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Article

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Nexus among Crypto Trading, Environmental Degradation, Economic Growth and Energy Usage: Analysis of Top 10 Crypto-friendly Asian Economies

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ABSTRACT

The higher discharge of carbon emissions in environment is endangering human life as well as eco system. With the emergence of digital technology, crypto trading and blockchain technologies are also causing the paradigm shift in technological needs, however, in parallel, creating unresolved environmental problems especially in the top 10 crypto-friendly Asian economies due to the higher percentage of poisonous emissions. Thereby, the study attempts to scrutinize the nexus among crypto-trading, environmental degradation, economic growth and energy usage. CO_2 emissions are taken as a proxy of environmental degradation in the context of crypto friendly Asian economies. The data extracted from WDI and coin market cap covering the period from 2012 to 2020. The article applied CS-ARDL technique in order to find the association between variables in short and long run. Granger Causality test is also applied to find out the causality among constructs. Findings expose that bi-directional causality exists between crypto trading and carbon emission and crypto trading and energy usage, hence, disturbing environmental sustainability due to high emissions. The paper suggests policy makers and other institutional officers to de-socialize those block chain technologies which consumes high energy and use green technology as their substitute. This helps in the reduction of environmental damages.

Keywords: Crypto-Trading, Environmental Sustainability, Asian Economies, Economic Growth
JEL Classifications: **Q**56, R11, F18, O13, P18, P28, P48

1. INTRODUCTION

In present environment, digital economy especially with higher digital currency trends along with the government regulation are vital for economic growth (Fakunmoju et al., 2021), Literature at international level also established this fact that digital currency economy gives birth to various aspects such as more economic activities, high employment, less poverty, higher capital formation and finally the economic growth. As it is observed that the ratio of poor masses to this date still at higher percentages, therefore, it is quite clear that the economic growth benefits are not shared equally across nations and countries because of insufficient technology related to digital currency economy especially in emerging nations (World Bank Group, 2018), In this regard, the digital innovation and transformation along with industrial revolution riled up the concept of this new currency type, known as, crypto currency which is considered to be the most significant innovation of the century (Mi´skiewicz et al., 2022), According to Mohsin et al. (2023), cryptography has such a long history just like humans and its impact on global economy is more like a modern development. Authors pointed out that the phenomenon might become a pipe line or fade away with the passage of time. However, looking into current scenario, it is quite different. Researchers highlights this fact that in developed nations it has remarkably viewed as legitimate investment opportunity, hence, is potentially significant to embarks its impact globally (Krause and Tolaymat, 2018), It is noted that when bitcoin crypto currency prices were jumped from 527,3 US dollars to 4.764,8 US dollar in 2017, it started gaining much attention across regions. Moreover, in 2019, the contribution gets bigger among all the value of cryptocurrencies with seven million users (Náñez Alonso et al., 2021), Due to its significance at higher level, economic agents and government institutions are now focusing to reach their desirable economic related goals with the help digital financial systems. Chuen et al. (2018) also argued that high economic growth is attainable through digital financial system such as crypto currencies. However, even with the greater significance, the main challenge occurs in crypto structure due to the involvement of both parties; known and unknown. Moreover, intermediary financial authorities also do not regulate it, hence, various government and fiscal policies reject it or ban crypto currency structure especially in the case of less established economies (Martynov, 2020).

Desmond et al. (2019) stipulated that crypto currencies are transforming the industries and markets by encouraging decentralized interaction among firms, consumers and policy makers. Ever since the birth of digital currency, mainly from the year 2010, billion number of crypto currencies have been developed that utilize technology based on digital ledger. According to Hayes (2019), the rapid development in said technology become the reason of crypto related innovations. Industrial firms which are enjoying market leadership are supposedly taking interest in crypto currency and blockchain technology so that they may enhance their portfolios. According to Sparviero and Ragnedda (2021), the emergence of crypto currency shows that it will be transformed drastically in next years. In addition, it is now considered as a safe haven asset as investors are taking huge interest in it (Dyhrberg, 2016), Many of studies in recent times have analyzed crypto currency returns from different perspectives such as crypto currencies' technical indicators, conditional tail risk, media attention or other macro-economic situations (Cheng and Yen, 2019; Gerritsen et al., 2019; Philippas et al., 2019; Turatti et al., 2019), Pertaining to environmental pollution, crypto currency also seems to be crucial as well. As with the increase in carbon emissions, environmental pollution has become a global issue along with several issues such as economic growth. Due to environmental degradation, human survival is now being questioned and socio and economic sustainability is also being threatened (Naseem et al., 2020), This is why, simultaneously handling climate changes and sustainable usage of already existing resources to mitigate harmful emissions has become quite challenges for nations. Coming back to the discussion, crypto currency is also associated with carbon emissions, energy usage and economic growth of country. Although the decentralized pattern of crypto currency provides secure connection for money transfer but it also creates disturbance in environmental sustainability.

Cryptocurrency is viewed as an innovator step for technology as well as money evaluation process, However, it affects socio, economic and environmental sustainability. The reason is that crypto miners belong to different part of ecological system; digital eco system (Faulkner and Runde, 2013; Hoque and Zaidi, 2019), Moreover, this ecosystem is consisted of super computers, hard drives, digital files etc. Due to this these currencies contain digital artefacts for crypto miners. According to Krause and Tolaymat (2018), it is estimated that the amongst all, top four crypto currencies were responsible to emit 3 to 15 million tons of carbon during the period of 2016-2018. This shows that the trading of crypto currency causes environmental unsustainability. Argued by Li et al. (2021), bioeconomy development is viewed as tool for some nations to attain green goals through smart and innovative technologies. It means that cryptocurrency appears to be core source of bioeconomy development in terms of finance, Howsoever, its development equally needs a higher volume of energy that ultimately be the cause of environmental degradation (Mi´skiewicz et al., 2022), Also, a single transaction of the said currency leads to 358.10 g of electronic waste. Hence, the reasonings indicate that crypto trading gives birth to a kind of loop as on one hand, it helps nation in economic growth, which provides edge to institutions to attract further resources that could be helpful in the extension of green and smart technologies, leading to zero carbon economic growth, whereas, the other side of coin shows that crypto trading intensifies energy resources, hence allowing GHG emissions in a greater ratio which further leads to environmental degradation (Chiriac, 2018).

In this context, it is argued by several scholars that crypto currencies could be treated as a fundamental resource in poorest countries where citizens might not have this possibility to open an account. According to Kewell et al. (2017), the around 1.8 billion world's population do not have recognized identity in legal manner, hence, making it not possible for them to transfer the money without utilizing blockchain and cryptos. Further to more, the region which has largely been touched by crypto innovations is Asia. It could be due to two plausible reasons, first is their increasing interest towards innovation especially in last two decades in which China holds a prominent position to achieve highest growth. Secondly is the lower electricity and mining cost which is present in Asian economies. The statistics from the report of Hileman and Rauchs (2017) are appropriate in the scenario to reveal that how much Asian economies are touched by blockchain and crypto technologies in a deeper manner. Figure 1 and Table 1 dictates the most interesting insights:

From Table 1, it can be comprehended that Asia region has the highest crypto currencies users amongst all. It also depicts that

Figure 1: Crypto currencies users-region wise

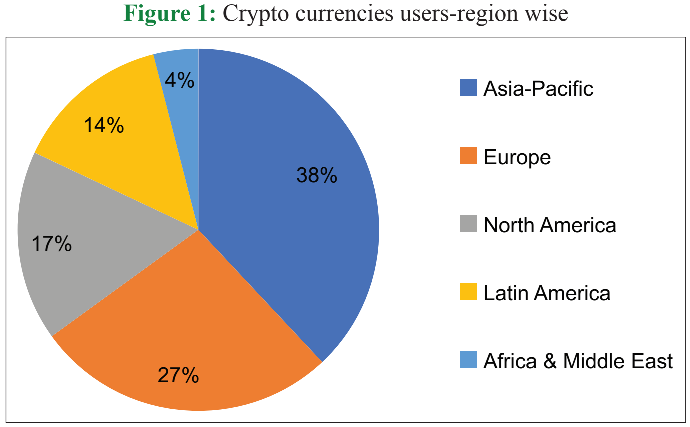

Table 1: Cryptocurrencies % region wise

Crypto type	Asia-pacific (%)	Europe (%)	North America (%)	Latin America (%)	Africa and Middle East (%)
Exchanges	27	37	18	14	4
Wallets	19	42	39	-	-
Payments	33	33	19	11	4
Miners	50	13	33	4	-

(Source: Hileman and Rauchs, 2017)

Table 2: Measurement of variable

S#	Variables	Measurement	Source
01	Environmental degradation	CO_2 emission (% change from 2013)	WDI
02	Crypto trading	Crypto volume	Coin Market Cap
03	Economic growth	GDP growth (annual percentage)	WDI
05	Renewable energy consumption	% of total energy demand	WDI

half portion of crypto currencies is mined in Asia and 1/3 of global payments are done in the said regions in terms of crypto. The statistics are enough to justify that how much the crypto holds the importance in Asian region, this is why the present study intends to explore the nexus between crypto trading, environmental degradation and economic growth. This way, the present study addresses the gap in literature by evaluating long and short-term nexus among crypt trading, environmental sustainability, renewable energy consumption and economic growth in the context of top Asian countries. In addition, the evidences might become legit to raise public awareness regarding the relationship between crypto trading and environmental sustainability. Therefore, we can conclude that the main contribution of the article is that the analyses is not solely stick to the wonders of crypto trading in terms of economic viability but the most important aspect is added in the framework which is crucial for climate change; environmental sustainability.

2. LITERATURE REVIEW

The rapid involvement of innovation and technology in all areas aggravated digitalization in financial, energy and agriculture sector (Bilan et al., 2020; Dzwigol et al., 2020; Melnychenko, 2019), Researches specifically on crypto currency development has been increasing rapidly since 2015. In 2021, a 6 times increment has been seen in publications related to the phenomenon, considering 2015 as a base year. In addition, it can also be seen that mostly published researches are conducted in the context of US, UK and Germany. The evidences indicates that scholars are now taking keen interest with passing time, hence highlighting the significance of crypto currency (Chiriac, 2018; Rahmanov, 2021; Sadraoui et al., 2021).

The development of cryptocurrency is viewed as a future growth by global community. Scholars confirmed that crypto currency appears to be a powerful tool for economic growth in future. Meanwhile, researchers also confirmed that crypto currency development enhances the % of GHG emission. Resultantly, restricts the global communities to reach out the goal of zero carbon economy and sustainable climate under the notion of SDG goals (Kwilinski and Kuzior, 2020), Hence, in this situation, it is imperative to evaluate crypto currency development from different perspective.

2.1. Crypto Currency and Economic Growth

There is no doubt that the revolution of industry introduced the concept of blockchain development which eventually transformed economies and financial markets, resultantly boosted economic growth. With this emergence, it further leads to crypto development (Bogachov et al., 2020; Cosmulese et al., 2019; Petroye et al., 2020; Yang et al., 2021), According to Hazard et al. (2016), digital currency helps in the transformation of economic growth framework and declining of contractual costs. Another study discussed the positive and significant connection of crypto currency in regard to economic development (Masharsky and Skvortsov, 2022), The authors also stated that there is need of relevant government regulation in financial markets. Study conducted by Bojaj et al. (2022) also argued that that economic growth is accelerated due to bitcoin. However, shocks in crypto market could influence the investor's decision, wreck the traditional market and reduce the macro-economic indicators. However, in another study, the outcomes were vice versa, the research conducted by Sadraoui et al. (2021), established the fact that exchange rate are positively correlated with bitcoin prices, however, influence the economic openness in negative manner. According to Hunter and Kerr (2019), bitcoin may complicate the monetary policies and provide some restrictions in the development of stable economy.

2.2. Crypto Currency and Energy Consumption

De Vries (2021) articulated that the development of crypto market increases the consumption of energy. On the other hand, Us et al. (2021) argued that the boom in bitcoin stabilize the economic growth and brings changes in the architecture of financial market. According to Truby (2018), crypto currency enhances energy consumption but the author also emphasized that relevant laws and policies have the potential to decolonize crypto market and create the way to minimize the percentage of energy consumption. Further to discussion, several studies indicate that the energy consumption is vital for any nation as it reflects on the energy security of the country. Also, the economic reliance on energy resources and environmental issues demands the higher development of renewable energy which eventually increase the % share in total energy consumption. Due to this, countries must allocate alternative source in order to increase renewable energy (Cebula and Pimonenko, 2015; Hussain et al., 2021; Prokopenko et al., 2017; Saługa et al., 2020).

The pile of literature also exists which highlights the fact that the greening energy consumption should be done via digital technologies, alternative measures and crypto technology. In this lieu, 61 stipulates that innovative and smart technologies are helpful in the promotion of renewable energies in the country. Vakulenko et al. (2021) and Lyulyov et al. (2021), also stated that smart grid play a vital role in reducing energy consumption from traditional resources, hence enhancing renewable consumption. Studies also debated that in order to extend energy resources, an additional finance is required, Moreover, if the cost of bitcoin in comparison to energy cost is lower, then it might limit the mining of bitcoin. According to Küfeoğlu and Özkuran (2019), mining tools and hardware are only be fruitful when they are energy efficient. Additionally, Vranken (2017) suggested that crypto mining consume less energy because of other alternative technological tools. The same is concluded by Küfeoğlu and Özkuran (2019) and Sedlmeir et al. (2020) too. But these studies also confirmed the bidirectional association between crypto profitability and energy consumption. Lastly, another pile of studies articulates that bitcoin development leads to inefficient usage of traditional energy resources. Thereby, it is imperative to explore the linkage between crypto trading and energy consumption.

2.3. Cryptocurrency and Environmental Degradation

The study done by Erdogan et al. (2022) provides the evidence where causal association between crypto development and environmental degradation was found. The study applied Toda Yamamoto test to evaluate the association between constructs. In that very particular study, the author used carbon emission as an indicator of environmental degradation. Several studies indicated that crypto currency is harmful for environment as it increases the percentage of energy consumption and mining pollution (Goodkind et al., 2020; Jiang et al., 2021; Wang et al., 2022), One of the studies specifically constructed the crypto currency index which was based on environmental attention. The evidences shows that crypto development along with the efficient Government policies could increase the harmful emission which are dangerous for environment. Similar evidences were also provided by Jiang et al. (2021), which stated the energy consumption in China form crypto mining will be increased up to 296.6 TWh. This excessive increase of energy also increases air pollution by almost 130.5 million metric tons of carbon emissions. In this scenario, the study argued that government regulation is necessary with the strict tax policies regarding carbon emission and mining pollutions. The study used MVMQ-CAViar Model as well granger causality to evaluate the association of bitcoin prices with carbon credit market. The empirical evidences indicate that both the constructs are significantly related to each other. Moreover, the causality impact was not confirmed in the study. Another study De Vries and Stoll (2021), empirically revealed that that crypto currency increases the wastage of electricity, hence, pollute land and ground water. Thereby, the development of digital currency needs the mechanism which can mitigate the environmental issues via alternative measures. Studies also confirmed that green financing and smart grids are helpful in the reduction of air pollution (Kwilinski et al., 2022; Pimonenko et al., 2021; Polcyn et al., 2022), The study conducted by Chyhryn et al. (2018) revealed that 1 bitcoin in USD does the health damage around 0.49 USD in USA context and 0.37 in China context. However, the opposite evidences were stated by Cocco et al. (2017), stated that blockchain technologies and crypto technologies promotes green technologies, hence, could be helpful in achieving SDG goals.

It is argued by several scholars that crypto currency impacts environment in a more severe and dangerous manner. The UN climate report indicates that the temperature at global level has risen 1.5°C above and bitcoin alone can raise around 2 centigrade temperature in coming years. Another researcher claimed that majority portion of electricity which is being used for crypto related process, comes from coal-based power plants which are inefficient and are normally build in rural areas, hence are not so flourished as well as materialized. It is stated in many articles that the networking computing power of bitcoin is 100,000 times higher as well as efficient, if we merge the efficiency of 500 fastest super computers all over the world. This shows that how much damage crypto currency could done to environment. During 2009-2019 period, it is observed that global temperature has been increased from 0.61 centigrade to 0.88°C because of high usage of technology (Hern, 2018), It shows that the excessive technology usage deteriorates environmental quality via electronic wastages, scarcity of technology recycling activities, short span of digital technology and innovation. Thereby, the research aims to evaluate the effect of crypto trading on environmental sustainability. Hence, this way it contributes a visionary point that is something new in the sustainability literature.

2.4. Environmental Degradation and Economic Growth

The association of environmental quality and economic growth is not that straight forward. The reason being versatile challenges due to the economy size. Studies argued that environmental Kuznets curves indicate that countries where the share of GDP is higher, are more compatible with environment as compare to those countries whose economy is industrial based or manufacturing based (Artene et al., 2020; Sarfraz et al., 2018), It is argued that the environmental quality could be enhanced in industrial and manufacturing-based economies through technological means of change when making decision regarding production and energy consumption. According to Sibanda and Nadlela (2020), there exists a long run connection between country's GDP and carbon emission, on the other hand, the study conducted by Menyah and Wolde-Rufael (2010), provided the evidence of unidirectional association of environmental degradation with growth of economy. Similarly, the study of Peng et al. (2016) provided the bidirectional causality between these two constructs in the context of China.

Also, there exists another bundle of literature which scrutinized the connection of environmental degradation and economic growth (Alkhathlan and Javid, 2013; Baek, 2015; Dong et al., 2018; Khoshnevis Yazdi and Dariani, 2019; Li and Ouyang, 2019; Ozturk et al., 2010). The evidences from literature also indicate the majority of emerging economies are causing environmental destruction. Meanwhile, the established economies are now taking keen interest on way through which environmental sustainability can be enhances, however, the process is time taken. Thereby, the study also intends to examine the association of economic growth with carbon mission in Asian countries which are crypto friendly including Vietnam, Malaysia, South Korea, Japan, Singapore, HongKong, China, Iran, Pakistan and India.

Based on the above argument, the formulated hypothesis states that:

There is causal association among crypto trading, environmental degradation, energy consumption and economic growth.

3. METHODOLOGY

The current article aims to evaluate the association among crypto trading, environmental degradation, energy consumption and economic growth. The author chose Asian region and considered the sample of those countries which are Top 10 crypto using countries including Vietnam, Malaysia, South Korea, Japan, Singapore, HongKong, China, Iran, Pakistan and India. The articles extracted data from secondary sources covering the period from 2012 to 2020. The data was extracted from multiple resources such as WDI, world data bank and Coin market cap from top 10 crypto Asian countries. In the paper, carbon emission is taken as dependent variable and crypto trading as independent variable, whereas GDP and energy use are considered as control variables (Table 2). Following is the expression established by using understudy constructs:

$$CO2I_{it} = \alpha_0 + \beta_1 CT_{it} + \beta_2 EG_{it} + \beta_3 EU_{it} + e_{it} \quad (1)$$

Where,
CO_2 = Carbon emissions
i = country
t = time period
CT = crypto trading
EG= economic growth
EU = Energy Use

The article runs various tests such as "descriptive methods, correlation matrix, CS-ARDL test, granger causality test." In descriptive, mean, standard deviation, minimum, maximum and number of observations are showed. The correlation matrix is performed to evaluate the directional association among constructs. Moreover, CSD technique was chosen for the study as it seems to be best fit technique when the sample contains multiple countries. The CSD expression is formulated below where p_T symbolizes "pair wise correlation," T means time and cross-sections units are represented by I

$$CSD_{IT} = [\frac{IT(T-1)}{2}]^{\frac{1}{2}} p_T \quad (2)$$

Stationarity of constructs is also investigated through CIPS test whose expression is given below:

$$\Delta W_{i,t} = \varnothing_i + \varnothing_i Z_{i,t-1} + \varnothing_i \bar{Z}_{t-1} + \sum_{l=0}^{p} \varnothing_{il} \Delta \bar{W}_{t-1} + \sum_{l=0}^{p} \varnothing_{il} \Delta W_{i,t-1} + \mu_{it} \quad (3)$$

Where
$\bar{W}$ = cross section

$$W^{i,t} = \varnothing^1 \overline{CO2}^{i,t} + \varnothing^2 CT^{i,t} + \varnothing^3 \overline{EG}^{i,t} + \varnothing^4 EU^{i,t} \quad (4)$$

The CIPS equation by considering equation 4, can be written as

$$CIPS = N^{-1} \sum_{i=1}^{n} CADF_i \quad (5)$$

Where
CADF = cross-sectionally augmented dickey fuller test

Cointegration has also been inspected via Westerlund and Edgerton (2008) cointegration test. The test is not a conventional type and has the ability to assess "regime shift and no-shift breaks" at the structure.

$$llog(L) = \alpha_0 - \frac{1}{2}\sum_{i=1}^{N}\left(Tlog(\sigma_{i,t}^2) - \frac{1}{\sigma_{i,t}^2}\sum_{t=1}^{T} eit^2\right) \quad (6)$$

Also, CS-ARDL technique was considered in order to scrutinized long and short run nexus.

Lastly, CS-ARDL technique was used to examine long and short run nexus among constructs. The approach is famous and well accepted in case of panel data. Thereby, the CS-ARDL technique is used whose equation is written below:

$$\Delta Y_{it} = \varphi_i + \sum_{l=1}^{p} \varphi_{it} \Delta Y_{i,t-1} + \sum_{l=0}^{p} \varphi_{il}^{'} EXV_{s,i,t} + \sum_{l=0}^{1} \varphi_{il}^{'} \overline{CSA}_{i,t-1} + \varepsilon_{it} \quad (7)$$

The article formulated an expression based on study constructs:

$$\Delta CO2_{it} = \varphi_i + \sum_{l=1}^{p} \varphi_{it} \Delta CO2_{i,t-1} + \sum_{l=0}^{p} \varphi_{il}^{'} CT_{s,i,t} + \sum_{l=0}^{p} \varphi_{il}^{'} EG_{s,i,t} + \sum_{l=0}^{p} \varphi_{il}^{'} EU_{s,i,t} + \sum_{l=0}^{1} \varphi_{il}^{'} \overline{CSA}_{i,t-1} + \varepsilon_{it} \quad (8)$$

Lastly, the current research also used the granger causality test that exposed the "bidirectional, unidirectional and no linkage" among the constructs. The equations are mentioned below:

$$Y_t = \beta_0 + \sum_{j=1} \beta_{1j} Y_{t-1} + \sum_{h=1} \beta_{2h} Y_{t-p} + \varepsilon_t \quad (9)$$

$$X_t = \acute{\alpha}_0 + \sum_{s=11s} \acute{\alpha} Y_{t-s} + \sum_{t=1} \acute{\alpha}_{2t} X_{t-m} + \varepsilon_t \quad (10)$$

4. FINDINGS

As discussed above, the descriptives applied in the article to evaluate the mean, maximum, minimum, skewness and kurtosis value for sampled data. Table 3 provides the details of descriptives in cross-sectional panel of Top 10 Asian countries.

From Table 3, we can see that the minimum value of carbon emission is 1.53×10^8 whereas maximum is 8.21. Whereas mean value is 3.64. The min value of crypto trading is 2123.567 and maximum is 52018.43 with the mean value 117665.5 In case of economic growth, mean value is 11.546, having the maximum value 157.656 and minimum value 53.456. Similarly, the minimum value of energy usage is 2.6 and maximum is 18.278 with the mean value 88.456.

The authors also performed correlation matrix to find out the directional association among constructs. The results reveal that carbon emissions, energy usage, economic growth and crypto trading all have positive relation among each other. Table 4 shows the value of correlation.

Table 3: Descriptives

Variable	Obs	Mean	Min	Max	Skewness	Kurtosis
CO_2	08	3.64×10^8	1.53×10^8	8.21×10^8	1.265	3.821
CT	08	117665.5	2123.567	52018.43	6.452	42.22
EG	08	11.546	53.456	157.656	0.945	2.798
EU	08	88.456	2.6	18.278	−0.287	1.672

CT: Computed tomography, EG: Economic growth, EU: Energy use

Table 4: Correlation

Variables	CO_2	CT	EG	EU
CO_2	1.000			
CT	0.687			
EG	0.712	0.659	1.000	
EU	0.428	0.645	0.346	1.000

CT: Computed tomography, EG: Economic growth, EU: Energy use

Table 5: CSD test

Variable	Test Stat (prob-values)
CO_2	2.382*** (0.00)
CT	3.99*** (0.00)
EG	4.472*** (0.00)
EU	5.654***(0.00)

CT: Computed tomography, EG: Economic growth, EU: Energy use

Table 6: Unit root test

Variables	I (0)		1st Difference I (1)	
	CIPS	M-CIPS	CIPS	M-CIPS
CO2	−1.182	−1.162	−5.902***	−6.086***
CT	−2.910***	−3.782***	-	-
EG	−1.034	−1.038	3.092***	5.803***
EU	−5.792***	−5.773***	-	-

CT: Computed tomography, EG: Economic growth, EU: Energy use

Furthermore, CSD test was also used to apply the cross-sectional dependency. The results expose that t-statistics values are higher than 1.96 and $P < 0.05$, means, the CSD issue is not existed in the model. Table 5 shows the details.

Along with it, through CIPS unit root test, variables stationarity was checked. Obtained results reveal that crypto trading and economic growth are stationarity at level, whereas energy use and carbon emissions are stationarity at first difference (Table 6).

The findings in Table 7 CO_2 emissions and REC are stationary at level where as RDE and FDI inflows are stationary at first difference.

To check cointegration, Westerlund and Edgerton (2008) cointegration test was applied. The findings reveal that t-stats are >1.96 and $P < 5\%$

The findings expose that renewable energy consumption is negatively associated with carbon emissions in the context of sampled Asian economies. However, crypto trading and economic growth both are positively correlated with carbon emissions in long and short run, hence, pointing out that crypto volume is damaging the environment in greater extent. Table 8 provides the clear summary of statistics.

The study also applied granger causality test in order to expose the "bidirectional, unidirectional or no association" among the constructs. The findings indicate that there exists a bidirectional association between crypto trading and carbon emission and crypto trading and energy usage. However, unidirectional association is found between crypto trading and economic growth and economic growth and energy and carbon emissions (Table 9).

Table 7: Cointegration test

Test	Without break	Mean shift	Regime shift
Explained variable: CO_2			
$Z_\varphi(n)$	−4.092***	−4.066***	−4.217***
P_{value}	0.00	0.00	0.00
$Z_\tau(n)$	−5.099***	−3.042***	−5.148***
P_{value}	0.00	0.00	0.00

Table 8: CS-ARDL method

Long run findings			
Variables	Coeff	t-stat	Prob
Explained variable: CO_2			
CT	0.676***	3.802	0.003
EG	0.593***	4.439	0.00
EU	−0.454***	−3.873	1.001
CSD-statistics	-	0.028	0.611
Short run results			
REC	0.574***	4.812	0.000
FDI	0.786***	3.071	0.022
RDE	−0.657**	−1.983	0.011

CT: Computed tomography, EG: Economic growth, EU: Energy use

Table 9: Granger causality test

Null hypothesis	F-statistic	Prob.	Decision
CT does not granger cause CO_2	5.98303	0.0000	Bidirectional
CO_2 does not granger cause CT	4.73039	0.0000	
CT does not granger cause EG	3.98302	0.0032	Unidirectional
EG does not granger cause CT	0.09839	0.7639	
CO_2 does not granger cause EG	6.76348	0.0000	
EG does not granger cause CO_2	1.42329	0.2928`	Unidirectional
CT does not granger cause EU	6.87363	0.0000	
EU does not granger cause CT	5.83762	0.0000	Bidirectional

5. DISCUSSION AND CONCLUSION

As it is understood that the rapid advancement in technology and its linkage with all the areas justifies the development of crypto currency and crypto market. In this particular study, the focus was majorly on environmental degradation, energy consumption, effectiveness of crypto currency and economic growth. The findings expose the bidirectional association between crypto trading and carbon emission, crypto trading and energy usage and unidirectional association of crypto trading and economic growth and carbon emission and economic growth. Considering these findings, it indicates that the high growth in crypto trading increase the economic growth of country in terms of GDP. Similar evidences were provided in the research (Mi´skiewicz et al., 2022; Mohsin et al., 2023).

The above evidences exhibit that there is a dynamic effect of crypto trading on environmental degradation (carbon emission), It shows that the excessive technology usage deteriorates environmental quality via electronic wastages, scarcity of technology recycling activities, short span of digital technology and innovation. The evidences are consistent with prior studies, hence confirming that crypto currency impacts environment in a more severe and dangerous manner. The study evidences are also in line with the study of Hern (2018), which indicate that the temperature at global level has risen 1.5°C above and bitcoin alone can raise around 2 centigrade temperature in coming years. Another researcher claimed that majority portion of electricity which is being used for crypto related process, comes from coal-based power plants which are inefficient and are normally build in rural areas, hence are not so flourished as well as materialized. It is stated in many articles that the networking computing power of bitcoin is 100,000 times higher as well as efficient, if we merge the efficiency of 500 fastest super computers all over the world. This shows that how much damage crypto currency could done to environment (Kwilinski et al., 2022; Pimonenko et al., 2021; Polcyn et al., 2022).

This particular causality results would help policy makers to focus on the carbon emission areas especially in those countries which are crypto friendly. Also, with these evidences they may plan to mitigate the challenges with efficient tool and better management in the future. The evidences since confirmed that crypto volume and carbon emissions share bidirectional association, hence, the evidences indicate that policies could be restructured in a way to achieve sustainable environment considering the effects crypto currency. The modified policies in particular areas would help to reduce the challenging pollution effects and improve environmental quality in crypto friendly countries. The obtained results of this study strongly support the proposed hypothesis in the sample of top 10 crypto friendly Asian countries. Specifically focusing on bidirectional associations, the crypto traded countries should encourage the purchase of eco-friendly technology for crypto trading and implement green energy management systems in IT houses. The reason is that crypto trading is strongly linked to economic growth in a positive manner, means the growth can be sustained via increased volume of crypto currency, however, ecological technologies should be considered for crypto trading so that the % of carbon emissions can be supressed and do not become the cause of environmental degradation. The incorporation of green agenda in technological advancement improves the efficiency of energy and minimize the carbon emission. Less developed economies are recommended to use “ultra-super critical and gasification combined cycle plants in electric and power sector, if the installation of renewable energy plant is not practical. Also, it is suggested to control the emissions of primary sectors such as industry, transport, buildings as it will help in releasing less carbon emission, hence, economic growth won’t be compromised.

Like other papers, the current study also has few limitations, which are needed to be considered by future scholars. The study focused on top 10 crypto friendly Asian countries, hence not paid attention to the status of countries in terms of developed or less developing. As there is a rapid increase in crypto trading, it is recommended to chose sample as per economies status. Moreover, the environment is contaminated with multiple green house gases such as NO_2, SO, O3, CO, CFC which are also responsible for environmental degradation. The paper specifically focused on carbon emissions; hence, it is recommended to consider other GHG emissions. Moreover, the variables can be scrutinized with extended time period, as results might be different.

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