Impact of Fintech, Mineral Resources, and Social Capital on Climate Quality: A Perspective of Institutional Quality

Abstract

The study aims to uncover the impact of financial technologies, natural resource rents, and social capital on Climate sustainability in the context of intuitional quality in Asian countries. Over the period from 2019 to 2023, we observe the cross-sectional dependencies in data series. The outcomes of CIPS and CADF models show the presence of mixed-order cointegration among variables. The study employs a second-generation cointegration test to explore the long-run equilibrium connectedness among variables.Significant structural breaks with no, mean, and regime shifts show that national and international shocks in Asian economies influence each other. Furthermore, cup-FM and cup-BC estimators are applied for robustness checks to explore the long-run connectedness. The coefficients of the cup-FM model reveal that institutional quality and social capital improveenvironmental sustainability. In contrast, Fintech and mineral resource rents destroy the environmental quality in Asian economies in the long run. The coefficients of the cup-BC modelsupport the outcomes of the cup-FM model. The findings have several policy implications.

Keywords: Fintech; Climate Quality; Institutional Quality; Social Capital; Mineral Resources; Cointegration

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1. Introduction

The global pursuit of sustainable development is at the forefront of academic, policy, and public discourse as the world deals with the escalating challenges of climate change. Carbon emissions contribute significantly to anthropogenic climate change and have broad repercussions for the world's ecosystems and the global climate system. Excessive carbon dioxide in the atmosphere traps heat, causing global warming and climate change[1]. Thus, tracking and minimizing carbon emissions while addressing their underlying causes are now essential elements of global sustainable development plans.

Mineral resource rents refer to the income generated from extracting natural resources such as oil, gas, and minerals. Though nations with abundant natural resources might have an inherent advantage, theories such as the "resource curse" and the "Dutch disease" contend that excessive dependence on natural resources might impede long-term development and industrialization[2,3]. Mineral resource rent often drives economic development, but this process comes with environmental concerns. Using mineral resource rents for fossil fuel-based energy production directly results in carbon emissions, worsening climate change. Furthermore, mineral resource extraction, processing, and transportation directly generate significant carbon emissions due to their energy demands. Mineral extraction often damages land and water resources, releasing pollutants that escalate greenhouse emissions and contribute to global warming[4,5].Research indicates a direct link between high levels of mineral resource rents and increased carbon emissions, fueled by the expansion of industries dependent on those resources[6,7].

Beyond mineral resource rents, the rise of financial technologies (fintech) introduces innovative solutions in the financial sector, aiming to streamline processes, foster innovation, and support entrepreneurship[8].Fintech challenges traditional banking roles by facilitating easier access to loans for small businesses (SMEs) and consumers, potentially impacting bank liquidity and overall economic development[9]. Moreover, fintech could contribute to better environmental preservation by enhancing the efficient and transparent management of natural resources. Fintech has the potential to revolutionize green finance by leveraging big data analytics and artificial intelligence to support sustainability efforts such as investments in clean energy infrastructure, green technologies, and climate-friendly businesses[10,11]. In addition, the technological innovation of fintech, promoting financial inclusion, stands as a potential driver for economic development and environmental sustainability, leading to CO_2 reduction[12]. While some studies acknowledge fintech's potential in addressing environmental concerns, there remains a gap in the literature exploring direct connections between fintech and carbon emissions[2,9].

Institutional quality (IQ) stands as a critical determinant of a country's ability to manage and regulate its economic development effectively. Strong institutions can curb corruption, uphold the rule of law, limit the military's influence in politics, and ensure responsible management of public funds[13]. Likewise, IQ, representing a well-functioning legal system, can directly or indirectly impact environmental sustainability[14]. IQ significantly impacts carbon emissions through formulating and implementing environmental policies, fostering efficiency in programs like renewable energy and energy efficiency[15,16]See Fig-2, which shows the renewable energy consumption in Asian economies. Conversely, poor institutions attract investments in polluting industries and outdated technologies, highlighting the crucial role of strong environmental governance for sustainable development. Simultaneously, informal IQ, such as social capital, establishes economic activity rules and serves as a mechanism for enforcement within the community[17]. Social capital can influence the adoption of sustainable behaviors and technologies and the development of policies aimed at reducing carbon emissions (Fig. 1 represents the climate quality measured through carbon emissions). Guan et al. (2024)propose that stronger social capital fosters collaboration on environmental issues, trust in joint decision-making, and public awareness of development's ecological impact, leading to effective solutions for reducing carbon emissions[19].

While research has examined the individual relationships between mineral resource rents, fintech, institutional quality, social capital, and carbon emissions, a comprehensive understanding of their interconnected effects remains vague. This study aims to address this gap by analyzing the combined influence of these factors on carbon emissions. By demonstrating their comprehensive and collaborative impact on environmental sustainability, this research advocates for integrated policy solutions to mitigate climate change.

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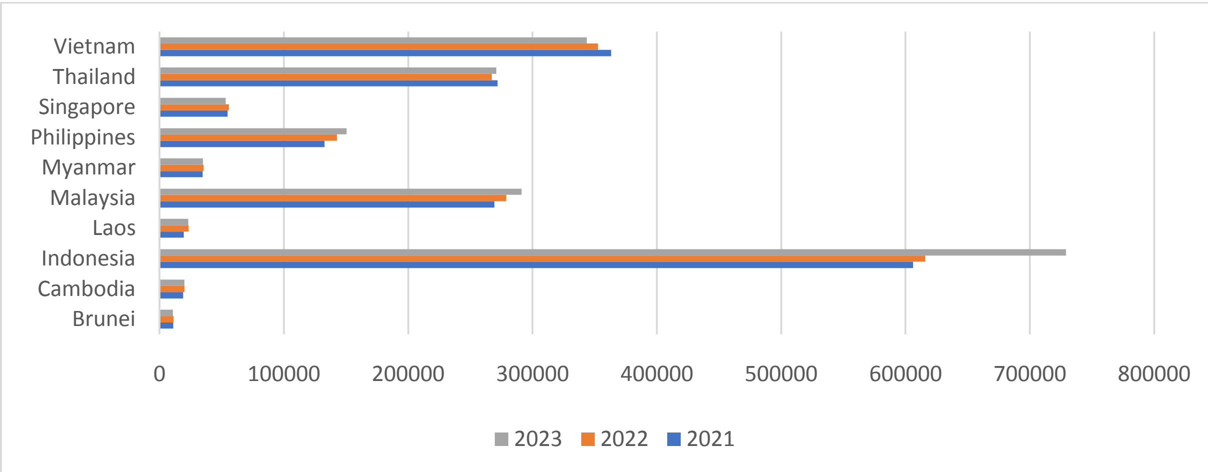
Figure 1: Climate Quality (carbon emission measured in billion metric tons) for selected Asian Economies



2. Review of Literature

The environmental consequences of mineral resource extraction, particularly through increased carbon emissions, have prompted significant debate in the literature. Some research highlights the interrelationships between mineral resource rents and environmental quality. Using machine learning, Chen et al. (2023) found that resource availability shaped green technology adoption and, thus, carbon emissions and called for government action to ensure sustainable growth[20]. Sadiq et al. (2023) established a positive link between emissions and resource rents in 10 Asian economies, revealing a conflict between COP26 goals and resource dependence[21]. They underscore how fossil fuel consumption driven by resource extraction heightens the environmental impact.

Research examining BRICS nations reveals a complex relationship between natural resource abundance and carbon emissions; Danish et al. (2019) found that natural resources mitigate carbon emissions in Russia but increase pollution in South Africa[22]. Joshua &Bekun (2020) underlined the direct link between natural resource use and carbon emissions in the South African context, advocating for sustainable resource management and renewable energy adoption[23]. Bekun et al. (2019) identified a positive significant relationship between natural resource rent and CO2 emissions in the long run[24]. They pointed out the role of natural resources in fueling economic development while causing potential environmental harm through excessive dependence. The authors suggest dependent countries should prioritize diversification and structural changes for ecological sustainability. Research by Huang et al. (2023) [25]in the USA and Tufail et al. (2021)[26]in China all identified a positive link between natural resource rents and increased carbon emissions, highlighting the potential for significant environmental degradation in resource-dependent economies.

While the environmental impact of traditional financial systems has been extensively explored, the emergence of FinTech presents a new and evolving landscape with potential implications for carbon emissions. Wen & Liu (2023)[8] and Muganyi(2021)[10]highlighted

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FinTech's key significance in China, demonstrating its ability to cut carbon emissions, improve collaboration in pollution management, and achieve a variety of environmental goals through innovation. Concurrently Ma et al. (2023)[9]contributed to this narrative by investigating the impact of FinTech development on air pollution. They revealed a substantial positive relationship between FinTech development and reduced air pollution and carbon emissions. The study highlighted FinTech's contribution to digital finance and green innovation, reducing air pollution and advancing environmental sustainability.

The impact of FinTech development on renewable energy consumption in OECD countries was explored byCroutzet& Dabbous (2021)[11].They found a significant positive relationship between FinTech development and increased renewable energy consumption, suggesting that the evolution of FinTech positively influences the adoption of renewable energy sources. Ahmad et al., (2022) examined the bidirectional causal association between financial inclusion, technological innovation, and CO2 emissions[12]. Their study observed that increased technological innovation can enhance financial inclusion and vice versa, implying that both financial inclusion and technological innovation play a role in influencing CO2 emissions.

These studies highlight the broad potential of mineral resource rents and FinTech development in addressing environmental challenges and promoting sustainable practices. However, realizing their full potential will require the presence of strong institutions. Effective institutions are essential to ensure responsible resource extraction management and the responsible advancement and utilization of innovative technologies such as FinTech. Zeng et al. (2024)explored the relationship between institutional quality and carbon emissions in resource-rich nations[15]. The study emphasizes the significance of institutional quality to growth and its positive impact on environmental governance and green growth. Furthermore, it indicated that good environmental governance could mitigate the negative effects of natural resource rents and financial technology on the environment. Examining the link between institutional quality and carbon emissions in developing countries, Azam et al. (2021) found a positive association[28], suggesting higher quality institutions might prioritize freedom over environmental concerns. However, Haldar & Sethi (2021) revealed that strong institutions also moderate the energy consumption-emissions relationship, supporting the EKC hypothesis by enhancing the efficiency of energy use and curbing emissions[16].

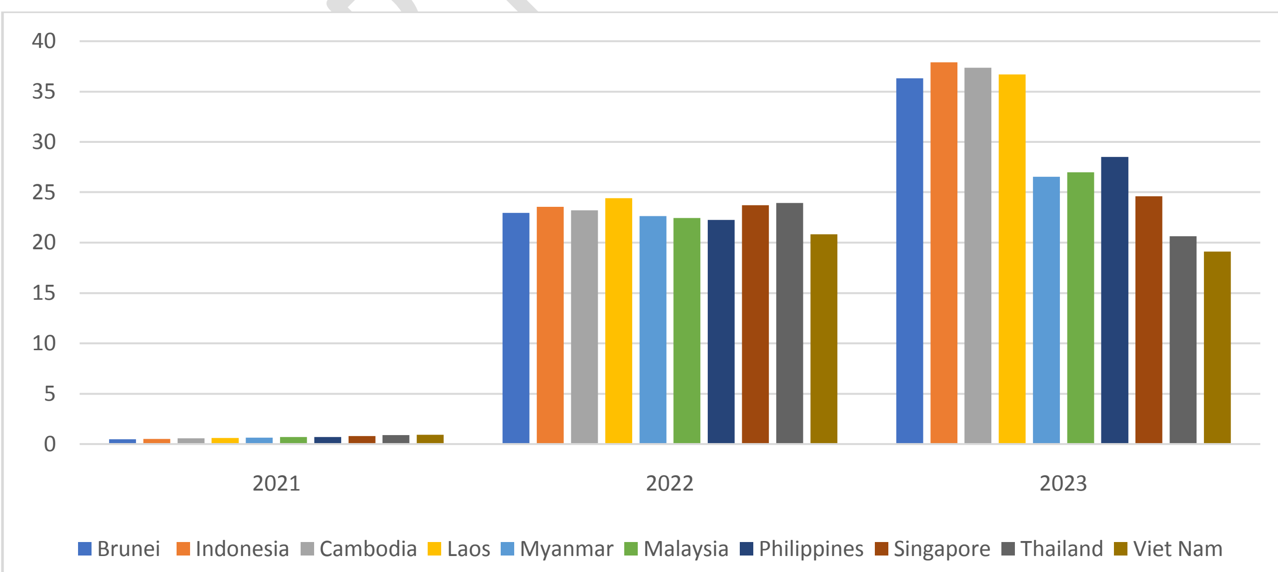
According to Salman et al. (2019)14, efficient and impartial domestic institutions are crucial in decreasing carbon emissions. The study suggested that well-developed institutional systems in Indonesia, South Korea, and Thailand can enhance economic growth and reduce carbon emissions. Investigating the impact of institutional quality on carbon emissions in Pakistan, Hassan& Danish (2020)[13]revealed a positive relationship, implying that poor institutional quality contributes to increased carbon emissions. Strong institutions are crucial for mitigating environmental effects and reducing carbon emissions in the country.Makhdum et al. (2022)[6]argued that greater institutional quality reduces pressure on the environment and plays a vital role in economic, governance, and social readiness to address global warming. Their study supports the idea that strong political management and institutions can manage and redesign strategies and investments to encourage climate-smart progress and low-emission building blocks.

On a further approach, Guan et al. (2024) highlighted the pivotal role of effective institutions in environmental protection[19]. They maintained that strong institutions are crucial for curbing pollution, whereas weak governance leads to environmental degradation. This finding aligns with Marbuah and Gren (2015) who investigated the specific impact of trust in the government on CO2 emissions in Sweden. Their research implies that a higher level of trust leads to lower emissions by facilitating the implementation of effective environmental regulations. Zhang & Fu (2023)revealed that higher social trust is linked to lower urban CO2 emissions, suggesting informal social rules play a significant role in environmental outcomes[30]. This trust is expected to influence businesses, governments, and citizens, towards more sustainable practices and ultimately contribute to reduced carbon emissions.

Table 1: Variable Descriptions

Variable List	Measurement	Abbreviation	Type	Data source
Climate Quality	Carbon Emissions	CQ	Dependent	WDI
Fintech	Fintech Transaction Value in USD	Fintech	Independent	Statista.com
Institutional Quality	Control of Corruption	IQ	Independent	WDI
Mineral Resources	Mineral resource rents	MR	Independent	WDI
Social Capital	Socio-political integration	SC	Independent	Statista.com

Figure 2. Renewable energy consumption (% of total final energy consumption) in Asian Economies during the post-COVID era.



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3. **Methodology and Data Description**

Table 1 presents the variables along with their abbreviations and data sources. The panel data is collected over the period from 2019 to 2023. The period incorporates the pandemic era and both pre- and post-COVID periods. Incorporation of the COVID-19 era in the sample period is very important because all the economies have suffered different shocks which have changed the financial and economic scenarios of all the economies[31].The Asian Economies are selected for the analysis and the investigation on such a topic is ignored in Asian countries. According to Shahid et al. (2022)[32] panel data suffer from a cross-sectional dependency problem;therefore, the current study uses a B.P LM test (Lagrange Multiplier) of and the CD test[33] to capture the CSD issues. Examination of prevailing CSD in panel data series is necessary for reliable results. Therefore, the B.P test has the following Equation.

$$\text{CD}= T\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij}^{2} \quad 1$$

The following Equation presents the CD test ofPersaran et al. (2012)[33]

$$\text{CD}=\sqrt{\frac{2T}{N(N-1)}\sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \rho_{ij}} \quad 2$$

Equation 1 presents the time duration with *t* and cross-sections (Asian economies) with *N*, while the correlation coefficient is indicated with ρ_{ij}. The null hypothesis of the CD test implies the absence of CSD while the presence being the alternative. Under the presence of CSD, the first-generation tests cannot discover unit root properties. Therefore, the study employs second-generation tests including CADF, CIPS, and IPS introduced byPesaran (2012)[33]. Based on this discussion, Equation 3 is a more justified form for unit root implications.

$$\Delta CA_{i,t} = \varphi_i + \varphi_i Z_{i,t-1} + \varphi_i \overline{CA}_{t-1} + \sum_{I=0}^{p} \varphi_{iI} \Delta\overline{CA_{t-1}} + \sum_{I=0}^{p} \varphi_{iI} \Delta CA_{i,t-1} + \mu_{it} \quad 3$$

Where $\varphi_i \overline{CA}_{t-1}$ and $\varphi_{iI} \Delta\overline{CA_{t-1}}$ in Equation 3 represents the averages of cross-sections and the following equation represents the execution of the CIPS test

$$\text{C}\widehat{IPS} = \frac{1}{N}\sum_{i=1}^{n} CDF_i \quad 4$$

Moreover, detecting cointegration association among variables is also necessary under such a panel analysis.Based on the cross-sections and structural breaks, the study applied co-integration test proposed by Westerlund &Esgerton (2008)[34]. The function format of this test is represented with the following Equations:

$$LM_{\tau} = \frac{\widehat{\Phi}_i}{SE(\widehat{\Phi}_i)} \quad 5$$

$$LM_{\Phi} = T\widehat{\Phi}_i \left(\frac{\widehat{\omega}_i}{\widehat{\sigma}_i}\right) \quad 6$$

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Where in the above Equations $\widehat{\Phi}_i$ represents the least square estimations, the standard error of $\widehat{\Phi}_i$ is $\hat{\sigma}_i$, while $SE(\widehat{\Phi}_i)$ is the reflection of standard error of $\widehat{\Phi}_i$. The absence of cointegration is the null hypothesis of cointegration test of Westerlund and Edgerton (2008), where the presence of long-term associations is the alternative hypothesis. As suggested by Bai and Kao (2006)[35], the study employs the cup-FM and cup-BC tests to uncover the nexus between the dependent and independent variables. A factor model is fomalized and described in the following Equation.

$$\hat{\beta}cup, \hat{F}cup = argmin\ \frac{1}{nT^2}\sum_{i-1}^{n} \quad (y_i \ - x_i\ \beta)'\ M_F(y_i - x_i\beta) \qquad 7$$

Where identity matrix is indicated with T and $M_F = I_T - T^{-2}FF'$

4. Results and Discussion

Table 2 presents the scores for descriptive statistics for all variables under study. Itis clear from the table that the maximum points for carbon emissions (Climate Quality) is 11.643 with a mean value of 7.837. The mean value for Fintech is 0.838, for IQ is 2.474, for MR is 1.374 and for SC is 0.637. However, climate quality has the highest value for standard deviation.

Table 2: Summary statistics.

Variable	Mean	Std. Dev.	Min	Max
CQ	7.837	2.649	3.989	11.643
Fintech	0.838	0.832	0.026	2.844
IQ	2.474	0.402	1.836	3.013
MR	1.374	0.284	0.483	2.374
SC	0.637	0.249	0.293	0.9802

Table 3: Correlations, Tolerance and VIF.

Variables	CQ	Fintech	IQ	MR	SC	VIF	1/VIF
CQ	1						
Fintech	-0.457*** (0.000)	1				1.238	0.807754
IQ	0.437*** (0.000)	0.247*** (0.000)	1			2.546	0.392773
MR	0.320*** (0.000)	0.474*** (0.000)	0.402*** (0.000)	1		1.643	0.608643
SC	0.546*** (0.000)	0.382*** (0.000)	0.536*** (0.000)	0.584*** (0.000)	1	1.943	0.514668

Note: *** is an indication of level of significance @ 1 %.

The correlation Matrix is presented in Table 3, which reports a positive association between dependent and independent variables except Fintech, which is negatively associated with climate quality. the Variance inflation factor is used to calculate the multicollinearity while tolerance level is measure through (1/VIF). All the variable shows that VIF score is below 5, and tolerance level values are above 0.10, both the values confirms that no higher inter-dependencies are there among independent variables exist.

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Table 4: Cross-sectional dependence findings.

Variables	Breusch-Pagan LM	Pesaran Scaled LM	Pesaran CD
CQ	373.7***	45.5***	17.2***
Fintech	473.8***	34.2***	20.9***
IQ	674.1***	82.0***	19.3***
MR	601.5***	49.6***	26.9***
SC	397.8***	99.3***	24.5***

Note: *** is an indication of the level of significance @ 1 %.

Outcomes for cross-sectional dependencies are presented in Table 4 for Climate Quality (CQ), Fintech, Institutional Quality (IQ), Mineral Resources (MR), and Social Capital (SC). The Table reveals that the cross-section dependencies (CSD) are present among variables; therefore, we reject the null hypothesis of the non-existence of CDS. Such findings indicate that Asian economies are interlinked, and economic/financial shocks in one Asian economy influence the economies of other Asian countries. After the analysis of CDS in the data series, we further explore the integration of variables under study. Table 5 reports that all the variables exhibit non-stationarity at the level. But when the authors take the first difference, all the data series become stationary at a 1 % confidence interval. It is an inherent character of data series to suffer from stationarity issues, but the first difference of the entire series solves this problem[32].

Table 5: CIPS and CADF unit root tests result

Variables	CIPS		CADF	
	@Level	1st Difference	@Level	1st Difference
CQ	− 0.394	− 3.647***	− 1.558	− 4.735***
Fintech	− 0.119	− 4.129***	− 1.194	− 5.129***
IQ	− 0.484	− 5.982***	− 1.433	− 5.752***
MR	− 1.193	4.494***	− 1.661	− 4.644***
SC	− 0.675	− 4.204***	− 1.931	− 6.940***

Note: *** is an indication of the level of significance @ 1 %.

Furthermore, the authors extend the analysis and estimate the cointegration properties via the cointegration test proposed by Westerlund and Edgerton (2007) and present the results in Table 6. The Table presents the results with regime shift, mean shift, and No shift. The findings reveal that there exists a long-term connectedness (cointegration)among variables which is significant at 1 % level of confidence. However, regime shift provides more higher coefficients in economies under study.

Table 6: Outcomes of Westerlund and Edgerton cointegration Estimator.

Model	No-Shift	Mean-Shift	Regime-Shift
	Coefficient	Coefficient	Coefficient
LMτ	− 3.8***	− 4.1***	− 5.8***
LMφ	− 4.3***	− 4.5***	− 5.9***

Note: *** is an indication of level of significance @ 1 %.

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Table 7: Outcomes of Westerlund and Edgerton (2008) test to capture structural breaks.

Country	No Shift	Mean Shift	Regime Shift
Cambodia	2019	2020	2020
China	2021	2022	2020
India	2023	2023	2019
Indonesia	2023	2019	2020
Malaysia	2020	2022	2019
Philippines	2021	2020	2021
Thailand	2022	2023	2020
Vietnam	2022	2023	2020

Moreover, we further develop a break point estimator based on the suggestions of Westerlund and Edgerton (2008) to explore the breakpoints for each stated economy from the Asian region. This approach was initially proposed by Bai and Perron (1998) to explore the structural break trends. Table 7 exhibits the multiple points for structural breaks. We find that structural breaks in each selected Asian economy influence each other. After confirming the presence of long-term integrations, we further explore the associations among the variables via cup-FM and cup-BC estimators and present the results in Table 8.

Table 8: Outcomes of "cup-FM" and "cup-BC"estimators,DV: CQ(measured through CO_2 emissions)

Variables	CUP-FM	CUP-BC
Fintech	0.261***	0.315***
IQ	-0.320***	-0.267***
MR	0.127***	0.114***
SC	-0.072***	0.089***

Note: *** is an indication of the level of significance @ 1 %.

It is clear from Table 8 that fintech has a positive association with Carbon emissions, which means Fintech enhances carbon emission by up to 26.1% with cup-FM and 31.5% with cup-BC estimators. It means Fintech brings more environmental destruction to Asian Economies. Hussain et al. (2022) find that financial technologies deteriorate climate quality[36]. Using Panel data models from 1995 to 2018, Fareed et al. (2022) find that financial technology is a major determinant of climate quality[37]. However, Zeraibi et al. (2021)[38]observe financial technologies enhance the climate quality in ASEAN economies.

Secondly, we observe a negative connection between institutional quality and carbon emissions, where institutional quality reduces carbon emissions by up to 32.0% with cup-FM and 26.7% with cup-BC estimators. Thus, institutional quality enhances climate quality. From BRICS economies, Hussain and Dogan (2021) report that institutional quality derives the climate quality. Moreover, Ahmad et al. (2022)finds similar outcomes from G7 economies[12]. Table 8 indicates a positive connectedness between mineral resources and climate quality in selected economies.

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More specifically, we observe a 12.7% (cup-FM) and 11.4% (cup-BC)rise in carbon emissions (decline in climate quality) with the increase in mineral resource rents. The findings are like the outcomes of the study of Danish et al. (2020), who observed a positive association between mineral resources and carbon emissions in BRICS economies[39].Kongbuamai et al. (2020)[40] find the same for ASEAN economies, while Ahmad et al. (2022)12 find the same for the Chinese economy. Social capital (measures through socio-economic integration)shows an inverse association with carbon emissions, which means that an increase in social capital reduces carbon emissions by 7.2% (with cup-FM) and 8.9% (with cup-BC) in Asian economies. Similarly, Ahmed and Wang (2019) find human social capital enhances the use of renewable energy, thus reducing carbon emissions[41]. Danish et al. (2019)[39] apply the ARDL model and find that human capital reduces carbon emissions and enhances climate quality. over the period from 1970 to 2015, Zafar et al. (2020)[42]find similar results from US economy.

5. Conclusion and policy implications

Globally, academicians, researchers, policymakers, and Governments have paid much attention to SDGs and sustainable environmental quality. The study aims to investigate the impact of Fintech, Institutional quality, mineral resource rents, and social capital on climate quality in Asian Economies from 2019 to 2023. The cointegration method of the second generation is employed to test the cross-section dependencies (CSDs) in the data series. Furthermore, the authors employ CIPS and CADF unit root tests to uncover the stationarity properties in the presence of CSDs.A panel cointegration test is applied to explore the cointegration among variables. To justify the robustness of outcomes, cup-FM, and cup-BC estimators are also calculated to discover long-runassociations. The outcomes of the CD model accept the H1, while mixed order cointegration is confirmed among variables via CIPS and CADF. Moreover, a second-generation cointegration test by Westerlund and Edgerton (2008) confirms the long-run equilibrium connections among variables. Withno means or regime shifts, we find significant structural breaks indicating that local and global shocks in Asian economies influence each other. Lastly, the outcomes of the cup-FM model reveal that institutional quality and social capital enhance climate quality. In contrast, Fintech and mineral resource rents deteriorate the climate quality of Asian economies in the long run. The cup-BC estimator supports the findings of the cup-FM model.

The Governments of Asian economies should pay more attention to macro-nature aspects of climate quality. Asian economies should reduce their dependency on mineral energy resources and enhance the usage of renewable energy in industrial production and FinTech mining. Moreover, economies should promote education and integrate the participation of social and political groups in decision-making to enhance sustainable, clean, and green trends in environmental quality. Finally, Asian economies should control corruption and ensure the rule of Law to promote a productive nexus between institutional quality and climate sustainability.

To suggest several avenues for further research, we mention a few limitations of the current study. Further research may extend the model used in the current study by incorporating other important explanatory variables, i.e., energy use, ecological innovations, corporate freedom,

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digital trade, and information and communication technologies. Future studies may focus on other economies to explore the nexus developed in the current study.

References:

1. Bekun FV, Alola AA, Sarkodie SA. Toward a sustainable environment: Nexus between CO2 emissions, resource rent, renewable and nonrenewable energy in 16-EU countries. *Science of The Total Environment*. 2019;657:1023-1029. doi:10.1016/j.scitotenv.2018.12.104
2. Wang J, Zhu G, Chang TC. Unveiling the relationship between institutional quality, fintech, financial inclusion, human capital development and mineral resource abundance. An Asian perspective. *Resources Policy*. 2024;89:104521. doi:10.1016/j.resourpol.2023.104521
3. Wu S, Li L, Li S. Natural resource abundance, natural resource-oriented industry dependence, and economic growth: Evidence from the provincial level in China. *ResourConservRecycl*. 2018;139:163-171. doi:10.1016/j.resconrec.2018.08.012
4. Hanif S, Lateef M, Hussain K, et al. Controlling air pollution by lowering methane emissions, conserving natural resources, and slowing urbanization in a panel of selected Asian economies. *PLoS One*. 2022;17(8):e0271387. doi:10.1371/journal.pone.0271387
5. He Y, Wang S, Chen N. Mineral rents, natural resources depletion, and ecological footprint nexus in high emitting countries: Panel GLM analysis. *Resources Policy*. 2024;89:104472. doi:10.1016/j.resourpol.2023.104472
6. Makhdum MSA, Usman M, Kousar R, Cifuentes-Faura J, Radulescu M, Balsalobre-Lorente D. How Do Institutional Quality, Natural Resources, Renewable Energy, and Financial Development Reduce Ecological Footprint without Hindering Economic Growth Trajectory? Evidence from China. *Sustainability*. 2022;14(21):13910. doi:10.3390/su142113910
7. Ling G, Razzaq A, Guo Y, Fatima T, Shahzad F. Asymmetric and time-varying linkages between carbon emissions, globalization, natural resources and financial development in China. *Environ Dev Sustain*. 2022;24(5):6702-6730. doi:10.1007/s10668-021-01724-2
8. Wen H, Liu Y. Can Fintech Lead to the Collaborative Reduction in Pollution Discharges and Carbon Emissions? *Sustainability*. 2023;15(15):11627. doi:10.3390/su151511627
9. Ma Y, Wei X, Yan G, He X. The Impact of Fintech Development on Air Pollution. *Int J Environ Res Public Health*. 2023;20(4):3387. doi:10.3390/ijerph20043387
10. Muganyi T, Yan L, Sun H ping. Green finance, fintech and environmental protection: Evidence from China. *Environmental Science and Ecotechnology*. 2021;7:100107. doi:10.1016/j.ese.2021.100107
11. Croutzet A, Dabbous A. Do FinTech trigger renewable energy use? Evidence from OECD countries. *Renew Energy*. 2021;179:1608-1617. doi:10.1016/j.renene.2021.07.144

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12. Ahmad M, Ahmed Z, Bai Y, Qiao G, Popp J, Oláh J. Financial Inclusion, Technological Innovations, and Environmental Quality: Analyzing the Role of Green Openness. *Front Environ Sci*. 2022;10. doi:10.3389/fenvs.2022.851263

13. Hassan ST, Danish, Khan SUD, Xia E, Fatima H. Role of institutions in correcting environmental pollution: An empirical investigation. *Sustain Cities Soc*. 2020;53:101901. doi:10.1016/j.scs.2019.101901

14. Salman M, Long X, Dauda L, Mensah CN. The impact of institutional quality on economic growth and carbon emissions: Evidence from Indonesia, South Korea and Thailand. *J Clean Prod*. 2019;241:118331. doi:10.1016/j.jclepro.2019.118331

15. Zeng C, Ma R, Chen P. Impact of mineral resource rents and fin-tech on green growth: Exploring the mediating role of environmental governance in developed economies. *Resources Policy*. 2024;89:104547. doi:10.1016/j.resourpol.2023.104547

16. Haldar A, Sethi N. Effect of institutional quality and renewable energy consumption on CO2 emissions−an empirical investigation for developing countries. *Environmental Science and Pollution Research*. 2021;28(12):15485-15503. doi:10.1007/s11356-020-11532-2

17. Ibrahim MH, Law SH. Social capital and CO2 emission—output relations: A panel analysis. *Renewable and Sustainable Energy Reviews*. 2014;29:528-534. doi:10.1016/j.rser.2013.08.076

18. Guan L, Ali Z, Uktamov KF. Exploring the impact of social capital, institutional quality and political stability on environmental sustainability: New insights from NARDL-PMG. *Heliyon*. 2024;10(2). doi:10.1016/j.heliyon.2024.e24650

19. Guan L, Ali Z, Uktamov KF. Exploring the impact of social capital, institutional quality and political stability on environmental sustainability: New insights from NARDL-PMG. *Heliyon*. 2024;10(2):e24650. doi:10.1016/j.heliyon.2024.e24650

20. Chen F, Tiwari S, Mohammed KS, Huo W, Jamróz P. Minerals resource rent responses to economic performance, greener energy, and environmental policy in China: Combination of ML and ANN outputs. *Resources Policy*. 2023;81:103307. doi:10.1016/j.resourpol.2023.103307

21. Sadiq M, Chavali K, Kumar VVA, Wang KT, Nguyen PT, Ngo TQ. Unveiling the relationship between environmental quality, non-renewable energy usage and natural resource rent: Fresh insights from ten asian economies. *Resources Policy*. 2023;85:103992. doi:10.1016/j.resourpol.2023.103992

22. Danish, Baloch MA, Mahmood N, Zhang JW. Effect of natural resources, renewable energy and economic development on CO2 emissions in BRICS countries. *Science of The Total Environment*. 2019;678:632-638. doi:10.1016/j.scitotenv.2019.05.028

23. Joshua U, Bekun FV. The path to achieving environmental sustainability in South Africa: the role of coal consumption, economic expansion, pollutant emission, and total natural resources rent. *Environmental Science and Pollution Research*. 2020;27(9):9435-9443. doi:10.1007/s11356-019-07546-0

UNDER PEER REVIEW

24. Bekun FV, Alola AA, Sarkodie SA. Toward a sustainable environment: Nexus between CO2 emissions, resource rent, renewable and nonrenewable energy in 16-EU countries. *Science of The Total Environment*. 2019;657:1023-1029. doi:10.1016/j.scitotenv.2018.12.104

25. Huang SZ, Sadiq M, Chien F. The impact of natural resource rent, financial development, and urbanization on carbon emission. *Environmental Science and Pollution Research*. 2021;30(15):42753-42765. doi:10.1007/s11356-021-16818-7

26. Tufail M, Song L, Adebayo TS, Kirikkaleli D, Khan S. Do fiscal decentralization and natural resources rent curb carbon emissions? Evidence from developed countries. *Environmental Science and Pollution Research*. 2021;28(35):49179-49190. doi:10.1007/s11356-021-13865-y

27. Ahmad M, Ahmed Z, Bai Y, Qiao G, Popp J, Oláh J. Financial Inclusion, Technological Innovations, and Environmental Quality: Analyzing the Role of Green Openness. *Front Environ Sci*. 2022;10. doi:10.3389/fenvs.2022.851263

28. Azam M, Liu L, Ahmad N. Impact of institutional quality on environment and energy consumption: evidence from developing world. *Environ Dev Sustain*. 2021;23(2):1646-1667. doi:10.1007/s10668-020-00644-x

29. Marbuah G, Gren IM. Carbon Emissions and Social Capital in Sweden. *Swedish University of Agricultural Sciences, Department of Economics* . 2015;ISSN 1401-4068.

30. Zhang Y, Fu B. Social trust contributes to the reduction of urban carbon dioxide emissions. *Energy*. 2023;279:128127. doi:10.1016/j.energy.2023.128127

31. Shahid MN. COVID-19 and adaptive behavior of returns: evidence from commodity markets. *Humanit Soc Sci Commun*. 2022;9(1):323. doi:10.1057/s41599-022-01332-z

32. SHAHID MN, ISLAM MU, ALAM N, ALI M. Time-Varying Return Predictability and Adaptive Behavior in The U.S. Commodity Markets During COVID-19. *International Journal of Economics and Management*. 2022;16(Special Issue 1):59-80. doi:10.47836/ijeamsi.16.1.005

33. Pesaran MH, Schuermann T, Weiner SM. Modeling Regional Interdependencies Using a Global Error-Correcting Macroeconometric Model. *Journal of Business & Economic Statistics*. 2004;22(2):129-162. doi:10.1198/073500104000000019

34. Westerlund J, Edgerton DL. A Simple Test for Cointegration in Dependent Panels with Structural Breaks*. *Oxf Bull Econ Stat*. 2008;70(5):665-704. doi:10.1111/j.1468-0084.2008.00513.x

35. Bai J, Kao CD. On the Estimation and Inference of a Panel Cointegration Model with Cross-Sectional Dependence. *SSRN Electronic Journal*. Published online 2005. doi:10.2139/ssrn.1815227

36. Hussain M, Dogan E. The role of institutional quality and environment-related technologies in environmental degradation for BRICS. *J Clean Prod*. 2021;304:127059. doi:10.1016/j.jclepro.2021.127059

37. Fareed Z, Rehman MA, Adebayo TS, Wang Y, Ahmad M, Shahzad F. Financial inclusion and the environmental deterioration in Eurozone: The moderating role of innovation activity. *Technol Soc*. 2022;69:101961. doi:10.1016/j.techsoc.2022.101961

UNDER PEER REVIEW

38. Zeraibi A, Balsalobre-Lorente D, Murshed M. The influences of renewable electricity generation, technological innovation, financial development, and economic growth on ecological footprints in ASEAN-5 countries. *Environmental Science and Pollution Research*. 2021;28(37):51003-51021. doi:10.1007/s11356-021-14301-x

39. Danish, Ulucak R, Khan SUD. Determinants of the ecological footprint: Role of renewable energy, natural resources, and urbanization. *Sustain Cities Soc*. 2020;54:101996. doi:10.1016/j.scs.2019.101996

40. Kongbuamai N, Bui Q, Yousaf HMAU, Liu Y. The impact of tourism and natural resources on the ecological footprint: a case study of ASEAN countries. *Environmental Science and Pollution Research*. 2020;27(16):19251-19264. doi:10.1007/s11356-020-08582-x

41. Ahmed Z, Wang Z. Investigating the impact of human capital on the ecological footprint in India: An empirical analysis. *Environmental Science and Pollution Research*. 2019;26(26):26782-26796. doi:10.1007/s11356-019-05911-7

42. Zafar MW, Zaidi SAH, Khan NR, Mirza FM, Hou F, Kirmani SAA. The impact of natural resources, human capital, and foreign direct investment on the ecological footprint: The case of the United States. *Resources Policy*. 2019;63:101428. doi:10.1016/j.resourpol.2019.101428

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