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Analysis of the Asymmetric Causal Relationship between Oil Prices, Oil Consumption and Environmental Degradation in Kazakhstan

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ABSTRACT

This study aims to analyze the asymmetric causal relationships between oil prices (OP), oil consumption (OC) and environmental degradation (CO_2 emissions) in the context of the Kazakh economy. In this context, the asymmetric causality test developed by Hatemi-J (2012) was applied using annual data for the period 1993-2024. The study presents findings that can guide policy makers in the axis of energy economy and environmental sustainability. The results obtained revealed that there is no significant causal relationship between oil prices and oil consumption in any direction. This finding shows that price fluctuations have a limited effect on consumption behavior. On the other hand, a significant causal relationship between oil consumption and environmental degradation, operating through bidirectional and negative shocks, was determined. This situation shows that reductions in energy consumption lead to environmental improvements and that environmental regulations can also have an effect on energy consumption. An asymmetric structure was observed in the relationship between oil prices and environmental degradation. Positive (negative) shocks in oil prices cause positive (negative) shocks in CO_2 emissions; however, shocks in emissions do not have a significant effect on prices. The general findings of the study emphasize that energy and environmental policies should not be designed independently of each other, but in interaction; and point to the necessity of a holistic policy approach in line with sustainable development goals.

Keywords: Oil Prices, Oil Consumption, CO_2 Emissions, Kazakhstan Economy, Asymmetric Causality
JEL Classifications: Q41, Q53, C22

1. INTRODUCTION

Energy resources are considered one of the fundamental dynamics of economic growth, and oil in particular stands out as one of the indispensable elements of the global economy. Oil prices significantly affect not only energy markets, but also economic activities, environmental sustainability, and social welfare. Kazakhstan is an important actor in global energy markets with its large oil reserves and export capacity. However, there are limited studies in the literature on the effects of changes in oil prices on the country's economic structure and environmental sustainability. In this context, the analysis of the causal relationship between oil prices, oil consumption, and environmental degradation will play a critical role in the formation of sustainable development policies. Previous studies have examined the relationship between energy consumption and environmental degradation with different methodological approaches. Within the scope of the Environmental Kuznets Curve (EKC) hypothesis, many studies suggest that environmental pollution decreases after economic growth reaches a certain level, while some studies indicate that energy consumption directly increases environmental degradation. Studies conducted specifically for Kazakhstan have generally focused on the relationship between energy consumption and economic growth (Syzdykova et al., 2020), and there is a lack of a comprehensive analysis of the asymmetric effects of oil prices on environmental degradation.

Therefore, our study aims to fill this gap in the literature. In this study, the causal relationships between oil prices, oil consumption, and environmental degradation in Kazakhstan will be analyzed using the asymmetric causality test developed by Hatemi-J (2012). Asymmetric causality analysis provides a more in-depth perspective compared to traditional causality tests by revealing that the relationship between variables can respond differently to positive and negative shocks. Thus, it will contribute to the creation of more effective and sustainable energy policies for policy makers. The findings to be obtained will provide important implications for the development of a balanced policy framework between energy supply security, environmental sustainability, and economic growth.

2. LITERATURE REVIEW

Oil price fluctuations (or oil shocks), oil consumption, and environmental quality/degradation have been examined in the literature through various channels. Accordingly, the existing studies can be categorized into three distinct groups. The first group comprises studies that investigate the relationship between oil price changes, energy consumption, and emissions. Among these, Chai et al. (2016) analyzed the impact of oil price changes on energy consumption and emissions in China over the period 1987-2014. The findings obtained from the Structural Vector Autoregression (SVAR) analysis indicated that a 1% increase in international oil prices leads to a 0.092% increase in energy consumption per unit of GDP and a 0.053% increase in carbon dioxide (CO_2) emissions. In the study by Zaghdoudi (2018), the asymmetric effects of oil price shocks on CO_2 emissions in China during the period 1980-2016 were examined using a nonlinear autoregressive distributed lag (NARDL) model. The results revealed that both increases and decreases in oil prices have significant short- and long-run effects on CO_2 emissions, and that in the long run, the impact of rising oil prices on CO_2 emissions occurs more rapidly than the decline in emissions caused by falling prices. Agbanike et al. (2019) investigated the causal relationships between oil prices, energy consumption, and CO_2 emissions in Venezuela for the period 1971-2013. The results of the ARDL Bounds Testing approach demonstrated that an increase in crude oil prices significantly boosts the country’s energy consumption, which in turn leads to an increase in CO_2 emissions.

Oil price fluctuations significantly influence environmental degradation through various mechanisms across different countries. The relationship is often asymmetric, with positive and negative shocks affecting carbon emissions differently. In many Gulf Cooperation Council (GCC) countries, positive oil price shocks are associated with a decrease in CO_2 emissions, particularly in Qatar and Saudi Arabia (Ebaid et al., 2022). This suggests that higher oil revenues may facilitate investment in cleaner technologies. Conversely, negative oil price shocks tend to exacerbate environmental degradation, as observed in Pakistan, where declining oil prices have led to increased CO_2 emissions (Chaudhry et al., 2020). This pattern resonates in other countries as well, indicating a broader trend where economic downturns linked to falling oil prices hinder environmental progress.

In APEC countries, while increased energy use and access are positively correlated with CO_2 emissions, oil price volatility is shown to have a negative effect on emissions (Zhang and Khan, 2024). This highlights the critical role of energy efficiency measures and clean energy investments in mitigating environmental degradation. Although evidence suggests that higher oil prices may lead to better environmental outcomes in certain contexts, the overall relationship is complex and influenced by economic conditions, policy responses, and patterns of energy consumption.

Hassan and Mhlanga (2023) identified a unidirectional causal relationship from oil prices to ecological footprint, GDP, and non-renewable energy consumption, while supporting the feedback hypothesis between ecological footprint and GDP. The authors also emphasize the asymmetric impact of oil prices on environmental degradation in oil-producing African countries.

Chaudhry et al. (2020) present an asymmetric causal relationship, showing that decreases in oil prices significantly increase CO_2 emissions, while increases in oil prices lead to a relatively smaller reduction in emissions. Other factors such as foreign direct investment (FDI), energy consumption, and population also positively influence emissions.

Constantinos et al. (2019) confirm a long-run asymmetric causal relationship between crude oil prices and carbon emissions, while indicating only short-term effects from carbon emissions to oil prices. Nevertheless, the authors underline the importance of environmental policies for sustainable economic growth.

Munir and Riaz (2020) highlight the asymmetric causal relationship between oil consumption and environmental degradation in Australia, China, and the United States, showing that increased oil consumption leads to higher carbon emissions in the long run in these countries.

Boufateh (2019) found that asymmetric oil price fluctuations affect CO_2 emissions differently in the United States and China, suggesting that rising energy prices potentially support pollution control in the U.S., whereas China’s growth priorities overshadow environmental concerns, thereby undermining the Environmental Kuznets Curve (EKC) hypothesis.

Ullah et al. (2020), examining the asymmetric effects of oil price changes on environmental pollution, show that positive and negative oil price shocks affect carbon emissions differently among the top ten carbon-emitting countries, emphasizing the need for targeted environmental policies.

Yaghoubi and Yaghoubi (2025) focus on the asymmetric effects of oil price volatility on corporate environmental responsibility, revealing that increases in oil prices lead to a greater decline in environmental scores compared to decreases, with financial constraints playing a key role.

Ajayi (2024) demonstrates that oil prices, energy consumption, and CO_2 emissions Granger-cause economic growth in high- and upper-middle-income countries, pointing to an asymmetric relationship. However, the effects are statistically insignificant for low- and lower-middle-income countries, highlighting disparities in environmental impacts.

Saboori et al. (2016) found that oil price fluctuations reduce environmental damage by negatively affecting the ecological footprint in countries such as Algeria, Ecuador, Iran, Kuwait, the UAE, and Venezuela. Higher oil prices reduce consumption, leading to lower emissions and mitigating environmental degradation in these countries.

Khan and Sun (2024) investigate the asymmetric relationships between energy growth and CO_2 emissions in BRICST countries, noting that both positive and negative shocks in energy consumption correspond to environmental degradation, thereby emphasizing the need for alternative energy sources and improved energy efficiency.

Ahmad et al. (2022) reveal a nonlinear asymmetric relationship between oil consumption and environmental pollution in Pakistan, India, and Bangladesh, showing that increased oil consumption leads to higher carbon emissions, while reducing oil usage can mitigate environmental degradation in the long run.

3. DATA AND METHODS

In this study, which investigates the asymmetric relationships among oil prices (OP), oil consumption (OC), and environmental degradation (CO_2), data on CO_2 emissions and oil consumption (in million tons) were obtained from the British Petroleum database, while crude oil prices (in USD per barrel) were retrieved from the International Energy Agency database using Brent crude prices. The natural logarithms of the variables were taken, and the analyses were conducted in terms of percentage changes. The dataset covers the period from 1993 to 2024.

In the literature, several approaches are available for causality analysis, including Granger (1969), Toda and Yamamoto (1995), and Hacker and Hatemi-J (2006). However, since the assumption of normally distributed errors may not always hold in these tests, bootstrapped critical values are often used to address this issue. Moreover, these traditional tests do not differentiate between shocks, assuming that positive and negative shocks have symmetric effects (Syzdykova et al., 2022).

In contrast, the Hatemi-J (2012) causality approach does not suffer from distributional distortions even when the dataset does not exhibit normality. More importantly, this method is based on the assumption that the effects of shocks on markets may differ depending on whether they are positive or negative, and therefore these shocks must be separated accordingly (Hatemi-J, 2012).

Given that the primary motivation of this study is to determine whether positive or negative shocks in one variable lead to different causal effects on the others, the asymmetric causality test developed by Hatemi-J (2012) is employed for the analysis.

In the case where the causal relationship between two different integrated series, γ_{1t} and γ_{2t}, is examined, the Hatemi-J (2012) asymmetric causality test follows the steps outlined below:

$$\gamma_{1t} = \gamma_{1t-1} + \varepsilon_{1t} = \gamma_{10} + \sum_{i=1}^{t} \varepsilon_{1i} \quad (1)$$

$$\gamma_{2t} = \gamma_{2t-1} + \varepsilon_{2t} = \gamma_{20} + \sum_{i=1}^{t} \varepsilon_{2i} \quad (2)$$

Here $t = 1,2,\ldots\ldots,T$; γ_{10} and γ_{20} are the initial values and ε_{1i} and ε_{2i} are the white noise error terms. Positive and negative shocks can be defined as follows:

$$\varepsilon_{1i}^{+} = \max(\varepsilon_{1i}, 0),\ \varepsilon_{2i}^{+} = \max(\varepsilon_{2i}, 0),\ \varepsilon_{1i}^{-} = \min(\varepsilon_{1i}, 0),$$
$$\varepsilon_{2i}^{-} = \min(\varepsilon_{2i}, 0) \quad (3)$$

It is also expressed as $\varepsilon_{1i} = \varepsilon_{1i}^{+} + \varepsilon_{1i}^{-}$ and $\varepsilon_{2i} = \varepsilon_{2i}^{+} + \varepsilon_{2i}^{-}$

Thus, the equations of γ_{1t} and γ_{2t} can be expressed as follows:

$$\gamma_{1t} = \gamma_{1t-1} + \varepsilon_{1t} = \gamma_{10} + \sum_{i=1}^{t} \varepsilon_{1i}^{+} + \sum_{i=1}^{t} \varepsilon_{1i}^{-} \quad (4)$$

$$\gamma_{2t} = \gamma_{2t-1} + \varepsilon_{2t} = \gamma_{20} + \sum_{i=1}^{t} \varepsilon_{2i}^{+} + \sum_{i=1}^{t} \varepsilon_{2i}^{-} \quad (5)$$

Finally, the positive and negative shocks of each variable can be described in a cumulative form as:

$$\gamma_{1t}^{+} = \sum_{i=1}^{t} \varepsilon_{1i}^{+},\ \gamma_{1t}^{-} = \sum_{i=1}^{t} \varepsilon_{1i}^{-},\ \gamma_{2t}^{+} = \sum_{i=1}^{t} \varepsilon_{2i}^{+},\ \gamma_{2t}^{-} = \sum_{i=1}^{t} \varepsilon_{2i}^{-} \quad (6)$$

The next step is to test the causal relationship between these components. Assuming that $\gamma_t^{+} = (\gamma_{1t}^{+}, \gamma_{2t}^{+})$, the causal relationship between positive cumulative shocks is obtained with the "P" lagged VAR (p) model as in equation (7):

$$\gamma_t^{+} = v + A_1\gamma_{t-1}^{+} + \ldots\ldots\ldots\ldots\ldots\ldots + A_p\gamma_{t-1}^{+} + u_t^{+} \quad (7)$$

4. RESULTS

Before presenting the findings on the asymmetric relationships between oil prices, oil consumption, and environmental degradation in Kazakhstan during the period 1993-2024, the stationarity levels of the variables and their respective decomposed components are examined. The results of the unit root tests for the variables and their components are provided in Tables 1 and 2.

When examining the unit root test results for the level and first difference values of the variables, it is observed that the series are non-stationary at their level values under both the constant and constant with trend models. However, all series become stationary after taking their first differences. When the variables are decomposed into their positive and negative components, some evidence of stationarity is found at different significance levels in level values; nevertheless, the series generally exhibit unit root behavior in levels. Therefore, both the original variables and their positive and negative components are stationary at their first differences. After identifying the unit root properties of the variables, the appropriate lag lengths required for the causality analysis were determined using the VAR model and are presented in Table 3.

According to the results of the VAR model, the optimal lag length was determined to be 1 for all the series to be analyzed for causality. At this lag length, all diagnostic test conditions were found to be satisfied. The subsequent step involves the presentation of the findings from the asymmetric causality analysis, which are provided in Table 4.

According to the findings presented in Table 4, the null hypothesis stating that positive and negative shocks in oil prices do not cause positive and negative shocks in oil consumption cannot be rejected at any conventional level of significance. The same result holds for the causality running from oil consumption to oil prices. That is, neither increases nor decreases in oil prices significantly affect oil consumption, and similarly, changes (shocks) in oil consumption do not significantly influence oil prices. In other words, there is no evidence of bidirectional causality between these two Yesiables.

This suggests that oil price fluctuations are not a driving factor behind oil consumption patterns in Kazakhstan. It may indicate that pricing policies—such as subsidies or tax-based interventions—fail to produce the expected influence on consumption behavior. Likewise, since fluctuations in consumption levels do not affect prices, it can be inferred that the price mechanism based on supply-demand equilibrium either functions weakly or is more dependent on external factors such as global market dynamics or exchange rate fluctuations.

In a petroleum-rich country like Kazakhstan, it is likely that domestic oil consumption is relatively stable or determined independently of domestic price changes. Government subsidies

Table 1: Unit root test results for the variables (level values)

Variables	ADF unit root test		Phillips Perron (PP) test	
	Intercept	Intercept and Trend	Intercept	Intercept and Trend
$lnop$	−1.772 (0.213)	−2.722 (0.303)	−1.772 (0.787)	−2.644 (0.203)
$lnop^+$	−2.437 (0.345)	−2.868 (0.760)	−4.432 (0.303)	−5.007 (0.308)
$Lnop^-$	−2.499 (0.701)	−3.113 (0.310)	−7.147 (0.768)	−6.738 (0.103)
$lnoc$	−0.979 (0.309)	−3.803 (0.608)	−1.021 (0.706)	−2.326 (0.730)
$Lnoc^+$	−4.247 (0.764)	−4.227 (0.786)	−2.742 (0.786)	−2.236 (0.465)
$Lnoc^-$	−3.173 (0.342)	−3.133 (0.402)	−3.573 (0.231)	−3.875 (0.783)
$lnCO_2$	−1.010 (0.437)	−3.188 (0.378)	−1.124 (0.347)	−2.825 (0.230)
$lnCO_2^+$	−3.031 (0.976)	−3.225 (0.865)	−5.054 (0.101)	−5.384 (0.103)
$lnCO_2^-$	−5.395 (0.705)	−5.808 (0.867)	−6.172 (0.403)	−6.285 (0.088)

The values in parentheses represent the P-values. The+and – signs above the series denote the positive and negative components of the respective series

Table 2: Unit root test results for the variables (first difference values)

Variables	ADF unit root test		Phillips Perron (PP) test	
	Intercept	Intercept and Trend	Intercept	Intercept and Trend
$lnop$	−6.423 (0.000)*	−6.319 (0.000)*	−8.175 (0.000)*	−8.088 (0.000)*
$lnop^+$	−6.381 (0.000)*	−6.159 (0.000)*	−20.435 (0.000)*	−18.385 (0.000)*
$Lnop^-$	−4.858 (0.000)*	−4.623 (0.000)*	−11.790 (0.000)*	−10.778 (0.000)*
$lnoc$	−5.861 (0.000)*	−5.652 (0.000)*	−5.894 (0.000)*	−5.787 (0.000)*
$Lnoc^+$	−6.622 (0.000)*	−6.510 (0.000)*	−17.322 (0.000)*	−16.806 (0.000)*
$Lnoc^-$	−5.448 (0.000)*	−5.199 (0.000)*	−11.197 (0.000)*	−11.308 (0.000)*
$lnCO_2$	−6.361 (0.000)*	−6.452 (0.000)*	−7.545 (0.000)*	−6.660 (0.000)*
$lnCO_2^+$	−6.620 (0.000)*	−6.596 (0.000)*	−20.717 (0.000)*	−20.582 (0.000)*
$lnCO_2^-$	−8.213 (0.000)*	−6.559 (0.000)*	−14.751 (0.000)*	−14.827 (0.000)*

The values in parentheses represent the P-values. The+and – signs above the series denote the positive and negative components of the respective series. Additionally, Δ indicates the first difference of the variables, and the * symbol denotes statistical significance at the 1% level

Table 3: Optimal lag length selection results for the VAR model

Variables	**Optimal lag selection for the VAR model**	Diagnostic tests at the optimal lag length		
		Autocorrelation (LM)	Heteroscedasticity (White)	Normality (Jarque-Bera)
$lnop – lnoc$	1	7.678 (0.104)*	14.558 (0.428)*	4.148 (0.544)*
$lnoc – lnco_2$	1	4.442 (0.464)*	6.681 (0.877)*	4.244 (0.518)*
$lnop – lnco_2$	1	1.267 (0.866)*	8.884 (0.617)*	4.474 (0.457)*

The appropriate lag length in the VAR model was determined according to the Schwarz (SIC) information criterion. The values in parentheses indicate the probability values of the test statistics, and * indicates the 1% significance level

Table 4: Asymmetric causality findings

H_0 hypothesis	Test value	Bootstrap critical values			Decision
		1%	5%	10%	
$lnop^+ \nRightarrow lnoc^+$	2.166	10.707	5.717	3.713	No
$lnop^- \nRightarrow lnoc^-$	0.799	11.739	6.126	3.960	No
$lnop^+ \nRightarrow lnoc^-$	0.056	12.660	5.711	3.600	No
$lnop^+ \nRightarrow lnoc^+$	0.122	11.550	5.743	3.202	No
$lnoc^+ \nRightarrow lnop^+$	0.150	12.677	5.620	3.575	No
$lnoc^- \nRightarrow lnop^-$	0.170	10.371	5.699	3.745	No
$lnoc^+ \nRightarrow lnop^-$	0.019	10.512	5.351	3.437	No
$lnoc^- \nRightarrow lnop^+$	0.129	11.909	5.603	3.666	No
$lnoc^+ \square lnCO_2^+$	0.152	22.791	5.954	3.377	No
$lnoc^- \square lnCO_2^-$	5.651	11.293	5.577	3.571	Yes **
$lnoc^+ \square lnCO_2^-$	1.955	10.311	5.371	3.462	No
$lnoc^- \square lnCO_2^+$	0.050	13.956	6.216	3.734	No
$lnCO_2^+ \square lnoc^+$	0.365	12.722	5.597	3.457	No
$lnCO_2^- \square lnoc^-$	5.232	11.773	5.520	3.333	Yes ***
$lnCO_2^+ \square lnoc^-$	0.259	12.717	5.692	3.637	No
$lnCO_2^- \square lnoc^+$	0.010	12.530	5.729	3.522	No
$lnop^+ \square lnCO_2^+$	5.315	23.037	7.343	4.207	Yes ***
$lnop^- \square lnCO_2^-$	15.356	17.221	5.659	3.977	Yes**
$lnop^+ \square lnCO_2^-$	0.523	13.305	5.261	3.404	No
$lnop^- \square lnCO_2^+$	0.005	15.916	5.025	3.051	No
$lnCO_2^+ \square lnop^+$	0.575	10.335	5.206	3.206	No
$lnCO_2^- \square lnop^-$	0.019	10.570	4.757	3.059	No
$lnCO_2^+ \square lnop^-$	0.266	17.390	6.043	3.606	No
$lnCO_2 \square lnop^+$	2.351	10.717	5.126	3.257	No

The expression X⇏Y represents that variable X does not cause variable Y. + and - signs indicate positive and negative shocks, respectively. ** and *** indicate 5% and 10% significance levels, respectively. The bootstrap number was taken as 10,000 when generating critical values

on oil prices or consumption patterns that operate somewhat independently of broader economic activity could help explain this outcome.

If the price mechanism is not effective in influencing consumption, it implies that price-based policies alone may be insufficient for achieving environmental sustainability targets through reduced oil consumption. In such cases, more direct interventions—such as regulatory measures or incentives for alternative energy adoption—may be necessary. In conclusion, the absence of a significant causal relationship between oil prices and consumption offers an important message for policymakers. It highlights that strategies aimed at managing energy consumption based solely on price signals may prove ineffective in the context of Kazakhstan, underscoring the need for more comprehensive and structural policy approaches.

Regarding the bidirectional causal relationship between oil consumption and environmental degradation (emissions), the results reveal that negative shocks in oil consumption—i.e., a reduction in consumption—lead to negative shocks in emissions (a decrease). Conversely, a decline in emissions also causes a reduction in oil consumption. These findings confirm the expected environmental-economic relationship: as consumption decreases, emissions also decline.

The reduction in fossil fuel consumption—such as oil—directly results in lower greenhouse gas emissions, representing a causal direction frequently observed in the classical environment-economy literature. On the other hand, a decline in emissions leading to lower oil consumption may indicate that environmental regulations or green transition policies exert downward pressure on energy use. For instance, carbon taxes, environmental standards, or technological transformation may simultaneously reduce both emissions and fossil fuel consumption.

This bidirectional and symmetric causality is of high relevance for policymakers: Policies aimed at reducing oil consumption will bring about environmental benefits. Similarly, environmental policies that aim to reduce emissions—such as carbon pricing or incentives for green energy—may also lead to a decrease in energy consumption. This outcome suggests that in the context of Kazakhstan's sustainable development goals, energy and environmental policies should be integrated in a mutually reinforcing manner.

As for the bidirectional relationship between oil prices and emissions, the results indicate that positive shocks in oil prices cause positive shocks in emissions, and negative shocks in oil prices lead to negative shocks in emissions. At first glance, this may appear counterintuitive, as conventional expectations suggest that "price increase → consumption decrease → emission reduction." However, in the specific context of Kazakhstan, this can be interpreted differently.

An increase in oil prices likely coincides with increased economic activity or a rise in oil production, which in turn may elevate industrial activities and hence emissions. In oil-exporting countries, price increases are often associated with economic expansion and higher production levels, both of which intensify environmental impacts. Conversely, a drop in oil prices may reflect economic slowdown or stagnation in the energy sector, resulting in lower production and energy use and thereby reducing emissions.

Lastly, no significant causal relationship is found from emissions (both positive and negative shocks) to oil prices. This is also noteworthy, as emissions levels are generally outcomes—not drivers—of price dynamics. Market actors typically price oil based on geopolitical developments, production costs, and demand projections, rather than environmental conditions. The evidence suggests a unidirectional structure where oil prices influence environmental outcomes, but environmental Yesiables do not have a significant impact on price formation.

This underscores the importance of integrating environmental protection strategies into price mechanisms in Kazakhstan, while acknowledging that such strategies are unlikely to influence oil prices directly. Especially during periods of high prices, emission control becomes even more critical, as these periods are associated with upward pressure on emissions.

5. CONCLUSION

The primary objective of this study is to investigate the asymmetric causal relationships between oil prices (OP), oil consumption

(OC), and environmental degradation (measured by CO□ emissions) in the context of the Kazakhstani economy. To this end, annual data covering the period from 1993 to 2024 have been utilized, and the asymmetric causality test developed by Hatemi-J (2012) has been employed.

According to the empirical findings, there is no evidence of a bidirectional causality between oil prices and oil consumption. In other words, positive or negative shocks in oil prices do not significantly affect oil consumption, and conversely, shocks in oil consumption do not exert a meaningful influence on oil prices. This result suggests that energy prices have a limited impact on consumption behavior in Kazakhstan.

On the other hand, a statistically significant and bidirectional relationship is observed between oil consumption and environmental degradation. In particular, there is mutual causality in response to negative shocks; a decrease in oil consumption reduces CO_2 emissions, and simultaneously, a decline in emissions leads to lower consumption. This finding indicates that environmental and energy policies should be designed in a complementary manner.

Furthermore, a bidirectional but asymmetric causal relationship is also identified between oil prices and environmental degradation. While increases in oil prices lead to higher CO_2 emissions, price decreases are associated with emission reductions. However, changes in emissions do not have a statistically significant effect on oil prices.

As a policy implication, it is crucial to develop an integrated set of policies in Kazakhstan that simultaneously target both energy consumption and environmental degradation in alignment with sustainable development goals. The price mechanism alone is insufficient; policy measures must include enhanced energy efficiency, the promotion of renewable energy sources, and the implementation of environmental regulations concurrently.

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