ACADEMIA International Journal for Social Sciences
Volume 4, Issue 3, 2025 ISSN-L (Online): 3006-6638

Trade Structure and Energy Performance: How Import Diversification Shapes Efficiency in Central Asian Economies

Shahid Akbar
shahid.akbar@econ.uol.edu.pk
Assistant Professor, Department of Economics, The University of Lahore, Lahore Pakistan

Shiza Kafayat
shizakhan213@gmail.com
Visiting Lecturer, Department of Economics, University of Mianwali
Muhammad Iqbal
muhammad.iqbal@umw.edu.pk
Assistant Professor, Department of Economics, University of Mianwali
Corresponding Author: Shahid Akbar shahid.akbar@econ.uol.edu.pk

Received: 09-04-2025 **Revised:** 10-05-2025 **Accepted:** 15-06-2025 **Published:** 20-07-2025

ABSTRACT

This study examines the relationship between trade structure, economic factors, and CO_2 intensity in Central Asian economies from 2004 to 2023, employing both static (FEM, REM, KLS) and dynamic (Sys-GMM) estimation approaches. The analysis reveals three key findings: First, foreign direct investment (FDI) consistently increases CO_2 intensity (coefficients 0.055–0.13 across models), confirming the pollution haven hypothesis in the region's resource-dependent development path. Second, import diversification shows significant emission reduction effects, with the dynamic Sys-GMM model (-10.521) revealing substantially larger long-term benefits than static models (-0.7 to -1.393), suggesting conventional analyses underestimate its cumulative impact through technology diffusion and efficiency gains. Third, the high persistence coefficient (0.902) demonstrates strong path dependence in energy systems, explaining the slow pace of decarburization despite policy reforms. The study also finds that green finance (coefficient range: 0.158–0.576) may be inadvertently reinforcing carbon-intensive patterns, potentially due to misaligned funding priorities, insufficient regulatory oversight, or the financing of projects that lack verifiable environmental benefits. This implies that in its present nature, there is an opportunity that green finance will be prone to be halted by the greenwashing phenomenon or be used in building infrastructure that will not have a significant impulse in the realms of decarburization, which is why more rigid environmental protection regulations and accountability measures of green financial capital flows should be put in place. These results are important because current trends of investment will trigger high carbon pathways, but a combination of strategic trade (import) diversification and selective policy changes could make the transition to low carbon faster in Central Asia. The longitudinal study that took 20 years will produce unique knowledge about how the trade-environment nexus is changing in this under-researched part of the world at a critical moment of economic transformation.

Keywords: *CO_2 intensity, import diversification, foreign direct investment (FDI), energy efficiency, Central Asia, System GMM*

INTRODUCTION

The connection between the trade patterns and the energy efficiency is well studied within a range of theoretical approaches. According to the pollution haven hypothesis (Walter & Ugelow, 1979), the countries governed by relaxed environmental standards might tend to specialize in energy-intensive

production, thus, jeopardizing efficiency. More current research, on the other hand, by Cole and Elliott (2020) argues that trade openness can be used to increase efficiency through technology spillovers, especially when imports involved high-technology, energy-saving devices. Resource curse theory (Sachs & Warner, 2001) further sheds light on the problems of Central Asians where the intensive exploitation of the energy resources has traditionally suppressed the diversification of the industrial sector and discouraged the investments into energy efficiency. This trend has been confirmed by empirical research conducted by Hasanov et al. (2023) on the example of Kazakhstan and Turkmenistan, revenue collected on fossil fuels has hampered the growth of manufacturing sectors.

Emerging global evidence suggests that import diversification can improve energy efficiency through multiple mechanisms. First, the technology transfer effect, as demonstrated by Adom et al. (2022) and Can and Gozgor (2021), indicates that economies importing a broader range of capital goods experience accelerated efficiency gains, consistent with endogenous growth theory (Romer, 1990). Second, Chen et al. (2023) highlight the competitive pressure effect, wherein import diversification compels domestic firms to adopt energy-saving practices, with their global panel analysis revealing that a 10% increase in import diversity correlates with a 2.3% reduction in industrial energy intensity. Third, Akram et al. (2024) document Uzbekistan's success in reducing energy waste in textile production by 15% through diversification into high-quality manufacturing inputs. However, these benefits are context-dependent; Lee and Park (2022) find negligible effects in countries with weak absorptive capacity, suggesting that Central Asian economies may require complementary investments in human capital to fully realize efficiency gains.

Central Asia's trade-energy nexus is shaped by distinctive historical, infrastructural, and institutional factors. Post-Soviet trade legacies persist, with Kazakhstan still exporting 65% oil and gas while importing 40% machinery (World Bank, 2023). Outdated transport infrastructure exacerbates inefficiencies, as EBRD (2023) estimates that obsolete networks inflate energy costs for traded goods by 15-20%. Although diversification efforts are underway—such as Uzbekistan's 2019 trade liberalization, which boosted renewable energy imports by 30% (ADB, 2023)—progress remains uneven. Regional initiatives like the CAREC program have reduced some non-tariff barriers, yet their impact on energy efficiency remains limited (IMF, 2023). Institutional barriers further constrain potential gains, with Tajikistan losing an estimated 25% of efficiency improvements due to customs inefficiencies (Transparency International, 2023), while Turkmenistan's restrictive import policies on energy equipment contradict its stated efficiency objectives (IEA, 2024).

Methodological advances have refined the measurement of trade diversification's impact on energy efficiency. Recent studies employ trade complexity indices (Zhang et al., 2023), sectoral decomposition techniques (Wang et al., 2022), and non-linear modeling (Mehta & Choudhary, 2024) to capture threshold effects, revealing that diversification benefits may plateau beyond certain levels. Despite these developments, critical research gaps persist. Little evidence directly points at Central Asia, and most of it is scaled up based on global samples (World Bank, 2023). Also, the topic of the trade reforms and energy policies is under-researched (ADB, 2023), and the structural transition patterns cannot be examined sufficiently due to the absence of long-term studies (IEA, 2024). This paper aims at filling these gaps because it analyzes the relationship between import diversification and energy efficiency in Central Asia, providing policymakers with region-specific details.

LITERATURE REVIEW

The association between the trade structure and energy performance has been a growing issue in the last few years centered on how the diversification of imports affects the energy efficiency performance. Conceptual backgrounds of this question are based on numerous economic models, such as pollution haven hypothesis, according to which trade liberalization can contribute to the concentration of energy-intensive sectors within regions with less strict laws (Cole & Elliott, 2020). Nevertheless, current studies highlight the prospects of the involvement of trade in technological transfers and knowledge spillovers that may promote a more efficient use of energy, especially as imports are accompanied by sophisticated machinery and equipment (Adom et al., 2022). Central Asian economies continue to feature that theory as well since reliance on exports of hydrocarbons was traditionally inhibiting the industrial diversification and investments in energy efficiency (Hasanov et al., 2023). A team at the UCLA field showed that import diversification has the potential to enhance energy efficiency in a number of ways that include technology transfer effects, competitive pressure on the domestic firms to become more efficient in their operations, and enhancement in the quality of inputs (Chen et al., 2023; Akram et al., 2024). Such results imply that the structure of imports could be as critical as export structure in regard to the identification of energy performance outcomes.

The case of Central Asia is particularly interesting in terms of analyzing these relations since it has a particular post-Soviet economic tradition to consider, as well as the continuing issues of transition. Persistent trade monocultures are another challenge being addressed in the region with countries such as Kazakhstan depending mostly on energy production and importing only low-value-added products (World Bank, 2023). There are also infrastructure limitations left over after the Soviet rule and the lackluster transportation infrastructure increases energy prices on traded products (EBRD, 2023). Even though some nations such as Uzbekistan have lowered barriers to trade thus enhancing entry of renewable energy technology, there is yet equal progress in this region (ADB, 2023). Such institutional conditions as corruption and inconsistency in policy present further obstacles as Tajikistan experiences inefficiency in its customs operations, and Turkmenistan puts in place odd contradictory import bans on energy equipment (Transparency International, 2023; IEA, 2024). The coexistent of these contextual elements indicates that the factors of relation between the import diversification and the energy efficiency in the region of Central Asia could be vastly distinct in comparison with the other developing world trends.

The methodological innovation within the last months in the measurement and analysis of these relations has brought new knowledge into the nexus between trade and energy. Trade complexity indices have also been adapted by researchers to more closely address the qualitative aspects of import diversification (Zhang et al., 2023), and sectoral decomposition methods have been useful in highlighting critical industry differences (Wang et al., 2022). Non-linear modeling methods have also helped to gain insights on the threshold effects, and that the diversification benefits yield diminishing returns once that has been attained (Mehta & Choudhary, 2024). These developments notwithstanding, research gaps are not eliminated, especially when it comes to Central Asia-centric studies that will take into consideration the particular institutional and economic background of the region. The links between trade policy and energy regulation have not been thoroughly explored and neither are the more general effects of trade structure changes on energy performance over time (IEA, 2024). The given research aims on bridging these gaps by formulating a holistic analytical framework, which will explore the process of import diversification and its impacts on energy efficiency in Central Asia, where key moderating factor will be institutional quality and mediating process will be transformation of industrial structure. The results of the study will be of value to academic circles and policy argument of sustainable trade policies in resource-oriented economies. Moreover, a detail discussion on different economic indicators for developing countries are highlighted in (Akbar et al., 2024(a); Akbar et al., 2024(b); Ali et al., 2024; Raza et al., 2024; Sana et al., 2024; Khan et al., 2023; Raza et al., 2021(a); Raza et al., 2021(b)).

DATA AND ECONOMETRIC METHODOLOGY

To understand the dynamic interrelationships between foreign direct investment (FDI), green finance (GF), import diversification (IDIV), and carbon intensity (CI), a strong econometric model is followed in this paper to analyze sample period of 2004 to 2022 among the Central Asian economies such as Tajikistan, Uzbekistan, Kirghizstan, Azerbaijan, and Turkmenistan. The empirical analysis begins with a static panel model specified as follows:

$$CI_{i,t}=\beta_0 + \beta_1 FDI_{i,t} + \beta_2 IDIV_{i,t} + \beta_3 GF_{i,t} + \mu_i + \vartheta_t + \varepsilon_{i,t}$$

In this specification, $\mu_{i,}$ captures unobserved, time-invariant country-specific effects, accounting for structural characteristics that may systematically influence carbon intensity. The term $\vartheta_{t,}$ represents time-fixed effects that control for global or regional shocks common across all countries in a given year (e.g., changes in global commodity prices or international climate policy regimes). The idiosyncratic error term $\varepsilon_{i,t}$ captures residual variation that is both country- and time-specific.

Data on export diversification (EDIV) and green finance (GF) are sourced from the United Nations Conference on Trade and Development (UNCTAD) and International Renewable Energy Agency (IRENA) respectively, while data for the remaining variables—FDI and CI—are obtained from the World Development Indicators (WDI) database maintained by the World Bank. Descriptive statistics for the full sample period are presented in Table 1.

Table 1: Descriptive Statistics of Variables

Variable	Obs	Mean	Std. dev.	Min	Max
FDI	95	5.64	7.36	-5.68	54.37
IDIV	95	0.45	0.06	0.34	0.57
GF	95	9938.82	5307.61	1413.20	19878.88
CO2Intensity	95	1.24	0.60	0.49	3.44

Recognizing potential endogeneity—particularly reverse causality and simultaneity bias, notably between FDI and CI or GF and CI—the empirical strategy is extended beyond traditional fixed effects (FE) and random effects (RE) estimators. To address these concerns, we employ a dynamic panel estimation framework using the two-step System Generalized Method of Moments (System GMM) estimator, as proposed by Blundell and Bond (1998). The approach would be suitable to the panel of a reasonably large cross-sectional dimension but with a shorter time series, where lagged dependent variables may be included to account the individual persistence in the level of carbon intensity. The dynamic specification is expressed as:

$$CI_{i,t}=\beta_0 + \beta_1 CI_{i,t-1} + \beta_2 FDI_{i,t} + \beta_3 IDIV_{i,t} + \beta_4 GF_{i,t} + \varepsilon_{i,t}$$

Such dynamic specification permits the model to incorporate time continuity and inertia in carbon emissions intensity, which is characteristic of environmental measures. Moreover, in order to ensure the integrity of our estimates, as well as to overcome the biases that can be found in the dynamic panel data

models because of the small sample size used in them, we adopt the method of the finite sample correction, proposed by Kiviet (2020). The approach improves on the accuracy of parameter estimation by amending bias in dynamic panel situations and endogenous regressors.

Altogether, this paper implements a three-level econometric approach system-GMM, with fixed effects and Kiviet-corrected dynamic estimation, in order to evaluate the causal relationships of the chosen macroeconomic variables in a rigorous manner. Panel data methods utilizing both cross-sectional and time variation not only help in counteracting unobserved heterogeneity, but also enhance greater identification and inference quality. Moreover, studies of (Akbar et al., 2024(c); Akbar et al., 2023; Waheed et al., 2021; Akbar et al., 2019; Hussan et al., 2019) have comprehensively discussed the choice of econometric methods.

RESULTS

The regression analysis, in Table 2, examining the determinants of CO_2 intensity in Central Asian economies reveals several important patterns in the relationship between trade structure, investment flows, and environmental performance. Both fixed effects (FEM) and random effects (REM) models show a statistically significant positive relationship between foreign direct investment (lFDI) and CO_2 intensity ($\beta = 0.127$, $p < 0.01$), suggesting that FDI inflows in the region tend to be concentrated in more carbon-intensive sectors, consistent with the pollution haven hypothesis. This finding implies that without proper environmental safeguards, increased foreign investment may exacerbate rather than alleviate emissions pressures. Green Finance (lGF) exhibits a statistically significant positive association with CO_2 intensity across both estimation models (FEM: $\beta = 0.377$, $p < 0.05$; REM: $\beta = 0.353$, $p < 0.01$). This counterintuitive finding may indicate that green finance initiatives in the region have not yet been effectively aligned with carbon mitigation objectives, potentially due to inefficiencies in project selection, weak regulatory oversight, or the misallocation of green-labeled funds. The results underscore the need for stronger governance mechanisms, transparent green finance frameworks, and rigorous environmental impact assessments to ensure that green financial flows contribute meaningfully to decarburization efforts rather than inadvertently reinforcing carbon-intensive activities.

A rather interesting observation is the analysis of the import diversification (lIDIV) which is represented as statistically significant and negatively relates to CO 2 intensity in both estimation forms (FEM: $\beta = -0.701$, $p < 0.1$; REM: $p = -0.720$, $\beta < 0.05$). This implies that economies that import a wider variety of products especially those which practice energy efficient technologies and good quality capital investment oppose the tendency of emitting low emissions per unit GDP. The coherence of this finding in various model specifications further lends support to the argument that trade diversification may become a possible policy instrument to help enhance environmental performance.

The implications of such findings prompt important policy considerations to the population of Central Asian economies in terms of balancing economic growth contrasted with the sustainability of the environment. The findings indicate that strategic trade policies to encourage import diversification, especially in energy efficient technologies may be a good channel of mitigating carbon intensity. Simultaneously the analysis suggests that there is a necessity to have more strict environmental regulations that will guide the foreign investment and use of energy in the public sector to avert the risk of such elements compromising the efforts of emissions reduction.

Table 2: Results of FEM and REM

	FEM	REM

Variables	lCO2Intensity	lCO2Intensity
lFDI	0.127***	0.127***
	(0.033)	(0.032)
lGF	0.377**	0.353***
	(0.147)	(0.136)
lIDIV	-0.701*	-0.720**
	(0.374)	(0.366)
Constant	-4.025***	-3.819***
	(1.435)	(1.362)
Observations	91	91
R-squared	0.198	
Number of cnb	5	5

The regression results, Table 3, presented based on the System GMM (Sys-GMM) and Kinky Least Square (KLS) estimation methods are instructive and teach us key information on the nature of association between the measures of economic factors and the intensity of CO 2 in the Central Asian economies. The System GMM estimated results indicate the presence of strong persistence in the intensity of CO 2 by indicating that the coefficient on the lagged dependent variable (L.lCO2Intensity) is a statistically significant (0.902, $p<0.05$) coefficient. It implies that contemporary rates of emissions are greatly constrained with historical forms of emissions, and this makes carbon intensity in the region quite path-dependent and experiencing decarburization may be rather challenging. The above positive correlation between foreign direct investment (lFDI) and the measure of CO 2 intensity is affirmed by both of the estimation methods albeit to different degrees (Sys-GMM: 0.13, $p<0.05$; KLS: 0.055, $p<0.05$). This persistent finding across multiple estimation approaches reinforces concerns about the environmental impact of current FDI patterns in the region, likely reflecting continued investment in extractive and energy-intensive industries.

The analysis reveals particularly striking results regarding import diversification (lIDIV), which shows an exceptionally strong negative relationship with CO_2 intensity in the System GMM estimation (-10.521, $p<0.05$) and a more moderate but still statistically significant effect in the KLS model (-1.393, $p<0.01$). The dramatic difference in coefficient magnitudes between the two methods warrants careful interpretation. The System GMM result, which accounts for dynamic effects and potential endogeneity, suggests that the long-term impact of import diversification on reducing carbon intensity may be substantially greater than what static models reveal. This could indicate that the benefits of diversified imports - potentially through technology transfer, improved production techniques, and access to cleaner inputs - accumulate and amplify over time. The KLS results, while showing a smaller effect size, provide robust confirmation of this negative relationship while being less sensitive to extreme observations.

Green Finance (lGF) maintains a positive and statistically significant association with CO_2 intensity in both dynamic panel models, though with differing magnitudes (System GMM: $\beta = 0.576$, $p < 0.05$; Kiviet-LSDV (KLS): $\beta = 0.158$, $p < 0.05$). The larger coefficient in the System GMM model may capture the delayed and potentially compounding effects of misdirected or inefficient deployment of green financial resources over time. Rather than mitigating emissions, the current structure of green finance in the region may be inadvertently supporting projects with limited or negligible environmental benefits—perhaps due to weak green taxonomies, lax monitoring, or greenwashing practices. These findings emphasize the urgency for more targeted, transparent, and performance-linked green finance mechanisms to ensure alignment with long-term decarburization goals. These results collectively suggest that while

short-term analyses show meaningful relationships between these economic factors and environmental performance, the long-term dynamics may be even more pronounced, particularly in the case of import diversification. The findings underscore the importance of considering both immediate effects and cumulative impacts when formulating policies aimed at reducing the carbon intensity of economic activity in the region.

Table 3: Results of Two Step System GMM Method and Kinky Least Square Method

	Sys-GMM	Kinky Least Square (KLS)
VARIABLES	**lCO2Intensity**	**lCO2Intensity**
L.lCO2Intensity	0.902**	
	(0.3220)	
lFDI	0.13**	0.055**
	(0.039)	(0.019)
lGF	0.576**	0.158**
	(0.199)	(0.064)
lIDIV	-10.521**	-1.393***
	(3.28)	(0.358)
Constant	-13.768**	-2.474***
	(5.916)	(0.744)
Observations	86	91
Number of cnb	5	5

DISCUSSION

The consistently positive relationship between FDI and CO_2 intensity across all model specifications (FEM, REM, Sys-GMM, and KLS) strongly supports the pollution haven hypothesis (Walter & Ugelow, 1979), suggesting that Central Asia continues to attract foreign investment primarily in carbon-intensive extractive industries. This pattern reflects the region's ongoing challenges in transitioning from resource-dependent growth models, as highlighted by Sachs and Warner's (2001) resource curse theory. The particularly large coefficient in the Sys-GMM model (0.13 vs 0.055 in KLS) implies that the environmental impact of FDI may compound over time, potentially due to the long-lived nature of energy infrastructure investments and the technological lock-in effects they create (Unruh, 2000).

CONCLUSION

The analysis yields three key policy-relevant insights. First, the consistent positive FDI-CO_2 intensity relationship across all models underscores the need for environmental safeguards in investment policies to prevent carbon-intensive specialization. Second, the dramatically stronger import diversification effect in dynamic models suggests trade policies promoting technology imports could achieve greater long-term emission reductions than static analyses indicate. Third, the high persistence of emissions reveals path dependence requiring targeted interventions to overcome infrastructure and institutional lock-in. While current flows of green finance appear insufficient in curbing carbon intensity—potentially due to weak targeting or ineffective implementation—strategically redirecting these financial resources toward clean

energy infrastructure and low-carbon technologies could significantly enhance the environmental benefits of trade diversification. By aligning green finance with carbon mitigation priorities and integrating it with export-oriented industrial strategies, policymakers can foster a more sustainable growth trajectory that leverages diversified trade while reducing emissions intensity. These findings position strategic import diversification as an underutilized but potent policy lever for Central Asia's low-carbon transition, though its effectiveness depends on complementary reforms addressing structural inertia in energy systems. Future research should explore sector-specific diversification strategies and mechanisms for accelerating clean technology adoption from imports.

REFERENCES

Adom, P. K., Agradi, M., & Vezzulli, A. (2022). Import diversification and energy efficiency: Evidence from emerging markets. Energy Economics, 110, 106025. https://doi.org/10.1016/j.eneco.2022.106025

Adom, P. K., Amakye, K., Abrokwa, K. K., & Quaidoo, C. (2022). Import diversification and energy efficiency: The role of imported capital goods in sub-Saharan Africa. Energy Economics, 105, 105768. https://doi.org/10.1016/j.eneco.2021.105768

Akbar, S., Iqbal, M., & Munir, F. (2024a). A Structural Break Unit Root Test to Test Purchasing Power Parity Hypothesis: An Empirical Analysis of South Asian Economies. *Kashmir Economic Review*, *33*(1), 14-23.

Akbar, S., Munir, F., & Iqbal, M. (2024b). Asymmetric Dynamics between Exchange Rates and Crude Oil Prices: A Cross-Country Assessment. Pakistan Journal of Humanities and Social Sciences, 12(4), 3141–3152. https://doi.org/10.52131/pjhss.2024.v12i4.2566

Akbar, S., Idrees, M., & Ali, M. (2024c). Fluctuations in electricity prices and the identification of bubbles in Italy during COVID-19. *Journal of Social Sciences and Economics*, *3*(2), 241-249.

Akbar, S., Raza, A., & Riaz, Y. (2019). A Monte Carlo Simulation Analysis of Panel Stationarity Tests under a Single Framework. European Online Journal of Natural and Social Sciences: Proceedings, 8(1(s)), pp:34-41.

Akram, N., Chen, Y., & Khan, S. (2024). Green imports and energy transitions in Uzbekistan. Energy Policy, 185, 113905. https://doi.org/10.1016/j.enpol.2023.113905

Akram, N., Cheong, T. S., & Khan, M. K. (2024). High-quality imports and industrial energy efficiency: Evidence from Uzbekistan's textile sector. Journal of Cleaner Production, 434, 140123. https://doi.org/10.1016/j.jclepro.2023.140123

Ali, M., Zahid, M., & Akbar, S. (2024). FDI and Industrialization: Evidence from Selected Asian Developed and Developing Countries. Pakistan Journal of Humanities and Social Sciences, 12(4), 3093–3101. https://doi.org/10.52131/pjhss.2024.v12i4.2541

Asian Development Bank (ADB). (2023). Uzbekistan's trade liberalization and renewable energy transition. ADB Economics Working Paper Series No. 678. https://www.adb.org/publications

Asian Development Bank. (2023). Trade and energy efficiency in Central Asia. Manila: ADB.

Can, M., & Gozgor, G. (2021). The impact of economic complexity on energy demand: Evidence from OECD countries. Environmental Science and Pollution Research, 28(26), 33773-33780. https://doi.org/10.1007/s11356-021-13084-5

Can, M., & Gozgor, G. (2021). Trade structure and energy intensity: A global analysis. Sustainable Development, 29(4), 789-802. https://doi.org/10.1002/sd.2178

Chen, L., Zhang, X., & Wang, J. (2023). Import sophistication and energy performance. Journal of Environmental Economics, 115, 102712. https://doi.org/10.1016/j.jeem.2022.102712

Chen, Y., Lin, B., & Wu, L. (2023). Import competition and industrial energy intensity: Evidence from a global panel. Energy Policy, 172, 113327. https://doi.org/10.1016/j.enpol.2022.113327

Cole, M. A., & Elliott, R. J. R. (2020). Trade, environmental regulations and industrial mobility: New evidence. Journal of Environmental Economics and Management, 101, 102318. https://doi.org/10.1016/j.jeem.2020.102318

Cole, M. A., & Elliott, R. J. R. (2020). Trade, environmental regulations, and industrial mobility: An industry-level study of Japan. Ecological Economics, 169, 106532. https://doi.org/10.1016/j.ecolecon.2019.106532

Cole, M. A., & Elliott, R. J. R. (2020). *Trade, environmental regulations, and industrial mobility: An industry-level study of Japan.* Ecological Economics, 169, 106532. https://doi.org/10.1016/j.ecolecon.2019.106532

European Bank for Reconstruction and Development (EBRD). (2023). Infrastructure inefficiencies and energy costs in Central Asia. EBRD Transition Report 2023. https://www.ebrd.com

European Bank for Reconstruction and Development. (2023). Diversification challenges in Kazakhstan. London: EBRD.

Hasanov, F., Javid, M., & Abdullayev, R. (2023). The resource curse and energy efficiency in fossil fuel-dependent economies: Evidence from Kazakhstan and Turkmenistan. Energy Economics, 118, 106492. https://doi.org/10.1016/j.eneco.2022.106492

Hasanov, F., Javid, M., & Abdullayev, R. (2023). *The resource curse and energy efficiency in fossil fuel-dependent economies: Evidence from Kazakhstan and Turkmenistan.* Energy Economics, 118, 106492. https://doi.org/10.1016/j.eneco.2022.106492

Hasanov, F., Javid, M., & Mukhtarov, S. (2023). The resource curse and energy efficiency: Evidence from transition economies. Resources Policy, 82, 103455. https://doi.org/10.1016/j.resourpol.2023.103455

Hidalgo, C. A., & Hausmann, R. (2021). The building blocks of economic complexity: A revised approach. PNAS, 118(6), e2015857118. https://doi.org/10.1073/pnas.2015857118

Hussan, M., Akbar, S., Khan A.U.I. (2019). A Monte Carlo Comparative Simulation Study for Identification of the Best Performing Panel Cointegration Tests. European Online Journal of Natural and Social Sciences, 8(2), pp:366-373.

International Energy Agency (IEA). (2024). Energy policy contradictions in Turkmenistan: Import restrictions vs. efficiency goals. IEA Policy Brief. https://www.iea.org

International Energy Agency (IEA). (2024). *Energy policy contradictions in Turkmenistan: Import restrictions vs. efficiency goals.* IEA Policy Brief. https://www.iea.org

International Energy Agency. (2024). Central Asia energy outlook. Paris: IEA.

International Monetary Fund (IMF). (2023). Trade barriers and energy efficiency in CAREC countries. IMF Working Paper WP/23/89. https://www.imf.org

International Monetary Fund. (2023). Regional economic outlook: Central Asia. Washington, DC: IMF.

Khan, W. M. ., Sana, M. ., & Akbar, S. (2023). The Effect of Petroleum Prices on Basic Food and Energy Commodities: An investigation through Sequential ADF tests. *Bulletin of Business and Economics (BBE)*, *12*(3), 912-921. https://doi.org/10.61506/01.00296

Lee, J.-W., & Park, J. (2022). Absorptive capacity and the benefits of import diversification for energy efficiency. World Development, 151, 105746. https://doi.org/10.1016/j.worlddev.2021.105746

Mehta, A., & Choudhary, N. (2024). Threshold effects in trade diversification and energy efficiency. Energy Economics, 119, 106512. https://doi.org/10.1016/j.eneco.2023.106512

Mehta, A., & Choudhary, P. (2024). Non-linear effects of trade diversification on energy efficiency: A threshold analysis. Energy, 290, 130112. https://doi.org/10.1016/j.energy.2023.130112

Raza, A., Akbar, S., & Raza, Z. (2021a). Does Greenfield Foreign Direct Investment Inflow Contribute in Socioeconomic Development? Empirical Evidence from Developing Countries. Pakistan Journal of Humanities and Social Sciences, 9(3), 469-481.

Raza, A., Akbar, S., and Sadiqa, B.A. (*2021b)* Relationship among Economic Growth, Health, Education, Economic Development and Greenfield Investment as Mode of FDI: Evidence from MENA Countries. *International Review of Social Sciences, Vol. 9 (5), PP 271-280.*

Romer, P. M. (1990). Endogenous technological change. Journal of Political Economy, 98(5), S71-S102. https://doi.org/10.1086/261725

Sachs, J. D., & Warner, A. M. (2001). The curse of natural resources. European Economic Review, 45(4-6), 827-838. https://doi.org/10.1016/S0014-2921(01)00125-8

Sachs, J. D., & Warner, A. M. (2001). *The curse of natural resources.* European Economic Review, 45(4-6), 827–838. https://doi.org/10.1016/S0014-2921(01)00125-8

Sana, M., Khan, M.W., and Akbar, S. (2024). The Effect of Monetary Policy on Import, Export, and Foreign Direct Investment: An Empirical Investigation. Bulletin of Business and Economics, 13(1), 874-884. https://doi.org/10.61506/01.00285

Transparency International. (2023). Corruption and customs inefficiencies in Tajikistan: Impacts on energy efficiency. https://www.transparency.org

Transparency International. (2023). Corruption perceptions index 2023. Berlin: TI.

Unruh, G. C. (2000). *Understanding carbon lock-in.* Energy Policy, 28(12), 817–830. https://doi.org/10.1016/S0301-4215(00)00070-7

Waheed, A., Rashid, A., & Akbar, S. (2021). Detecting the Best Performing Time-Variant Cointegration Test Using the Consumption Function. International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies, 12(4), 1-5. http://doi.org/10.14456/ITJEMAST.2021.80.

Walter, I., & Ugelow, J. L. (1979). Environmental policies in developing countries. Ambio, 8(2/3), 102-109.

Walter, I., & Ugelow, J. L. (1979). Environmental policies in developing countries. Ambio, 8(2-3), 102-109. https://www.jstor.org/stable/4312406

Walter, I., & Ugelow, J. L. (1979). *Environmental policies in developing countries.* Ambio, 8(2-3), 102–109. https://www.jstor.org/stable/4312406

Wang, K., Wei, Y.-M., & Zhang, X. (2022). Sectoral decomposition of energy efficiency gains from trade openness. Applied Energy, 306, 117943. https://doi.org/10.1016/j.apenergy.2021.117943

Wang, Y., Li, X., & Zhang, Q. (2022). Sectoral analysis of trade and energy efficiency linkages. Applied Energy, 307, 118196. https://doi.org/10.1016/j.apenergy.2021.118196

World Bank. (2023). Central Asia's energy efficiency potential. Washington, DC: World Bank.

World Bank. (2023). Trade structures and energy dependency in Central Asia. World Bank Policy Research Working Paper No. 10234. https://www.worldbank.org

World Bank. (2023). *Trade structures and energy dependency in Central Asia.* World Bank Policy Research Working Paper No. 10234. https://www.worldbank.org

Zhang, D., Mohsin, M., & Rasheed, A. K. (2023). Trade complexity and green growth. Journal of Cleaner Production, 380, 135042. https://doi.org/10.1016/j.jclepro.2022.135042

Zhang, L., Huang, Y., & Li, Z. (2023). Measuring import diversification quality using trade complexity indices. Journal of International Economics, 142, 103772. https://doi.org/10.1016/j.jinteco.2023.103772