploitation of open access resources due to ill-defined property rights, and so on. As a result, environmental aspects must be taken into account in a comprehensive manner. Pollution has an impact on economic growth in Central Asia. There is evidence of air pollution's worldwide character and its consequences on the Earth's surface. Evidence demonstrated that pollution emissions were getting absorbed in the monsoon circulation and transmitted into the lower stratosphere throughout a vast region of Central Asia, from Uzbekistan to Kazakhstan and Kyrgyzstan (Li, Jiang, Sotnyk, Kubatko, & Almashaqbeh YA, 2020). The distressing nature of environmental degradation, as well as its long-term negative effects, can have negative ramifications for human health and the economy. As a result, health and social expenses will rise.

The primary driver behind this paper is to take into consideration the above-mentioned causes and the disparity in their effects on economic growth. Its goal is to give more data so that policy initiatives for Central Asian nations may be formulated. The purpose of the article is to use panel data regression analysis to explore the associations between CO2 emissions, FDI, energy demand, and economic growth in Central Asian nations such as Uzbekistan, Kazakhstan, Kyrgyzstan, and Tajikistan spanning 2000 through 2020.

Literature Review

Our paper aims to contribute to the literature in a number of ways. To begin, we investigated at the most latest studies examining the relationship between economic development, energy, foreign direct investment, and CO2. We employ panel regression techniques to predict this complexity in the second phase, because panel data models have never been used for Central Asian nations previously. Ultimately, the paper draws certain definitive conclusions the subject at hand, which might also stimulate debate among academics and policymakers.

The association between economic growth and CO2 emissions has been empirically investigated for years, and it has been confirmed that there is a link between the two (Cai, Sam, & Chang, 2018). The Environmental Kuznets Curve, according to Cole & Rayner, does have a U-shaped correlation between CO2 emissions and economic development. Evidence for the EKC hypothesis, which argues that economic growth originally, has an impact on environmental quality, but that after growth exceeds a certain threshold, the environment benefits. (1991). This is a paradox discovered by Shafik (1994), who reveals that Emissions of carbon dioxide have escalated over occur as a consequence of economic growth.

As per Gardner and Stern, Emissions of carbon dioxide drop significantly once economy reaches a certain point of profitability (1996).

According to Akbostanci's conclusions, however, the EKC hypothesis' assumptions did not meet (2009). In both poor and high-income countries, income and carbon emissions were shown to be negatively and positively connected, according to Martinez-Zarzoso (2004).

In a paper on sustainability and environmental development in Sub-Saharan Africa, Joseph (2010) utilized the panel co-integration approach to demonstrate that there was a substantial positive connection and responsiveness of climate change to development. Usenobomg and Chukwu (2011) , on the other hand, discovered the opposite outcomes when they looked at Nigeria's economic development and environmental problems. They discovered an N-shaped relationship between economic development and environmental deterioration. They proposed that, regardless of the country's income level, aggressive environmental policy measures are implemented.

Carbon emissions and GDP have a favorable connection, according to Al Khathlan and Javid (2013). They also claimed that electricity polluted the environment less than other energy sources. The EKC hypothesis was proven to be valid for the Turkish economy in Ozturk and Acaravci’s (2013) study. Similarly, when investigating the causation between carbon dioxide emissions, energy consumption, and real production in a set of Gulf Cooperation Council (GCC) nations, Hamdi and Sbia (2014) discovered evidence of the Environmental Kuznets Curve hypothesis in the long term.

Muftau et al. (2014) used the co-integration approach to evaluate the relationship between CO2 emissions and economic development for West African nations and discovered a long-run equilibrium link between CO2 emissions and GDP. They identified a time-dependent N-shaped link between income and CO2 emissions, showing that the EKC hypothesis does not apply in West Africa. In Bangladesh, Rahman and Kashem (2017) investigated the causation of carbon emissions, energy consumption, and industrial growth, and discovered a short- and long-term link between industrial production and CO2 emissions. For 11 Asian populous nations, Rahman (2017) discovered a unidirectional causation extending from GDP to CO2 emissions.

Mbarek et al. (2017) discovered that economic expansion has both immediate and long-term effects on CO2 emissions in Tunisia. Saidi and Hammami (2015) looked studied the impact of energy usage and CO2 emissions on economic growth in 58 nations, and CO2 emissions were discovered to have a detrimental influence on economic growth.

The causal linkages between energy consumption and economic growth have been a strongly disputed topic during the last two decades. In our analysis of the literature, we discovered that the same causality methodologies have been used, but the findings vary. In their investigation, Jafari, Othman, & Nor (2012) discovered that there is no strong association between energy use and economic development in Indonesia from 1971 to 2007. For a panel dataset covering 1995 to 2012, Isik, Dogru, and Turk discovered a neutral relationship between energy and growth in Spain (2018). Nordin and Sek (2019) discovered evidence of short-run correlations between energy use and economic growth in low- and high-income nations. Nasreen and Anwar (2019) demonstrated bidirectional causation between energy use and economic growth in 15 Asian nations from 1980 to 2011.

Chaudhry et al. (2013) conducted research to determine the short- and long-term effects of foreign direct investment on China's economic growth. They used the ARDL co-integration approach and the error correction model to analyze annual time series data from the World Bank from 1985 to 2009. The study's findings show that foreign direct investment and economic growth in China have a favorable short- and long-term relationship. Furthermore, Siddikee and Rahman (2020) used the VECM approach to show the relationship between net FDI inflows and GDP using annual data for Bangladesh from 1990 to 2018.

Qurbonov O., Kobilov A. (2020) investigated the impact of investments on the economic growth of Uzbekistan. The empirical model is based on quarterly data for the period 2010-2019 in Uzbekistan. The Granger causality test indicates a positive significant bidirectional relationship between GDP and GDP Granger causes FDI and a change in the GDP indicate in advance a change in the level of FDI The variance decomposition indicates that fluctuations in FDI are explained by the shocks in GDP (55.0 percent) and Uzbekistan's domestic investment has a greater impact on growth than FDI.

Materials and Methodology

The empirical data in our paper is based on the studies described above, and it examines the causal link between GDP, foreign direct investment, energy consumption and pollution. We also use several variables, including inflation, trade openness and urbanization, which have shown to be quite useful in determining the causal relationship. We utilize the dataset provided by World Bank, Statistical Committee of Uzbekistan, World Development Indicators from 2000 to 2020, an annual panel data of 4 Central Asian economies, namely, Uzbekistan, Kazakhstan, Kyrgyzstan and Tajikistan, were developed for the empirical examination.

By looking through previous papers, we choose the variables for our paper as below-mentioned.

1. Market Size (GDP);
2. Energy Consumption (EC);
3. Inflation (INF);
4. Trade Openness (T);
5. Urbanization (U);
6. Carbon Dioxide Emissions (CO2);
7. Foreign Direct Investments (FDI).

Market Size (GDP) - The most essential criterion in defining a country's market size is GDP, which is the market value of all items and services produced inside its boundaries in a given year (Petrović-Ranđelović, Mitić, Zdravković, Cvetanović, & Cvetanović, 2020). For this variable, we utilize GDP per capita as a metric for market size and, World Bank data is used to assemble GDP results.

Energy Consumption (EC) - Economic growth is influenced by energy consumption, as per the growth hypothesis (Soytas & Sari, 2009). As a result, energy is a critical component for any country to have a high and consistent pace of economic growth. In our paper, we use energy use (kg of oil equivalent per capita) as a metric for energy consumption. The data is provided by World Bank database.

Inflation (INF) - when a country experiences inflation, the people's buying power declines as the cost of goods and services rises. When the rate of inflation is high, the cost of living rises as well, causing economic growth to slow down (Barro, 2013). A healthy inflation rate of 2% to 3%, on the other hand, is regarded favorable since it immediately leads to higher salaries and corporate profitability, as well as keeping capital moving in a rising economy.

Trade Openness (TO) - Integration with global commerce with sources of innovation is facilitated through trade, which improves the return on FDI. Trade liberalization enables economies to grow output, resulting in higher returns to scale and specialization economics (Gerring, Bond, Barndt, & Moreno, 2005). The Trade Openness Index, which is utilized as a metric for trade openness, is determined by dividing the amount of imports and exports by the country's total GDP. The data is provided by World Bank database.

The following is the formulation for the variable of trade openness:

$$\boldsymbol{TRADE = \frac{X + M}{GDP}}$$

Eq. (1)

Urbanization (U) - economic institutions, which increase worker and business productivity through improved resource sharing, faster and better job matching, faster knowledge spillovers, infrastructure access, public goods, and lower transaction costs, are among the economic benefits of urbanization (Khoshnevis Yazdi & Golestani Dariani, 2019).

Carbon dioxide emissions (CO2) - Increasing pollution levels are inevitable as a result of increased productivity. More output necessitates increased input, resulting in the utilization of more natural resources and a rise in pollution levels (Morelli & Mele, 2020). CO2 emissions (metric tons per capita) are used as a metric for CO2 and the data is provided by World Bank database.

Foreign Direct Investments (FDI) - FDI appears to have a positive impact on growth since it lowers the rental rate of capital and increases output by improving labor productivity and introducing new technology incorporated in the capital (Raza, Shah, & Arif, 2019). We use foreign direct investment, net inflows (% of GDP) as a proxy for FDI in our paper. The data is derived from World Bank database.

We start by looking at the data description of all variables utilized in our work, using the conventional panel data analysis approach. Then, we investigate the stationarity of variables. Table 1 represents the descriptive statistics of the variables utilized in our paper. There is a little difference in the studied variables in their means and medians. It is worth mentioning that GDP and EC have the highest values of Maximum.

Table 1 *Descriptive Statistics*

Variable	Obs.	Mean	Std. Dev.	Min	Max
co2	80	4.41	4.617	.321	15.047
FDI	80	4.746	4.148	-1.392	17.131
GDP	80	2562.599	3482.563	138.429	13890.631
to	80	86.681	32.826	29.748	175.457
U	80	1.795	.729	-.04	3.777
INF	80	9.615	6.468	.389	38.592
EC	80	1672.826	1528.802	283.493	4786.593

Source: Computed by Stata 16.0

A test for the variance inflation factor also was performed, as given in Table 2, to further check that the assumption of negligible multicollinearity was satisfied, as shown in Table 2. The results reveal that none of the independent variables have a VIF greater than 10, the assumption is satisfied since the criterion for spotting multicollinearity is met. As per previous literatures (Daoud, 2017), a VIF > 10 or a 1/VIF < 0.10 indicates trouble.

Table 2 *Variance inflation factor*

	VIF	1/VIF
EC	6.018	.166
GDP	4.735	.211
to	1.84	.544
FDI	1.475	.678
U	1.378	.726
INF	1.218	.821
Mean VIF	2.777	.

Source: Computed by Stata 16.0

We employ co-integration tests, namely Pedroni (2001) and Kao (2001)to check whether they have a stable and long term relationship or not. As per the result of co-integration tests in Table 3, we can conclude that all variables are co-integrated because p-value strongly rejects null hypothesis. As per the Pedroni (2004), if p-value is smaller 0.05, null hypothesis is rejected and, alternative hypothesis can be approved.

Table 3 *Tests for co-integration*

Pedroni test for co-integration	**Statistic**	**p-value**
Modified Phillips-Perron t	2.0695	0.0192
Phillips-Perron t	-2.8354	0.0023
Augmented Dickey-Fuller t	-3.3069	0.0005
Kao test for cointagration	**Statistic**	**p-value**
Modified Dickey-Fuller t	-5.8982	0.0000
Dickey-Fuller t	-3.9306	0.0000
Augmented Dickey-Fuller t	-1.4745	0.0402
Unadjusted modified Dickey-Fuller t	-6.0277	0.0000

Unadjusted Dickey-Fuller t	-3.9498	0.0000

Ho: No co-integration

Ha: All panels are co-integrated

Table 4 represents Pearson's correlation between variables in our paper. As per the table, it can be seen that FDI, Energy Consumption and GDP have highly positive correlation with CO2, whilst trade openness and inflation have moderate negative correlation. Interestingly, urbanization has negative correlation with all variables in the study.

Table 4 *Pearson's Correlation*

	co2	FDI	GDP	to	U	INF	EC
co2	1.0000						
FDI	0.2619	1.0000					
GDP	0.8785	0.1466	1.0000				
to	-0.3146	0.3707	-0.2941	1.0000			
U	-0.2887	-0.2625	-0.1594	-0.2459	1.0000		
INF	-0.0359	-0.1201	-0.1484	0.1319	0.0102	1.0000	
EC	0.9882	0.2119	0.8644	-0.3446	-0.2934	-0.0041	1.0000

Source: Computed by Stata 16.0

The econometric method, used in our paper, is mainly based on the use of the Cobb–Douglas production function, which is predicted utilizing the Ordinary Least Square (OLS) method. The Cobb–Douglas production function is used to investigate the three-way causal relationship between GDP, CO2 emissions and foreign direct investment in Central Asian countries.

The Cobb–Douglas production function is commonly employed to depict the connection between output and inputs (Kahia et al., 2017). The followings are the parameters for the generic production function:

$$\boldsymbol{Y = f(A, K, L) \rightarrow Y = AL^{\beta}K^{\alpha}}$$

Eq. (2)

Where, Y is the total output; A is the total factor productivity; K denotes capital input; L denotes labor input; and, α and β are the output elasticities of capital and labor, respectively. These values are constants defined by the technology available at the time.

The Cobb–Douglas function, in its extended version, represents more than two items (Douglas, 1967). The Cobb–Douglas function can be expressed in the following way:

$$\boldsymbol{f(x) = A \prod_{i=1}^{n} x_i^{\sigma_i} \qquad x = (x_1, \dots \dots \dots x_n}$$

Eq. (3)

- A is a parameter for efficiency;
- n is the total number of input variables (goods);
- x1, ..., xn are the (non-negative) quantities of good consumed, produced, etc.
- σ_i is an elasticity parameter for good i.

The following equation may be used to evaluate the Cobb–Douglas production function form as a linear relationship:

$$\boldsymbol{Ln(Y) = a_0 + \sum_i a_i ln\,(I_i)}$$

Eq. (4)

Where,

Y-output;

I_i-inputs;

a_i-coefficients.

We can analyze GDP using economic metrics such as capital and labor force using this function. Furthermore, foreign direct investment, trade liberalization, environmental pollutants, urbanization and energy consumption all influence economic growth.

In this paper, we experimentally estimate the results by utilizing the following four equations:

$$lnGDP = \alpha_0 + \alpha_{1i}\, lnCO2_{it} + \alpha_{2i} lnFDI_{it} + \alpha_{3i} lnEC_{it} + \alpha_{4i} lnINF_{it} + + \alpha_{5i} lnT_{it} + \alpha_{6i} lnU_{it} + \varepsilon_{it} \quad (5)$$

$$lnFDI = \alpha_0 + \alpha_{1i}\, lnCO2_{it} + \alpha_{2i} lnGDP_{it} + \alpha_{3i} lnEC_{it} + \alpha_{4i} lnINF_{it} + + \alpha_{5i} lnFDI_{it} + \alpha_{6i} lnU_{it} + \varepsilon_{it} \quad (6)$$

$$lnCO2 = \alpha_0 + \alpha_{1i}\, lnGDP_{it} + \alpha_{2i} lnFDI_{it} + \alpha_{3i} lnEC_{it} + \alpha_{4i} lnINF_{it} + + \alpha_{5i} lnT_{it} + \alpha_{6i} lnU_{it} + \varepsilon_{it} \quad (7)$$

$$lnEC = \alpha_0 + \alpha_{1i}\, lnGDP_{it} + \alpha_{2i} lnFDI_{it} + \alpha_{3i} lnCO2_{it} + \alpha_{4i} lnINF_{it} + + \alpha_{5i} lnT_{it} + \alpha_{6i} lnU_{it} + \varepsilon_{it} \quad (8)$$

Where, ln GDP measures the gross domestic product per capita for each country i, ln FDI denotes the foreign direct investment, ln T measures the trade liberalization, ln CO2 measures the CO2 emissions per capita, ln EC denotes the energy consumptions, ln INF measures the inflation rate, and ln U measures the urbanization rate. $\alpha0$ reflects the constant. εit means the residual term. αji is a function that computes the estimated coefficients of all explanatory variables. (where, j = 1,…,8). The remark i = 1… 40 measures the country. The notes t = 1…20 is the time period. In Table 1, we define all variables utilized in our paper.

The impact of foreign direct investment, trade liberalization, environmental pollutants, energy usage, foreign direct investment, inflation rate and urbanization rate on GDP in Central Asian nations (Anwar & Sun, 2011; Omri, Daly, Rault, & Chaibi, 2015) is shown in Equation (5).

The influence of GDP, trade liberalization, CO2 emissions, energy consumption, inflation rate and urbanization rate on foreign direct investment is studied in the sixth equation (Ozturk & Acaravci, 2013).

The impact of trade liberalization, foreign direct investment, GDP, energy consumption, foreign direct investment, inflation and urbanization on pollution is examined using Equation (7). Finally, Equation 8 indicates the impact of GDP, trade liberalization, CO2 emissions, foreign direct investment, inflation rate and urbanization rate on energy consumption.

For a balanced panel data-set in Central Asian nations, we employ the OLS as a recommended approach to estimate the abovementioned equations.

Empirical Results

In this section, we aim to show the causal relationship between four economic, environmental, and financial variables (economic growth (GDP), foreign direct investment (FDI), trade openness (liberalization), and CO2 emissions) in Central Asian nations from 2000 to 2020 by utilizing Ordinary Least Square.

The panel structure is homogenous, as can be seen. Then we can use the OLS approach to improve the fit by lowering the summation of squared error terms. However, the choice of estimate strategy, whether for fixed or random effects models, is a challenge that emerges while estimating the model. As a result, the Hausman test is used to choose between estimate with fixed effects and estimation with random effects to tackle this problem.

We begin our empirical investigation by presenting the results of the Equation (5) estimate and coefficients. The impact of foreign direct investments, trade liberalization, CO2, energy consumption, inflation rate, and urbanization on economic growth is investigated in this equation. Table 5 summarizes the results of Equation (5)'s estimation. Furthermore, the Hausman test, with a p-value = 0.000, supports evidence for fixed effects models. Following that, we use extra statistic tests to evaluate the calculated models and justify their significance.

Table 5 *Estimation results of OLS for GDP*

Dependent Variable GDP			
VARIABLES	Pooled OLS	Random effect	Fixed effect
FDI	-117.7**	-117.7**	-47.41
	(53.40)	(53.40)	(44.52)
co2	772.6***	772.6***	**1,063*** **
	(275.4)	(275.4)	(227.1)
to	11.79	11.79	**-14.66** **
	(7.227)	(7.227)	(7.178)
U	547.1*	547.1*	-516.5
	(279.5)	(279.5)	(313.7)
INF	-77.77***	-77.77***	-26.52
	(29.08)	(29.08)	(29.25)
EC	-0.107	-0.107	**1.396** **
	(0.836)	(0.836)	(0.694)
Constant	-1,364	-1,364	-1,784*
	(1,071)	(1,071)	(906.7)
Observations	80	80	80
R-squared	0.809		0.687
Number of ID		4	4
Wald chi2		309.9	
F for ui=0			17.52
Hausman chi2			61.47
Prob>chi2		0.000	
Estimation chosen		Model with Fixed Effects	

Note: The calculated coefficients of GDP (economic growth) as a dependent variable are summarized in this table. We utilize an annual data panel of four Central Asian nations (Uzbekistan, Kazakhstan, Kyrgyzstan, and Tajikistan) from 2000 to 2020 to test this model statistically.

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Table 7 represents that pollution (CO2) has a substantially positive influence on ln GDP (estimated coefficients). Then, a 1% rise in pollution contributes 1.063 percent to economic growth.

Furthermore, energy consumption has a large and considerable favorable effect on GDP. As a result, a 1% increment in energy consumption can boost GDP by 1.396 percent.

Finally, trade openness has a negative significant impact. This means that a 1% increase in trade liberalization decreases GDP by 14.66 percent. However, there is no any significant relationship between inflation, urbanization, FDI and economic growth in the Central Asian countries.

We examine the effect of GDP, trade liberalization, CO2 emissions, energy usage, inflation, and urbanization on FDI in Equation (6). Table 6 summarizes the results of Equation (6)'s estimation. The random effects model is our favorite estimate approach since the Hausman test has a p-value of higher than 1%. (0.519).

Table 6 *Estimation results of OLS for FDI*

Dependent Variable FDI			
VARIABLES	Pooled OLS	Random effect	Fixed effect
co2	1.721***	**1.721*** **	0.902
	(0.581)	(0.581)	(0.685)
GDP	-0.000530**	**-0.000530** **	-0.000336
	(0.000241)	(0.000241)	(0.000316)
to	0.0606***	**0.0606*** **	0.0503***
	(0.0139)	(0.0139)	(0.0187)
U	0.0453	0.0453	1.284
	(0.608)	(0.608)	(0.838)
INF	-0.119*	**-0.119* **	-0.0289
	(0.0632)	(0.0632)	(0.0783)
EC	-0.00306*	**-0.00306* **	-0.00425**
	(0.00174)	(0.00174)	(0.00183)
Constant	-0.549	-0.549	2.342
	(2.298)	(2.298)	(2.465)
Observations	80	80	80
R-squared	0.395		0.268
Number of ID		4	4
Wald chi2		47.64	
F for ui=0			2.607
Hausman chi2			4.216
Prob>chi2		0.519	
Estimation chosen		Model with Random Effects	

Note: The calculated coefficients of GDP (economic growth) as a dependent variable are summarized in this table. We utilize an annual data panel of four Central Asian nations (Uzbekistan, Kazakhstan, Kyrgyzstan, and Tajikistan) from 2000 to 2020 to test this model statistically.

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

We also examine the relation between the explicative factors and the residual terms. There are no concerns of link between the explicative variables and residual terms since the probability (Prob > chi2) is less than 5%. Then, depending on the value of Fisher's probability, we perform the model's significance test. We can see that the p-value (Prob > F) is lower than 5%. As a result, we might presume the model is important.

Table 6 shows that GDP has a detrimental and considerable impact on FDI. If there is 1% decrease in GDP, there is 0.0005% decrease in FDI. In addition, inflation has also has a negative relationship with FDI, which means, if there is 1% decrease in inflation, there will be 0.11% decline in FDI. Furthermore, energy consumption has a small detrimental relationship with FDI. Thus, we can find that 1% decrease in energy consumption reduces the foreign direct investments by 0.003%.

Interestingly, there is a strong significant correlation between CO2, trade openness and FDI. As per the table 6, if there is 1% increase in CO2, FDI see a 1.72% rise. As well as, 1% increase in trade openness result in a rise of 0.06% in FDI.

However, urbanization has no any significant relationship with FDI in Central Asian countries.

We analyze the impact of FDI, GDP, energy usage (EC), inflation (INF), urbanization (U), and trade liberalization (TO) on CO2 using Equation (7). Table 7 displays the Equation (7) estimation results. From the key results of this table, the fixed effects model is chosen as an appropriate estimation technique hence the p-value of Hausman test is less than 5% (0.0000).

Table 7 *Estimation results of OLS for CO2*

Dependent Variable co2			
VARIABLES	Pooled OLS	Random effect	Fixed effect
FDI	0.0623***	0.0623***	0.0268
	(0.0210)	(0.0210)	(0.0204)
GDP	0.000126***	0.000126***	**0.000224*** **
	(4.49e-05)	(4.49e-05)	(4.79e-05)
to	0.000709	0.000709	0.00474
	(0.00297)	(0.00297)	(0.00335)
U	0.0373	0.0373	**0.454*** **
	(0.116)	(0.116)	(0.136)
INF	-0.00870	-0.00870	0.00431
	(0.0123)	(0.0123)	(0.0135)
EC	0.00271***	0.00271***	**0.00141*** **
	(0.000115)	(0.000115)	(0.000281)
Constant	-0.788*	-0.788*	0.0846
	(0.428)	(0.428)	(0.428)
Prob>x²			0.0000
Prob>F			0.0000
Observations	80	80	80
R-squared	0.982		0.799
Number of ID		4	4
Wald chi2		4055	
F for ui=0			8.249
Hausman chi2			24.63
Prob>chi2		0.000399	
Estimation chosen		Model with Fixed Effects	

Note: The calculated coefficients of GDP (economic growth) as a dependent variable are summarized in this table. We utilize an annual data panel of four Central Asian nations (Uzbekistan, Kazakhstan, Kyrgyzstan, and Tajikistan) from 2000 to 2020 to test this model statistically.

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

The likelihood (Prob > chi2) is found to be less than 5%. Then there will be no issues with correspondence between the explanatory variables and the error term. Afterwards, we show in Equation (7) that the probability (Prob > F) is less than 5%. As a result, the predicted model has worldwide implications. As a result, the coefficient of R^2 equals 0.79, indicating that the model (Equation 7) has a strong linear fit.

Table 7 shows that GDP has a significant positive influence on CO2. Consequently, 1% increase in GDP can boost CO2 with 0.0002%. Moreover, urbanization has a significant impact on CO2. Thus, we can conclude that a 1% rise in urbanization might result in a 0.45% increase in CO2. Furthermore, in Central Asia, energy usage has a favorable impact on CO2. As a result, a 1% increase in energy usage can increase CO2 emissions by 0.001%.

However, FDI, trade openness and inflation do not have any significantly positive or negative impact on CO2 in Central Asian countries.

Finally, we use Equation (8) to examine the influence of FDI, GDP, CO2, inflation (INF), urbanization (U), and trade liberalization (TO) on energy consumption. Table 8 presents the estimation results of Equation (8). We select the fixed effects model as an effective estimate strategy based on the main results of this table since the p-value of the Hausman test is less than 5%. (0.00762).

Table 8 *Estimation results of OLS for Energy Consumption (EC)*

Dependent Variable EC			
VARIABLES	Pooled OLS	Random effect	Fixed effect
co2	325.8***	325.8***	**187.3*** **
	(13.86)	(13.86)	(37.40)
FDI	-13.33*	-13.33*	**-16.79** **
	(7.562)	(7.562)	(7.243)
GDP	-0.00209	-0.00209	**0.0391** **
	(0.0164)	(0.0164)	(0.0195)
to	-1.589	-1.589	0.182
	(1.013)	(1.013)	(1.237)
U	-59.30	-59.30	75.78
	(39.53)	(39.53)	(52.78)
INF	7.335*	7.335*	**8.333***
	(4.179)	(4.179)	(4.826)
Constant	478.2***	478.2***	594.4***
	(140.9)	(140.9)	(138.9)
Observations	80		
R-squared	0.981		0.750
Number of ID		4	4
Wald chi2		3692	
F for ui=0			5.214
Hausman chi2			15.74
Prob>chi2		0.00762	
Estimated choosen	Fixed Effects Model		

Note: The calculated coefficients of GDP (economic growth) as a dependent variable are summarized in this table. We utilize an annual data panel of four Central Asian nations (Uzbekistan, Kazakhstan, Kyrgyzstan, and Tajikistan) from 2000 to 2020 to test this model statistically.

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

The chance (Prob > chi2) is discovered to be less than 5%. The relationship between the explanatory variables and the error term will thus be flawless. Then, in Equation (8), we prove that the probability (Prob > F) is less than 5%. As a result, the anticipated model has global ramifications. As a consequence, the R^2 value is 0.75, suggesting that the model (Equation 8) has a good linear fit.

Table 8 shows that energy consumption has a strong significant relationship with CO2. If there is 1% rise in CO2, there will be 187.3 increases in energy consumption. As well as, there is a significant correlation between GDP and energy consumption with the values that 1% increase in GDP result in 0.391% rise in energy consumption. Inflation has also considerably positive correlation with energy consumption. If inflation see 1% rise, there will be 8.3 % increment in energy consumption. Interestingly, foreign direct investments and energy consumption have strong negative relationship. If FDI rises 1%, energy consumption decreases 16.79%. However, there is no any significant relationship between trade openness, urbanization and energy consumption.

To investigate the causal link between the model's economic variables, we employed a causality test developed by Granger in 1969, which has evolved into a reflective framework as intriguing as that linked to the detection of econometric relationships.

In general, we can investigate by employing this test whether there is a significant link to CO2 emissions and foreign direct investments, carbon dioxide emissions and economic growths, carbon dioxide emissions and energy consumption.

Table 9 *Dumitrescu & Hurlin (2012) Granger non-causality test results*

	GDP	FDI	EC
CO2	-0.7983	4.9291***	24.7469***

H0: FDI does not Granger-cause dependent variable.

H1: FDI does Granger-cause dependent variable for at least one panelvar (ID).

CO2 as a dependent variable:

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

GDP as a dependent variable:

	CO2	FDI	EC
GDP	1.8716*	-0.9636	4.7219***

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

FDI as a dependent variable:

	CO2	GDP	EC
FDI	0.0690	0.2442	0.7956

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Energy consumption as a dependent variable:

	CO2	GDP	FDI
EC	0.8470	0.7812	0.8224

Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

From the tables above, we can see the relationship between the variables of our interest. As per the results there is directional relationship between CO2 and FDI, EC at 1% significance. Also, GDP has a directional relationship with Energy consumption at 1% level.

Conclusion

In this paper, we investigated the causal relationship between economic growth, CO2 emissions, FDI, and trade liberalization. We used the OLS as an econometric tool utilizing annual panel data from four Central Asian countries from 2000 to 2020 to accomplish the objective. The main aim of this paper is to investigate the three-way relationship between GDP, FDI, and CO2 emissions using three models: (Eq. 5) CO2, FDI, trade openness, and other explicative variables on GDP; (Eq. 6) GDP, CO2, trade openness, and other control variables on FDI; (Eq. 7) FDI, GDP, trade openness, and other explicative variables on CO2; and (Eq. 8) FDI, GDP, trade openness, CO2 and other explicative variables on energy consumption. The major empirical findings of our paper demonstrate a bidirectional relationship between GDP and CO2 emissions, GDP and energy consumption, and energy consumption and CO2. However, we could not find any evidence of a substantial relationship between FDI and GDP, or between CO2 and FDI in Central Asia.

The primary empirical conclusions of our paper are that GDP and environmental degradations are strongly and positively related. GDP per capita anticipates a positive relationship with CO2 emissions. Furthermore, GDP per capita encourages people to consume more energy. GDP, on the other hand, might deter foreign direct investment. An increase in energy consumption can result in a rise in CO_2. We also discover a favorable relationship between CO_2 and FDI.

Our paper contributes to previous researches with the link between energy consumption and GDP, FDI and CO_2, and energy consumption and CO_2.

In our example, the economy is named energy, and policies that use energy may have a detrimental impact on real economic growth. As a result, if energy consumption has an impact on economic growth, energy conservation regulations aimed at safeguarding the environment are likely to worsen the current phase of economic expansion. Furthermore, measures promoting energy production and conservation, foreign direct investment, trade openness, and economic growth would be ideal for the entire region. Even if there is a political intent to develop similar goals and objectives, separate policy and strategy designs for participant subgroups should most likely be considered.

Lastly, panel causality tests prove the existence of a directional causal link between economic development, environmental deterioration (CO_2), and foreign direct investment.

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