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Climate Change Mitigation via Green Investment and Energy Consumption: The Mediating Role of Energy Efficiency

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ABSTRACT

Climate change is one of the biggest challenges that the world is currently facing. Therefore, the present study aims to test the impact of carbon emission on climate change mitigation in China at provisional level. Further, this study aims to explore the role of green investment in reducing carbon emissions and enhancing climate change strategies. Data for the present study was gathered from the Organisation for Economic Co-operation and Development (OECD), the World Bank, and the European Union (EU) databases. While the data analysis was conducted through composite indicator estimates, the findings of the present study revealed that there exists a noteworthy association between specific greenhouse gas emission reduction responsibilities and climate change mitigation, with a correlation of 19%. Additionally, a significant 21.5% association is found between activities like carbon trading, production, and consumption of carbon allowances and the energy consumption necessary for effective climate change mitigation measures which are 20.6%. The importance of green investment becomes evident with its impact on energy consumption is 26.5% and its substantial contribution to climate change mitigation measures is 31.3%. These figures surpass the effectiveness of conventional climate management techniques. The study's insights have implications for policymakers and stakeholders, offering a deeper understanding of climate change mitigation measures and emphasising the role of green investment in reducing carbon emissions and energy consumption.

Keywords: Energy Consumption, Energy Efficiency, Green Investment

1. INTRODUCTION

Climate change is one of the significant threats and matters of concern for every part of the world. One major source of climate change is carbon emission. The 2023 Annual Climate Report by NOAA states that the average combined land and ocean temperature has risen by 0.11°F (0.06°C) every decade since 1850, totaling roughly 2°F. Since 1982, the pace of warming has been 0.36°F (0.20°C) every decade, which is almost three times faster than before. Countries collectively as well as individually trying to mitigate this issue to save themselves from its adverse effects. To prevent climate change, various other actions and approaches are proposed and implemented at different scales (Tiep et al., 2021; Aman-Ullah et al., 2023). In contrast to the fact that many activities and initiatives seem to be centered on the states, environmental change planning and mitigation should be a national endeavour. Various other, less apparent classifications emerge (Shah et al., 2019; Liu et al., 2021). Currently, a plethora of environmental concerns exist in contemporary society. The factors affecting climate change encompass the increase in pollutants and associated hazards and the degradation of ecosystems across extensive regions. The greenhouse effect as a result of high energy consumption is widely recognised as one of the most significant climatic hazards.

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One serious concern is the threat of heat retention from the earth's surface as a result of a frequent rise in greenhouse gas concentrations. This phenomenon is expected to lead to an elevation in surface temperature and sea levels. Green investment has emerged as a discernible and feasible trajectory for China's forthcoming progress. Green investment is an established financial methodology that aims to enable the provision of investment, operational capital, and a range of other financial services for projects that prioritise preserving and enhancing environmental sustainability.

Human actions that release greenhouse gases are affecting earth's climate and creating environmental damage. Reducing hazardous gasses is part of climate change mitigation strategies including renewable energy, energy efficiency, sustainable land use, and cleaner technologies. Further, carbon capture and storage, and international collaboration to reduce emissions are also ways that can help mitigate climate change. Climate change mitigation attempts to address the root causes of climate change and build a sustainable and resilient future by reducing greenhouse gas emissions and encouraging environmentally friendly behaviours across sectors.

According to Canelli et al. (2021), environmental assurance has relied on financial and market institutions for about 30 years before carbon dioxide (CO_2) advertising became widely popular. Canelli et al. (2021) employed a variety of monetary and market mechanisms, components, and foundations to evaluate the so-called state deceit including state deficits in the organisation of environmentally amassed commodities. All these issues are detrimental to any country, including high prices, insufficient appropriateness, a denial of mechanical development constraints, and poor authenticity (Ikram et al., 2019). Many industrialised countries adopted environmental levies, penalties, and restoration programs in the 1970s and 1980s, primarily in the United States (US) and European Union (EU).

By the mid-1990s, the state had coordinated and implemented market-constructed procedures, institutions, and programs to combat global warming and climate change. During the next thousand years, it looked like things had changed significantly. International carbon markets are growing, demonstrating that market manipulation is no longer limited to the 'country state holder' (Baloch et al., 2020). The carbon market did not exist ten years ago. In 2010, the international carbon markets were valued at $141 billion, more than quadrupling in 2007 (Sun et al., 2020). Business sectors are responsible for the emergence of environmental legal issues throughout time. The present financial crisis has brought the global financial system's instability to everyone's attention (Chandio et al., 2020).

Green finance or green investment is an initiative by the UN Environment Programme to reduce carbon emissions. The principal aim of green financing is to advance the cause of environmental preservation. Green financing includes green bonds funding environmental projects. Governments, banks, and corporations issue these bonds to fund renewable energy, energy efficiency, and other green projects. Overall, green investment promotes resolving environmental concerns through green money and green bonds which is expected to support sustainable finance and sustainable performances.

Alemzero et al. (2020) reported that green investment has a significant impact on China's financial sector. China used green financing as green investment and green loans. Through green financing, the private sector became able to contribute to environmental projects through green funding. Green bonds are becoming more popular to fund environmental activities over a period of time including long-term projects. Green bonds are bonds that assist the environment while providing a steady stream of revenue for longer periods (Tajdar et al., 2023; Lathifa & Aman-Ullah, 2022).

Green investment law is in place for smaller financial institutions and state-owned companies. China is a pioneer in the development of green credit laws. Green investment might use current

bank and company relations and existing technology (Yu & Solvang, 2020; Bodnar et al., 2018). Green investment that is based on carbon emissions is often beneficial to the economy, society, and individuals' well-being. Liu & Wu (2019) found a significant positive relationship between green investment and sustainable manufacturing which is making it feasible for China's conversion to an intelligent and ecological industry. Furthermore, private Chinese banks are assuming control of the green finance industry as compared to state-owned banks (Karpinska & Smiech, 2020).

Considering this background information, one of the primary objectives of this research is to assess the energy consumption in climate change mitigation. Furthermore, how might green investment solve energy consumption from the climate change mitigation perspective? The following three topics are addressed in this post: When it comes to turning back the clock on global carbon markets and putting them in place, who is in charge? According to previous research, the carbon market is a financial institution, but it also serves as an implement to prevent climate change. The carbon markets could become as ineffective as the financial system if the regulatory framework fails to function. These concerns contribute to the empirical understanding of the area. In contrast, investigating the creative effect of green money on energy consumption in the context of climate change contributes to the theoretical debate (Ren et al., 2022).

According to the report, readers are also encouraged to be skeptical of carbon markets as institutions that minimise the risks of climate change (Ren et al., 2022). Consequently, we must address the existing condition of global carbon markets, including any conflicts or issues that may arise. Finally, the administration of the carbon market is sometimes compared to that of the financial services industries.

2. LITERATURE REVIEW

Initially, researchers concentrated on market procedures and institutions for communal natural resource management, specifically when market deceit research showed the core cause of existing environmental concerns. During the 1980s and 1990s, much discussion and resistance to market-based limits on natural and environmental change existed. Regarding financial/private/monetary performers in ecological and environmental ascendancy, the emphasis has shifted from determining if financial entertainers can make the most significant contribution to management capacity to determining how, where, and how much they can provide. Private administrative concerns, public-private partnerships, and non-profit market administration have all been included in this research's scope (Chang, 2020).

Keohane and Olmstead (2007) illustrated markets' complex relationship with environmental protection. According to DeSimone and Popoff (1997), firms should plan for the environment (Prothero, 1999). These publications influenced the 1980s and 1990s market-based solutions and environmental sustainability discourse, but not exclusively (Stiglitz, 2017).

Environmental management and conservation initiatives are often the subjects of intense debate due to the neo-liberalisation of nature. Executive groups are selling and privatising fishery resources while misallocating timberlands, water resources, and, more recently, carbon. The emergence of carbon markets represents a relatively new indicator of the ongoing cycle of natural neo-liberalisation. Environmentalists' express concerns regarding the neo-liberalisation of nature writing, arguing that it will create a unique and problematic secondary condition that necessitates carefully considering appropriate measures. To illustrate the connection between commercial and financial neo-radicalism and environmental security, various examples can be identified. Numerous studies have supported this notion, employing diverse frameworks and methodologies to examine establishing global foundations and practices to address environmental challenges (Zhang et al., 2022; Manzoor & Jahangir, 2023; Ahsan & Aman-Ullah, 2023).

The importance of financial systems in fostering long-term economic prosperity has been recognised by the Association of Asia-Pacific (AAP). However, it is anticipated that several countries may fail to achieve the SDGs by 2030. The study's empirical findings are summarised in Table 1.

Table 1 Individual Indicator Index

Provinces	CC %	CD*	Provinces	CC%	CD*
Yunnan	0.34	1.32	Anhui	0.47	7.61
Zhejiang	0.31	2.56	Hunan	1.01	1.46
Hebei	0.21	3.52	Sichuan	3.33	1.44
Tianjin	0.47	2.15	Shanxi	2.15	2.54
Hainan	0.81	3.16	Jiangsu	2.81	6.23
Guangdong	0.32	4.34	Shanghái	3.17	3.25
Fujian	0.39	4.59	Heilongjiang	6.81	2.60
Qinghai	0.19	3.10	Jiangxi	2.34	2.86
Henan	0.77	0.71	Guizhou	0.56	3.17
Hubei	0.23	0.67	Chongqing	0.99	0.23
Jilin	0.78	0.43	Shanxi	0.71	1.14
Beijing	0.14	2.22	Liaoning	0.88	5.62
Shandong	0.45	3.14	Gansu	0.91	0.13

Source: GDP - World Bank Statistics

According to Zhang et al. (2022), China has accounted for 18% of all global green bond issuances, second only to the US. Additionally, in 2017, the green credit volume in China amounted to 8.29 trillion RMB. The primary and secondary CO_2 markets traded 282 million metric tons. The quality of this study must improve. High unit costs are currently limiting non-fossil energy development. Renewable energy sources, including solar, wind, and nuclear, may help reduce CO_2 emissions. Unrepayable large-scale venture funding Alternative energy firms need flexible and diversified service options. It should be encouraged to reduce inspection and approval costs for non-fossil energy projects. In addition to tax breaks and pretax payments, non-fossil enterprises should be allowed to write off bad debts (Aman-Ullah et al., 2023).

Analysing the world now through organisational and cascade humanism is an approach. These are the new global innovation building blocks. Solid and long-lasting linkages show streams' 'directional' flexibility, restricted by ecological-related constraints. These networks have powerful, long-lasting, and unexpected linkages between centers despite typically blocking stream pathways. Shell has taken an initiative to support the environment by supporting agrotourism which is a good example of extensive multinational collaboration (Taghizadeh-Hesary & Yoshino, 2020). The phrase 'global fluid' describes spatial formations with immense suppleness, fluidity, gel-like improvement, and penetrable restrictions (Yu et al., 2021). Liquids can only reterritorialise with no end condition or objective. It is hard to concentrate in a world that is constantly changing. Individuals such as (Zha et al., 2020) have emphasised the need for such flows notwithstanding the reterritorialisation of global GINs and liquid financial data.

Streams are accepted, avoided, and managed inside a network to determine its strength. This might be due to internal power dynamics. Ahmad et al. (2021) claim that wealthy elites control global investment, capital, and data to the disadvantage of others without access. Their power positions regarding stream mobility, stream 'rights of access', and stream constraint severity are 'constructed' by these bodies. The ability of countries to direct mobility varies (MacAskill et al., 2020). State administrations cannot determine societal norms and criteria in the globalisation era. Global linked networks make states less competent to govern stream speed, composition, content, and issues. Globally, liquids are gaining on governments and management. State exercises seldom move global liquids, and state experts do not need to build socio-material networks to be successful (Hafeez et al., 2023; Akbar et al., 2022; Lin et al., 2022). Understanding global streams and organisations is becoming more critical. A country's social sector's

transnational, borderless streams and organisations usually complement, if not replace, solid limitations and designated groupings. Carbon markets, which employ the notions of streams and organisations, combat ecological change.

Carbon markets act as a regulatory system, allowing for the trading and remittance of nursery gases and credits won by not damaging the ozone layer. This is not due to a single universal credit and remittance market but to a growing interconnectedness and amalgamation of varied economic zones. Carbon displays refer to carbon markets and displays (see Table 1). This research delivers them separately; their size, combination, progress, and management will vary. Unlike the US and the EU, which represent administrative and consistency markets, willing businesses are more structured, non-state, and typically operate without integrated oversight (Ling et al., 2020). Every purchase of carbon credit is scrutinised in deliberate carbon markets. Examples of existing economic sectors with a stated goal are the Chicago Climate Exchange (CCX) and the larger nonrestrictive over-the-counter balanced market. The CCX is a voluntary mechanism for exchanging non-ozone-depleting ozone-based chemicals. Large emitters have reduced emissions via fixed rates (Yu et al., 2020).

3. METHODOLOGY

The ecological change represents a paramount concern for the long-term sustainability of human civilisation. Promoting and supporting investments in green energy initiatives is imperative to mitigate the impacts of climate change. The preservation of the environment relies heavily on securing funds for developing and utilising renewable energy sources, including wind, solar, hydrogen, and geothermal energy. These innovative solutions play a crucial role in mitigating pollution, reducing greenhouse gas emissions, and slowing down the pace of global warming. Hence, assessing how much green investments contribute to pollution reduction is essential.

To address this need, the authors have developed a green investment index considering various factors (refer to Table 1). A selection of both developed and developing nations was contained in the research to analyse the impact of green investments on pollution reduction. Foreign direct investment (FDI) and expenditures on research and development (R&D) in renewable energy were utilised as proxy indicators for green investments. The authors argue that establishing a comprehensive low-carbon/green investment index is essential to tackle different nations' environmental and financial challenges and chart future decision-making paths. Consequently, the green investment index is pivotal in addressing environmental issues such as carbon emissions, offering crucial insights to key stakeholders and decision-makers (Mohsin et al., 2021). International Renewable Energy Agency reported that renewable energy sources have expanded by 36% in developing nations (Igogo et al., 2021). Since 2014, when green investment climbed by 17 percent each year, this is the second significant gain in the sector. FDI and green investment in research and development in the energy industry are crucial to lowering CO_2 emissions and other pollutants. As you can see in Table 1, any initiative that has a beneficial impact on carbon emissions is given a higher weight. According to Shen et al. (2021), the energy sector is included in the index since it contributes significant CO_2 emissions.

3.1 Estimation Strategy

To assess the empirical data, we used composite indicator estimates that were similar to Data Envelopment Analysis (DEA) estimates. From 2016 to 2020, data was gathered from the OECD, the World Bank, and the EU databases. The composite indicator approach, like the DEA, uses a weighted average strategy to infer study outcomes. The same technique may be used to analyse financial constructs e.g., green investment, and environmental variables similarly (e.g., climate change and energy consumption). Farooq et al. (2021) used a DEA-like evaluation technique to evaluate the total weights.

$$bIi = \min \sum_{j-i}^{n} W_{ij}^{g} \; I_{ij}$$

$$\text{s.t.bIi} = \sum_{j-1}^{n} W_{ij}^{b} \; I_{kj} \leq 1, k = 1,2, \ldots\ldots, m$$

$$W_{ij}^{b} \; \geq 0, j = 1,2, \ldots\ldots, n \qquad (1)$$

The aggregate and weighting approach developed by Costa and Popovi (2020) is used. Similar strategies have been used by many researchers in the past as well. There are various disadvantages to using this technique, particularly when computing entity ratings.

$$g_i^I = \max \sum_{j-i}^{n} W_{ij}^{g} \; I_{ij} \qquad \text{s.t.gIi} = \sum_{j-i}^{n} W_{ij}^{g} \; I_{ij} \leq 1, k = 1,2, \ldots\ldots, m$$

$$W_{ij}^{g} \geq 0, j = 1,2, \ldots\ldots, n \qquad (2)$$

There are poor inferences and outcomes from using numerous input variables with constant output variables while doing DEA. Several authors have advocated using an index-based method for variable performance evaluation in DEA using several inputs and outputs. To evaluate a country's performance, use Eqs. 1 and 2 in conjunction with the operationalised green investment index. Including index-based measures into the equation makes more sense to construct the green investment index (Mohsin et al., 2020).

$$(\text{CI})\lambda = \lambda \frac{gI_i - gI}{gI^* - gI} + (1 - \lambda) \frac{bI_i - bI}{bI^* - bI}$$

Where,

$$gI^* = max\{gI_i, i = 1, 2, 3, 4, ..., m\}$$

$$gI^- = min\{gI_i, i = 1, 2, 3, 4, ..., m\} \qquad (3)$$

and

$$bI^* = max\{bI_i, i = 1, 2, 3, 4, ..., m\}$$

$$bI^- = min\{bI_i, i = 1, 2, 3, 4, ..., m\}$$

Consequently, 5 percent and 20 percent contribution restrictions were employed to define the lower and higher bounds (5). The green investment index comprises research and development, an investment index, renewable production, energy output, and an investment risk index. The green investment index, calculated based on specific characteristics, helps minimise CO_2 emissions. The model results are improbable because the weights employed to construct the essential indicator components have a low discriminating power compared to other weights.

The value of each indicator was estimated solely based on the collected data. Because of this, some signals may be missed throughout the aggregation process. The MCDA-DEA international weighted model might be of assistance (3). Take, for example, the assumption that there is a variable that measures how far the entity is from being completely efficient.

$$\min M$$
$$M - d_i \geq 0 \quad W_{ij}\, I_{kj} + d_k + (\sqrt{S^+ + S^-} = 1, k = 1,2,3,\ldots,m$$
$$s.t. \sum_{j=1}^{n}$$

$$W_{ij} \geq 0,\ d_i \geq 0,\ j = 1, 2, 3, \ldots, n,\ i = 1, 2, 3, \ldots, m \tag{4}$$

$$gI_i = 1 - d_i$$

$$\min d_i$$
$$M - d_i \geq 0 \quad W_{ij}\, I_{kj} + d_k = 1, k = 1,2,3,\ldots,m$$
$$s.t. \sum_{j=1}^{n}$$

$$mW_{ij} \geq 0,\ j = 1, 2, 3, \ldots, n,\ k = 1, 2, 3, \ldots, m \tag{5}$$

In the equations above, W is represented as the weight of the indicator j for all the entities and specifically, M– di ≥ 0 for entity "i" confirm; M _ max {di, i _ 1, 2, 3, ...,m} moreover utilised by Reig-Martínez et al. (2011) as an applicable option.

$$\min M$$
$$M - d_i \geq 0$$

$$\min M - k \sum_{e \in EF} d_e \qquad W_{ij}\, I_{kj} + d_k = 1, k = 1,2,3,\ldots,m$$
$$\sum_{j=1}$$

$$W_j \geq \mathcal{E},\ d_i \geq 0,\ j = 1, 2, 3, \ldots, n,\ i = 1, 2, 3, \ldots, m \tag{6}$$

In this study, we utilised the Wald test to the Quintile estimation with the OLS parameter.

4. RESULTS

Errors in planning and execution, market research, and the 2008/2009 financial crisis all threaten the new carbon exhibits in production (Sadorsky, 2020). These discussions address four key issues, from the most fundamental to the most serious. While some research is essential to carbon markets, it is not being pursued. It has been almost a decade since the first collection of the most fascinating and instructive studies on carbon markets was released. The Clean Development Mechanism has supported several research initiatives, including carbon credit assessment agreements. These analyses compare a wide range of credit metrics. So-called 'low-hanging organic commodities' like hydrofluorocarbon (HFC) pipeline end-of-pipe installations distract from less profitable but vital agriculture operations (like renewables) (McKibbin & Vines 2020). Clean Development Mechanism (CDM) is cost-effective because of low exchange costs for gauge upgrades, project entry, and certification. Some say the CDM's activities are incompatible, especially paid validators who have no incentive to follow the CDM's defined patterns. Citing CDM's lack of clarity on productivity and decarburisation, Azad et al. (2021) examine CDM for prioritising project focus over defined productivity and decarburisation methodologies. However, Wara (2008) criticises the CDM for failing to link and hold non-Annex states accountable for their Kyoto Protocol obligations. Some designers think the CDM is useless in the fight against global warming. Several planning concerns have occurred throughout the first and second rounds of the European Union Emission Trading System (EU ETS). The EU ETS

will include a decentralised public distribution system that allows nations to determine their compensation amounts. Significant transmission regions, such as aluminum, aircraft, emanation coverings, and exchange zones, are excluded from the EU ETS. Also, the EU ETS only addresses CO_2 emissions. The EU Allowances (EUAs) for the gases have also been established. In Phase III of the ETS (2016–2020), the European Commission expects administrative improvements. Some goals are specified in US trade frameworks. The biological basis of carbon exchange markets is discussed in a second session, adding to prior insights into design and operationalisation. How related and ecologically justifiable are the myriad administrative and deliberate carbon displays, or are they merely profit-driven schemes that violate natural reasoning and cause-and-effect logic? Environmental non-governmental organisations, natural resource professionals, and academics have extensively publicised the study's conclusions.

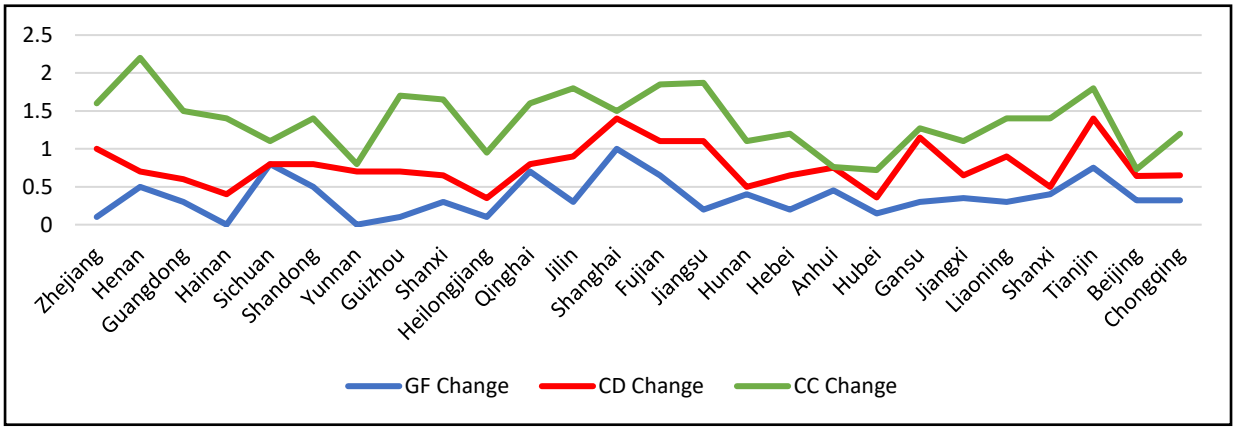


Figure 1. Change in Research Variables Across the Period of 2016 to 2020

A few experts doubt resource estimates when surplus carbon credits are provided without reducing emissions. Carbon loan uncertainty may reduce their value (see Table 2). Some studies claim that the carbon market argument increases funding for previously supported initiatives but primarily benefits those generating the investment. This market will inspire inventors to create new things for future use (see Table 3). We need frameworks that relate to natural assurance (reductions in discharges), emphasise the management board's relevance, and safeguard a corporation from large-scale expenditures if we want an ecological or financial market. The EU's ETS has recently varied in value (USD 10 to 30 per ton CO_2e) (mid-2009). Legislators, auditors, and merchants all support a direct-stock Carbon National Bank.

Table 2 Green Investment Index

Provinces	GFI	Provinces	GFI
Yunnan	0.52	Anhui	0.46
Zhejiang	0.44	Hunan	0.55
Hebei	0.34	Sichuan	0.61
Tianjin	0.41	Shanxi	0.25
Hainan	0.57	Jiangsu	0.18
Guangdong	0.34	Shanghái	0.32
Fujian	0.22	Heilongjiang	0.67
Qinghai	0.50	Jiangxi	0.15
Henan	0.48	Guizhou	0.88
Hubei	0.65	Chongqing	0.12
Jilin	0.52	Shanxi	0.31
Beijing	0.32	Liaoning	0.77
Shandong	0.69	Gansu	0.32

Regardless, the EU has consistently resisted market interventions based on natural occurrences. Carbon markets have evolved from essential credit purchases and sales to internationally harmonised and sophisticated monetary markets. These ecological-change markets abstract carbon credits and reductions from local time zones. As well as the 'neo-liberalisation of nature' issue, it is now possible to swap symbolic tokens over a broad egalitarian distance Certified Emission Reductions (CERs), Voluntary Emission Reductions (VER) and EUA. In 2009, it was highlighted that monetary transactions will advance the carbon market (Table 4); as it is current expanding private monetary influence on carbon markets.

Table 3 Percentage Change in Green Investment, Energy Consumption and Climate Change Mitigation and Mean Score

	Green Investment		**Energy Consumption**		**Climate Change**	
	Mean	**Change**	**Mean**	**Change**	**Mean**	**Change**
Yunnan	0.359	0.063	0.426	0.929	0.994	0.632
Zhejiang	0.454	0.794	0.747	0.438	0.784	0.963
Hebei	0.230	0.397	0.219	0.298	0.251	0.861
Tianjin	0.550	0.026	0.621	0.372	0.698	0.962
Hainan	0.416	0.803	0.416	0.046	0.327	0.245
Guangdong	0.514	0.521	0.305	0.266	0.5796	0.517
Fujian	0.226	0.014	0.211	0.723	0.278	0.119
Qinghai	0.120	0.0996	0.402	0.666	0.328	0.932
Henan	0.240	0.296	0.013	0.416	0.905	0.936
Hubei	0.015	0.077	0.846	0.223	0.655	0.627
Jilin	0.139	0.744	0.367	0.133	0.092	0.723
Beijing	0.704	0.231	0.384	0.727	0.911	0.911
Shandong	0.008	0.986	0.253	0.442	0.068	0.033
Anhui	0.039	0.678	0.698	0.413	0.182	0.752
Hunan	0.469	0.188	0.342	0.934	0.794	0.763
Sichuan	0.310	0.379	0.942	0.111	0.509	0.5929
Shanxi	0.006	0.139	0.942	0.517	0.407	0.497
Jiangsu	0.118	0.434	0.611	0.332	0.111	0.046
Heilongjiang	0.094	0.235	0.879	0.939	0.583	0.135
	Green Investment		**Energy Consumption**		**Climate Change**	
	Mean	**Change**	**Mean**	**Change**	**Mean**	**Change**
Jiangxi	0.155	0.3465	0.375	0.315	0.854	0.459
Guizhou	0.501	0.225	0.792	0.668	0.351	0.402
Chongqing	0.325	0.405	0.545	0.089	0.105	0.935
Shanxi	0.332	0.798	0.645	0.519	0.744	0.457
Liaoning	0.004	0.254	0.505	0.414	0.226	0.132
Gansu	0.026	0.248	0.463	0.418	0.389	0.499

Table 4 Changing Aspects of Research Variables Over the Particular Period in Chinese Provinces

Study Indicators	**2016**	**2017**	**2018**	**2019**	**2020**
Green investment	0.4616	0.1541	0.0038	0.1991	0.0056
Green energy	0.0742	0.0059	0.1129	0.2487	0.0715
Carbon emission index	0.8729	0.1046	0.6918	0.0482	0.0974
Forest area	0.0166	0.1207	0.0994	0.2954	0.5609
Investment index	0.0055	0.0126	0.1192	0.0534	0.4671
R and D	0.1404	0.6713	0.9698	0.3724	0.1493
Human capital	0.5149	0.0345	0.0037	0.1621	0.7209
Provincial-level GDP	0.0352	0.0877	0.0803	0.1803	0.3774
Energy consumption at the provincial level	0.5363	0.0013	0.0021	0.5588	0.9943
Public supports	0.0564	0.2045	0.5257	0.0301	0.0422
FDI	0.2965	0.3998	0.2132	0.0552	0.0328
Private financing	0.0555	0.0505	0.4574	0.0046	0.3618

Fuel pollution emission	0.1964	0.2048	0.1791	0.0181	0.2074

There are two significant ramifications of this. At first, carbon traders have obstacles connecting the incentives and credits they sell to specific CO_2 outflow reductions. As a result, the carbon market is growing, considering current registration techniques and frameworks, including risk assessments, protection frameworks, calculations, confirmations, and inspections, to ensure it continues as a private enterprise (see Table 5). Because of this, the scientific community and the market for voluntary carbon offsets have established complicated estimation theories and data vaults for carbon emissions.

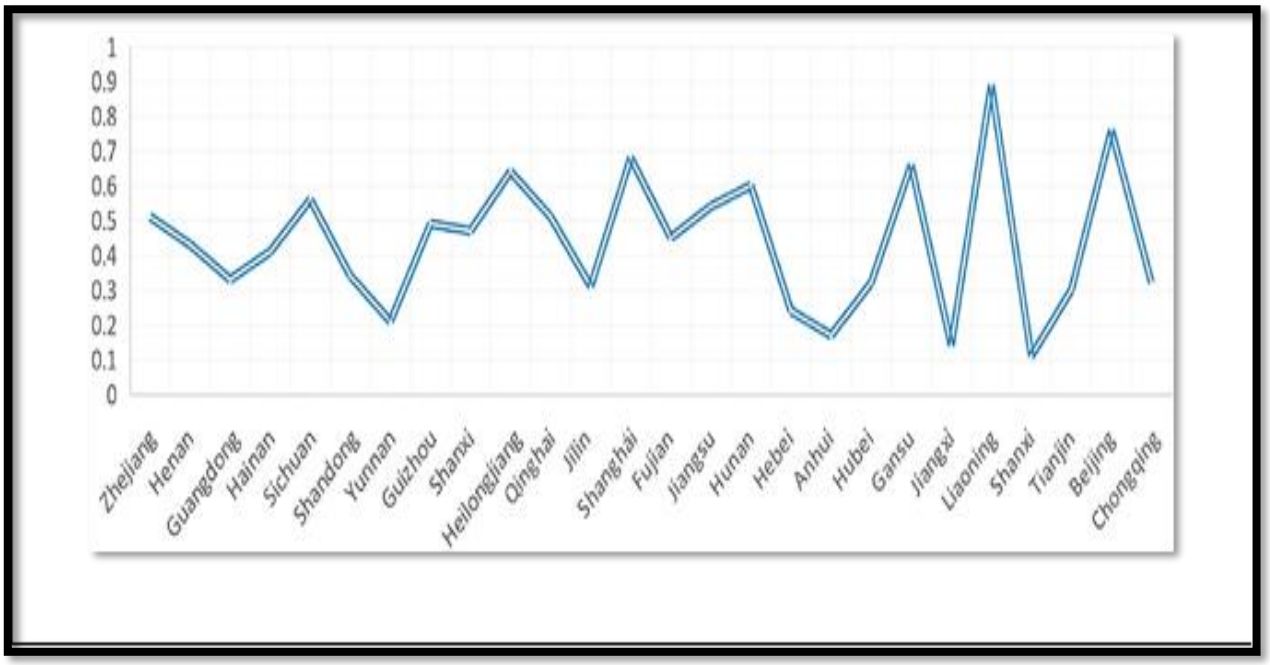


Figure 2. Green Investment Index

4.1 Sensitivity Analysis

The CDM requires that ozone-depleting chemical emissions and extra-currency conjectures be minimised or ducked in CDM projects. This is shown by the existing application of additional project approval limitations and the claim that many CERs are 'hot air'. A crazy deluge of CER_S findings necessitates implementing rules based on data analysis. In order to run a complex international carbon market, institutional spread control and capacity limits are met. Since no unified library system exists, certification concepts and methods are not harmonised. Such future theoretical transactions like CERs and EUAs will be safer. A few participants wonder when ultimate certainty will be supplied and whether the carbon market can be trusted. Carbon advertising is also theoretically more sensitive.

Table 5 Quintile Test for Robustness Analysis

Indicators	Estimated Outputs
Carbon emission index $_{t-1}$	0.532
Wald test	(0.12)*
p-value	(0.28)
Green investment $_{t-1}$	2.12
Wald test	(0.000)
p-value	(0.000)

Indicators	Estimated Outputs
Renewable electricity output $_{t-1}$	0.324
Wald test	(0.21)*
p-value	(0.17)
Gross Domestic Product	2.58
Wald test	(2.02)
p-value	(0.000)

*Note: *p < 0.05 is the significance level for the p-value.*

5. DISCUSSIONS

Governments must be prepared for significant and sudden drift or declines in the global ecological change framework. However, establishing a new global monetary system requires comprehensive justification, whether implemented soon or not. According to Alemzero et al. (2020), the complexity associated with energy consumption and ecological change infrastructure lies at the core of this predicament. The current monetary systems and cycles lack immediate transparency, suggesting a lack of accountability in the existing frameworks. The study further emphasises that complexity validly explains the lack of understanding among monetary actors, rendering organisational efforts challenging and susceptible to abstraction. Financial organisers are responsible for constructing a realistic financial world and should not be exempted from accountability or flaws. The overarching entity known as the New Financial Architecture is responsible for organising, creating, and maintaining the financial structure. Public and private actors failing to fulfill their duty and accountability would be deemed an abdication, mainly if involvedness is referred to as the prime reason.

The financial crisis of 2008/2009 was not solely precipitated by financial complexity but rather by the intricate interconnections and circulation of investment within the system. Consequently, a potential reconstruction or reevaluation of the complexity hypothesis could potentially avert a near-collapse of the monetary system. International cooperation plays a vital role in mitigating the risk of future catastrophic monetary crises. Therefore, it is imperative to closely monitor the present state of carbon markets, as they serve as a critical focal point. Numerous researchers are devoting considerable attention to the escalating intricacy and vulnerability of current and future carbon markets and flow.

The carbon market encounters numerous challenges. An analysis of 700 public and private carbon streams indicates that the market is vulnerable to accounting manipulations reminiscent of those employed by Enron and WorldCom. Expanding the secondary market introduces additional complexity, heightened theoretical considerations, and the potential for reduced profitability. The ambition to become the leading long-term derivative market has attracted new participants, including the International Monetary Fund (IMF), major energy companies, retailers, theorists, speculative investors, lobbyists, and even the IMF, which now dominates the carbon markets.

By placing our research within the backdrop of the 2008/2009 financial crisis, we might discern patterns, repercussions, and insights that may be relevant to our current findings. To emphasise the ongoing nature and significance of our research in the academic community, we establish a direct connection to these sources. This factor has far-reaching implications for carbon markets and flows across various industries. Current political concerns encompass the utilisation of cover-based protection for specific greenhouse gases within designated periods, the proportion of carbon exchange coverage relative to residential emissions, and demands for public oversight. The study's findings demonstrate that certain partner states, along with contemporary and monetary investment parties, exerted influence during the initial phase of the EU emission trading system which they later increased during subsequent periods. Consequently, administrative bodies are now politically developed and subject to oversight within the prevailing political

landscape, with their efforts aimed at reducing emissions contributing to preserving the ozone layer.

Organisations involved in managing industries and their carbon emissions face substantial financial burdens. To effectively advocate for change and influence critical events like the annual Carbon Expo, it is crucial to establish new partnerships and foster collaborative efforts among stakeholders. Entities such as the International Trade Exhibition Association, the Emission Marketing Association, and the Carbon Markets and Investors Association played a pivotal part. Companies' financial performance and carbon emissions are paramount in this context. Consequently, a sector comprising small and large purpose-driven firms emerges to regulate and oversee these aspects. Before the 2008 financial crisis, government-controlled enterprises and administrative companies were prominent in this sector. Intentional market organisations, comprising financial and corporate actors such as traders, investors, and banks, not only drive the growth of carbon credits and financial transactions, but they also wield significant influence in shaping the principles and regulations that govern the activities and decisions of market participants.

6. CONCLUSIONS AND POLICY IMPLICATION

A comprehensive analysis was conducted on six Asian and seven ASEAN nations using an envelope-based DEA methodology. DEA is a nonparametric method measuring relative carbon emissions reduction efficiency within a group of homogeneous decision-making units with multiple inputs and multiple outputs. To estimate the overall energy and environmental efficiency, the model considers both positive factors, such as GDP, and negative factors, such as CO_2 emissions, and energy and non-energy inputs, such as labour and capital stock. The DEA window analysis was also employed to examine efficiency based on cross-sectional and time-series data from 2010 to 2014. Empirical research indicates that the eastern regions of these nations exhibit higher energy and ecological efficiency than their western regions. However, there was only limited energy and environmental efficiency improvement from 2016 to 2020. The eastern regions outperform the central and western regions regarding energy and environmental performance, indicating that these nations can benefit from future low-cost energy markets. The findings of this study hold substantial significance and carry policy implications. Human greenhouse gas emissions are the primary cause of climate change. To achieve emission reduction and establish a durable, environmentally friendly future, it is necessary to transition to renewable energy sources and engage in sustainable practices. The imperative for sustainability necessitates immediate and synchronised global efforts to address climate change. This study assessed the relationship between renewable energy investment and ecological change in Asian nations. These economies' increasing modernisation and urbanisation has led to heightened energy consumption and global environmental challenges. Conducting energy efficiency research at the provincial level can contribute to developing and enhancing national energy and environmental policies.

The growing prominence of renewable energy sources carries political implications that can help overcome future obstacles. First, across 28 countries and their respective provinces, ample opportunities for improving environmental energy efficiency still exist. Pursuing enhanced energy efficiency remains a promising avenue for increasing output and significantly reducing CO_2 emissions. Regarding investment in energy efficiency initiatives, careful examination of non-parametric test results reveals discernible geographic variations within the countries. The Eastern, Middle, and Western regions, explicitly emphasising the Eastern region, exhibit higher efficiency levels than their Central and Western counterparts. This persistent efficiency disparity necessitates the integration of energy efficiency with environmental energy considerations across these three domains. Through a comprehensive assessment of each province, it becomes evident that 2014 witnessed a noticeable decline in efficiency attributed to environmental costs and regulatory expenses. The burden of environmental regulatory costs predominantly falls on most

provinces, with their economic development heavily reliant on environmental capacity. Consequently, these provinces face significant environmental costs as they strive for economic growth. Therefore, effecting transformative shifts in the prevailing economic growth paradigm and advancing environmental quality assumes paramount significance.

The disparity in economic growth among the three domains may not be the primary source of inefficiency. The economic growth objectives of these nations might contribute to higher energy and environmental efficiency. However, the imposition of government-mandated energy and environmental restrictions could have played a role in enhancing efficiency. The Asia-Pacific power market reforms are necessary to improve data availability and market dynamics. In recent years, significant legislative advancements have benefitted various sectors. Since 2010, there has been a notable increase in exports of high-tech, low-energy cell phones, and mobile devices, accompanied by a reduction in the role of state-led economies. The global shift towards more sustainable and environmentally friendly energy consumption directly influences energy production and manufacturing practices.

The policy consequences include prioritising and incentivising the use of renewable energy, setting ambitious emission reduction targets, and promoting international collaboration on climate change. Authorities should promote the adoption of environmentally friendly technology and offer monetary incentives. To address the issues of climate change and establishing a durable, low-carbon future, it is imperative to implement regulatory measures and foster public-private partnerships.

Future research could examine how project energy efficiency moderates green investment's carbon emission reduction benefit. Policymakers and researchers may benefit from analysing the long-term effects of green investment on climate change mitigation measures and finding sustainable practices barriers. Future research can address these components to improve green investment methods and policies for environmental sustainability.

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