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The Role of Mineral Resource Usage, Energy Tariffs, Fintech, Green Bonds, Carbon Policy in Adopting Net-Zero Supply Chain in Energy System

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With response towards the global responsibility in addressing the climate change, China has implemented a wider range of policy measures that aimed at limiting the emissions of growth and promotion of renewable energy consumption. These measures include the regulation of energy parameters, with increased funding for research and development, the digitalisation of financial services, and expansion of environmental taxation and energy efficiency policies. In this context, current study determines the impact of carbon policy, natural resource rents, financial technology (fintech), energy tariffs and green bonds on renewable energy consumption in China for the period of 2000-2023. With the use of Dynamic Auto-regressive Distributed Lag (Dynamic ARDL) approach, the outcomes indicate that carbon policy, green bonds, and energy tariffs exerts a significant and positive effect on renewable consumption of energy in long-run, where as fintech development and natural resource rents do not show statistically significant impact on renewable energy consumption, however carbon-policy, energy tariffs, natural resource rents and green bonds do not show significant effects. These outcomes offer significant policy implications for China, suggesting that strengthening green bond markets, enhancement of carbon policy frameworks, optimisation of energy tariff structures, and supporting fintech development could play a crucial role in promoting the renewable energy consumption.

Keywords: *Environment; Carbon Policy; Green Bonds; Energy Tariffs; Fintech and Natural Resource Rents.*

Introduction

China has occupied a significant position in global transition towards low-carbon development as this would simultaneously the world's largest consumer of energy and of one largest emitters of green house gases (GHG). Being global climate risks, intensifying China's energy systems and supply chain structures have become central for international efforts aimed at achieving the carbon neutrality and mitigation of climate change response. In recent years, the country has undertaken the substantial policy reforms for promoting green development and accelerate transition towards carbon neutrality. 20th National Congress of Communist Party of China has outlined the strategic measures aiming to enhance financial and taxation investment policies for supporting green industries and sustainable resource management (Streimikiene, 2024). All these initiatives have emphasized the expansion of clean energy production, improvements in energy efficiency and adoption of environmentally responsible business practices, being supported by increased research and development in advanced energy-saving technologies (Guan *et al.,* 2025).

Progress of China is reflected with its rising renewable indicators of energy with renewable energy consumption increasing by 0.4 % in 2022 being compared with previous year and installed renewable power generation capacity growing by 7.8 %, reaching 2.56 billion KW. Additionally, country has implemented more than 50 preferential tax policies for promoting clean energy consumption, environmental protection, and energy conservation. All these measures are designed for facilitating green economic transformation and reducing dependence on fossil fuels (Li & Umair, 2023). Against all these gaps the current study seeks to determine how net-zero supply chain management

approaches could be integrated into China's energy system. Especially, this study has determined the roles of mineral resources usage, energy tariffs, fintech development, green bonds, and carbon policy for supporting the adoption of net-zero supply-chain framework. With the analysis of these relationships among these factors, the study aims to determine effective mechanisms for the alignment of energy systems with sustainability objectives. The findings are expected to provide practical insights for firms seeking to transition toward net-zero supply chains and offer valuable guidance for policymakers, industry leaders, and stakeholders in designing policies that promote responsible resource use, green financial instruments, and carbon awareness. Ultimately, this research contributes to advancing a resilient, low-carbon, and environmentally sustainable energy system.

In recent years, sustainability has been emerged as central focus for supply chain management, which has been driven by escalation of environmental degradation, excessive resource consumption, and rise in greenhouse gas (GHG) emissions. Growing demand for material goods and energy-intensive production systems have increase the amount of pressure on natural resources, significantly contributing towards change in climate and environmental imbalance. By addressing these socio-economic and environmental challenges which requires development of integrated, knowledge-driven frameworks of supply-chain capable of achieving net-zero emissions (Singh *et al.,* 2023; Mosnja-Skare, 2024). Moreover, despite of increased academic attention, research on contemporary practices which aligns with supply chain operations with net-zero objectives specifically within energy systems. Accelerated risks are associated with climate change which have been reinforced with the urgency of transitioning towards sustainable and low-carbon energy systems. These responses are considerable attention that has been directed towards renewable energy adoption, energy efficiency, eco-energy solutions, and net-zero supply chain strategies. These all approaches are increasingly recognized for their potential to reduce emissions while supporting environmental conservation and long-term sustainability (Nevisi & Salehi, 2023). As part of global decarbonization agenda, the industrial systems have been evolved from conventional pollution-control approaches towards more crucial and integrated models which focus on material substitution grounded in industrial ecology principle (Nyangchak, 2022). Low-carbon energy transitions are inherently multi-dimensional and long-term, that requires a structural transformation across power generation, industrial activities, transportation networks, and supply chain configuration (Nikas *et al.,* 2020; Yan *et al.,* 2025). The renewable technologies specifically photovoltaic (PV) systems played a significant role for shaping sustainable energy systems due to their substantial improvements in efficiency and declining costs (Magni et al., 2022). Technological progress has widely been determined, non-technical dimensions of transition such as public awareness, acceptance, and institutional support, receiving comparatively lesser attention, and lack of trust could delay implementation of policy towards low-carbon energy systems (Kim *et al.,* 2021; Pye *et al.,* 2019; Lyu *et al.,* 2024; Li *et al.,* 2025). Education and public awareness could positively impact policy-makers willingness for adopting low-carbon technologies whereas weak awareness remains substantial barrier for transition of energy (Baek *et al.,* 2019). The resistance towards change could further complicate the process by triggering social debates related to employment, cost burdens and adjustment of lifestyles (Huang, 2021; Saraji *et al.,* 2023). The additional concerns related to energy justice encompassing distributional equity, the procedural fairness, and social inclusion which pose significant challenges. Successful low-carbon transition should ensure equitable access for energy while maintaining energy security, defined by reliability and resilience of energy supplies and flexibility of investment structures (Sorman *et al.,* 2020; Kasradze *et al.,* 2023; Sareen & Kale, 2018; Xuan *et al.,* 2025). Economic perspective, the transition towards net-zero systems is capital intensive and being constrained by financing gaps. Major disparities exist between current investment levels and those need to achieve decarbonization targets. The transition costs extended beyond infrastructure development to include operational expenses, social costs of carbon emissions and adjustments in productivity (Bachner *et al.,* 2020). Persistent fossil fuels subsidies continue to undermine the renewable energy competitiveness and to encourage excessive energy consumption thereby increasing CO2 emissions. The empirical findings suggest that phasing out such subsidies could substantially reduce the emissions and accelerate more towards clean energy adoption (Zhang *et al.,* 2020). Research within the context of supply chain, decarbonization efforts have primarily focus more on emission regulation, life-cycle assessment, and environmental and energy management practices (Mishra et *al.,* 2023; Mishchuk *et al.,* 2025; Khan *et al.,* 2024). There are recent studies that highlights the significance of digitalisation, circular economy practices and optimization of resources in advancing net-zero economic objectives. The computational modelling and energy-based supply chain frameworks have been further enabled with the identification of energy-intensive processes and evaluation of alternative energy-saving measures, which therefore support net-zero carbon goals (Ghosh *et al.,* 2020). With an approximation of 15-20 % of global energy consumption is linked with food, supply chain and production improving the energy-efficiency within these systems is crucial for achievement of sustainability targets (Malliaroudaki *et al.,* 2022; Zhang, 2024; Wu *et al.,* 2024; Xie *et al.,* 2025). China has made notable progress in advancing green development through targeted energy and environmental policies. The 20th National Congress of the Communist Party of China emphasised reforms in taxation, finance, and investment to support green industries, improve resource efficiency, and accelerate the deployment of clean energy technologies (Streimikiene, 2024; Nar, 2025). These efforts have translated into measurable outcomes, with renewable energy consumption increasing by 0.4 % in 2022 and installed renewable power capacity rising by 7.8 % to reach 2.56 billion kW. Additionally, China has implemented more than 50 preferential tax policies aimed at promoting clean energy consumption, environmental protection, and energy conservation (Tran-Thi-Thanh & Nguyen-Thi-Phuong, 2023). Despite these advances, the effectiveness of policy instruments such as energy tariffs, green bonds, carbon legislation, fintech development, and mineral resource utilisation in fostering net-zero supply chains

within China's energy system remains insufficiently explored. Existing studies tend to examine these factors in isolation, overlooking their combined and interactive effects on supply chain decarbonisation.

Research Objectives

To address these gaps, the present study aims to systematically investigate the role of key economic, financial, and policy factors in supporting the adoption of a net-zero supply chain within China's energy system. Specifically, the objectives of the study are to:

1. Examine the impact of mineral resource usage on the transition toward a net-zero energy supply chain in China.
2. Analyse the role of energy tariffs in influencing renewable energy adoption and supply chain decarbonisation.
3. Assess the contribution of fintech development to promoting sustainable and low-carbon energy supply chains.
4. Evaluate the effectiveness of green bonds as a financial instrument for supporting net-zero supply chain initiatives.
5. Investigate the influence of carbon policy and regulatory frameworks on achieving net-zero objectives within the energy system.

By addressing these objectives, the study seeks to provide practical insights for policymakers, industry leaders, and stakeholders involved in designing effective frameworks that promote responsible resource use, green financing mechanisms, and carbon-conscious decision-making. Ultimately, the findings aim to support the development of a resilient, low-carbon, and environmentally sustainable energy supply chain in China.

Literature Review

Green Supply Chain Management and Decarbonization Challenges

Green Supply Chain Management (GSCM) has extended traditional supply chain management with the integration of environmental considerations into core supply chain activities, that includes inventory management, logistics, production, information systems and location decision. However, the conventional supply chain management focuses specifically on cost efficiency and responsiveness, GSCM focuses more on minimization of environmental impacts specifically green house gas (GHG) emissions across the entire supply chain lifecycles (Hugos, 2018). Involvement of redesigning of production processes for reducing energy consumption, optimization of inventory levels for avoiding waste, selection of locations which supports low-carbon operations, adoption of sustainable transportation modes and leveraging information systems for measuring, monitoring and reporting environmental performance.

The decarbonization of supply chains have become increasingly crucial due to their substantial contribution for global emissions. Supply chains often account for major share of corporate carbon footprints, specifically through upstream activities such as downstream logistics and extraction of raw material. Covid-19 pandemic highlighted the vulnerability of global supply chains and emphasised requirement of resilient and sustainable supply-chain structures capable of adapting to large-scale disruptions (Craighead, Ketchen Jr., & Darby, 2020). Beyond this operational resilience, pandemic prompted firms for reconsidering carbon-intensive sourcing, long-distance transportation, and in-efficient production systems with acceleration of interest in greener and more localized supply chain configurations.

From perspective of decarbonization, firms faces multiple challenges that include limited visibility across multi-tier supply-chains, high costs of low-carbon technologies, coordination difficulties among supply chain partners and trade-offs between environmental between environmental goals and short-term economic performance. Addressing these challenges requires new analytical lenses and adaptive capabilities, enabling firms to restore certain processes while fundamentally transforming others-a capability referred to as transilience (Craighead *et al.,* 2020). Consequently, GSCM provides a relevant theoretical and practical foundation for understanding how supply chains can transition toward sustainability and net-zero objectives.

Net-Zero Supply Chain

The concept of net-zero supply chain is that decreasing new emissions in to the atmosphere in order to control global warming by lowering atmosphere's temperature. This can be done either through reduction of emission through supply chain activities or through offsetting emissions through carbon sinks *(Fankhauser et al.,* 2022).

Bataille (2020) discussed seven attributes which are essential in achieving net-zero supply chain. These attributes include Front Load emission reduction which contributes towards overall reduction of gases. The primary focus of emission reduction strategies is energy. Carbon dioxide removal is restricted by cost considerations and some other factors like biological, technical, geological etc. Carbon offset markets are enforced when the quality standards are met. Similarly private carbon off set markets is achieved through proper planning and implementing the procedures. Net-Zero depends on the fairness that how the burden of meeting the global target is distributed among different countries and within the same country and different countries adopt different strategies in meeting net-zero targets. Climate change is a challenge to socio-ecological perspective so for this purpose nature-based solutions need to be provided in order to restore ecosystems. Certain economic opportunities need to be addressed when achieving net-zero supply chain for instance investing in the economies which are recovering from COVID19 pandemic, taking young workforce to the market because they possess fresh skills that can help in achieving the goals.

A zero-net-emissions supply chain is one that yields no more greenhouse gases than it utilization. This specifies that the supply chain is weighing its emissions with the number of emissions removed from the atmosphere. As governments and corporations worldwide strive to lower carbon emissions, net-zero supply chains are acquiring significance. Use of renewable energy, amplified efficiency in energy use, and reduced waste are a few of the system of measurement that

may be commenced by combining a mix of actions, include switching to renewable energy, making buildings more energy resourceful, and cutting down on waste. (Nevisi & Salehi, 2023).

Role of Mineral Resource Usage

There is acceleration in global response to climate change so net-zero goals are becoming easy to achieve. Countries are presenting their maps towards carbon reduction and investing in emission reduction activities (Dou, Xu, Zhu, & Keenan, 2023). Taking into account the role of minerals in achieving net-zero targets and in order to meet this technological shift, critical minerals need to be considered. The World Bank estimates that in order to meet this carbon emission reduction strategies, 3 billion tons of critical minerals will be needed to decarbonize the system. The production of critical minerals like graphite, lithium, cobalt etc. needs to be increased by 500 % by 2050 in order to meet the goal of clean energy (Janardhanan *et al.,* 2023). There is huge demand of the critical minerals but their supply is also very inelastic and unpredictable. The deposits of these mineral s are either in developing or highly under developing countries and the major problem in these countries is the mining of these minerals and due to this the sustainable supply of critical minerals is a threat, even the International networks for mining are facing this threat (Cook, 2022). Role of mineral resources in achieving net-zero targets is significant in a way that carbon dioxide is reactive to the rocks containing calcium or magnesium and these minerals are regarded as reserve. Carbonate mineralization can contribute towards the reduction in carbon emission (Leon, Muller, Svilanovic, & Yolland, 2023).

Modern technology and nations rely on critical minerals, which are exposed if their supply lines are interrupted. To achieve the net-zero and sustainable development targets, there is a high demand for these minerals due to alterations in global economics and technology. The prospective for mineral extraction to have damaging effects on both society and the environment makes it a double-edged sword. The supply of these minerals is becoming more hazardous due to non-market causes, disturbances to global trade networks, and labour dynamic range in the countries that produce them (Dou *et al.,* 2023). Hazards from geopolitics, economic inequality, resource nationalism, and mining's effects on ecology, the environment, and human rights were among the factors emphasised in this study as potential threats to a reliable supply of essential minerals. One way to ensure a steady supply of essential minerals over the long run is to put more pressure on multinational mining corporations to help reach the Sustainable Development Goals (SDGs). Another is to make sure that people and the environment are considered when mining these minerals. To coordinate everyone's interests and guarantee there is enough supply to enable Net-zero, the international community should think about creating a global governance system for essential minerals (Dou *et al.,* 2023).

Role of Energy Tariffs

Adoption of net-zero emission targets requires the use of brown energy resources in order to control climate change. Many researches have been made to check the energy transition for net-zero targets. Successful transition of net zero emissions greatly depends on inexpensive and emission free electricity. Energy services like heating, cooling, lighting etc. contribute towards Decarbonization by using energy through various renewable and non-renewable energy resources. (Davis *et al.,* 2018). (Tsiropoulos, Nijs, Tarvydas, & Ruiz, 2020) in his study discussed the EU has set goals in reducing emission to zero by 2050 and their main focus is on energy transition which is named as "EU Green Deal". Few scenarios are discussed which are the priority of EU in order to achieve this goal.

1. Almost complete removal of usage of coal, oil and gas by 2050.
2. Growth of wind and solar production plants which will contribute in energy efficiency.
3. Taking up on 65 %-90 % of zero emission vehicles by 2050.

Many policies have been designed to encourage renewable energy through tax incentives and subsidies. Although there is a growing trend towards tenders and auctions but the incentives which are given by the government helps in motivation factor and this will lead to the achievement of targets (Renne, 2022).

Role of Green Bonds towards net-zero supply chain

Green bonds are the securities that aim to raise funds in order to contribute towards the activities which are helping in achieving green environment. The capital flow towards green bonds can increase through regulation and tax incentives (Lee, Wang, & Chang, 2023). Green bonds play an important role towards environment sustainable projects as it helps in mobility of capital towards such projects. According to the database of "Climate Bonds Initiative", the green market has seen an expansion of about 54 %. The issuance of green bonds at both governmental and corporate level contributes in investing in those activities which help in reduction of emission. Most of the green bonds are issued in the sectors like green transportation, clean water, electric batteries, and renewable energy (Alamgir & Cheng, 2023).

Most of these Climate bond policies have "sustainability" and "carbon emissions control" listed as their primary goals, according to the study (Abudu, Wesseh Jr, & Lin, 2024) . Energy projects (i.e., initiatives that are renewable, clean, and efficient) receive the lion's share of CB funding, according to this report. The distribution of CB funds has changed significantly from 2015 to 2019, moving away from environmentally friendly energy projects and toward the building industry. Furthermore, certain policies have doubtful attitudes on climate change, according to policy sentiment analysis, which could have a negative impact on climate initiatives. This show that CB policy aims, objectives, and sentiments are fundamental to the policies' successful execution**.**

Role of Carbon Policy & Awareness in Net Zero Supply Chain

Scientists agree that climate change is due to the industrial revolution as industries release gasses into the atmosphere and leaves negative impact on the environment. Government can apply reasonable carbon prices in order to regulate the emission. With effective carbon prices, firms can be held accountable for their actions and for any damage to the environment. According to OECD, carbon policy can be effective in decarbonization if designed effectively. When a fair carbon price is offered then the renewable energy becomes more competitive than that of high carbon energy resources and in this way the investors invest in clean technologies. (Acharya, 2022). The concept of carbon price was started I 1990 when certain countries adopted GHG measures for emission reduction. Two main instruments are used by countries to apply carbon policy mechanism i.e., a cap-and-trade mechanism on ETS (Emission Trading System) or carbon tax. The countries which are trying to achieve net-zero target are applying both these instruments of pricing (Fankhauser et al., 2022). Net zero carbon energy and buildings is more seen in North America and Europe and its mire likely due to the technology advancement in these countries (Ohene, Chan, & Darko, 2022).

Low carbon awareness in consumers affects the purchasing behavior of customers and companies' emission reduction strategies and operational strategies. Consumers are willing to pay high price of products which support environment. There are certain platforms where the number of customers supporting green environment has increased for instance on Ali Express. (Xia, Hao, Qin, Ji, & Yue, 2018).

Net-zero supply chain management is achievable through proper strategies and their implementation. Certain factors have been discussed which play part in achieving zero emission but the alternatives need to be adopted. The minerals which are required need to be mined in order to use them for decarbonization. Similarly green finance should be promoted in order to promote those activities which help in green environment. As well as giving awareness regarding carbon policy.

Research Methodology

Model Specification

The present research aims to assess the adoption of net-zero supply chain management strategies in the energy system. For this purpose, present study analyses the role of natural resources, energy tariffs, carbon policy, green bonds and fintech in renewable energy consumption in China over 2000 to 2023 period. Based on the research aims and objectives and its key context, the researcher has implemented a secondary quantitative research design to assess the relationship among variables. Considering the previous relevant studies Han, Zakari, Youn, and Tawiah (2023), Sreenu (2024), Croutzet and Dabbous (2021), Dogan, Hodzic, and Sikic (2023), the empirical model of the study is specified as follows:

$$REC_t = \beta_0 + \beta_1 FT_t + \beta_2 CPOL_t + \beta_3 ETARR_t + \beta_4 TNR_t + \beta_6 GB_t + \mu_t \quad (1)$$

Where, REC is the dependent variable which shows the renewable energy consumption. Carbon pliicy, fintech, energy tariffs, green bonds and natural resources are main independent variables of interest. All necessary description of the variables is given in Table 1.

Table 1

Description of Variables

Variables	Abbreviation	Measurement	Status	Source
Renewable energy consumption	REC	Renewable energy consumption (% of total energy consumption)	Dependant variable	WDI
Fintech	FT	Index comprising of individuals using internet (% of total population), Fixed telephone subscription and fixed broadband (per 100 people)	Independent variable	WDI
Carbon policy	CPOL	Environment related tax revenues (% of GDP)	Independent variable	OECD
Mineral Resources	TNR	Total natural resource rents (% of GDP)	Independent variable	WDI
Energy Tariffs	ETARR	Gasoline energy prices	Independent variable	International Energy Agency
Green Bonds	GB	International flow of finance from developed countries to developing countries for clean energy production and research and development	Independent variable	Our World in Data

Empirical Estimation

Unit Root Tests

The first step of the empirical analysis is to evaluate the stationarity properties of all variables to determine whether the variables are integrated of order 1 or zero. For this purpose, Augmented Dickey Fuller (ADF) test proposed by Dickey and Fuller (1979) and the Phillips and Perron (PP) test proposed by Phillips and Perron (1988) are applied. The null hypothesis of ADF test suggests the existence of a unit root and non-stationarity and the alternative hypothesis implies stationarity. We applied also PP test which assumes the mild distribution of error (Boontome, Therdyothin, & Chontanawat, 2017).

Dynamic ARDL Model (DARDL)

To assess the long run and the short run findings, the DARDL simulations model by Jordan and Philips (2018) is used. This model evaluates the counterfactual shock of a dependent variable factor keeping the effect of other

variables constant on the dependent variable. In the DARDL model, the model simulations assess the negative and positive changes in independent variables on the dependent variables (Sarkodie & Owusu, 2020). The DARDL model of the study is given in the following equation.

$$\Delta REC_t = \beta_0 + \beta_1 REC_{t-1} + \theta_1 FT_t + \tau_1 FT_{t-1} + \theta_2 GB_t + \tau_2 GB_{t-1} + \theta_3 TNR_t + \tau_3 TNR_{t-1} + \theta_4 CPOL_t + \tau_4 CPOL_{t-1} + \theta_4 ETARR_t + \tau_4 ETARR_{t-1} + \mu_t \quad (1)$$

Where, β_0 and β_1 represent the constant and the parameters to be estimated. Short run parameters are denoted by θ, whereas τ shows the long-run estimators. Nearly 5000 simulations are employed in DARDL model in a multivariate normal distribution.

Findings and Discussion

Summary Statistics

First of all, summary statistics which shows mean, standard deviation, maximum and minimum values of the variables under observation are given in Table 2. In addition, the normality of data series is also observed using Jarque Bera (J-B) test. Moreover, as the estimated values of J-B test are significant for REC, TNR, CPOL and GB showing that these data series are not normally distributed.

Table 2

Summary Statistics

Variables	Mean	Standard deviation	Minimum value	Maximum value	Jarque Bera Test
REC	16.310	5.476	11.300	29.600	8.04**
TNR	3.346	2.360	0.863	9.648	4.84**
CPOL	0.810	0.278	0.382	1.434	6.051**
ETARR	0.824	0.321	0.280	1.234	2.317
FT	-0.000033	1.000	-1.378	1.561	1.856
GB	2120000	2760008	248100	14000009	201.25***

Unit Root Test

In the next step, the stationarity properties of the variables are evaluated using ADF and PP unit root tests and the findings are given in Table 3. The findings of both tests indicate that except GB, all of the variables are non-stationary at level and they become stationary the first difference.

Table 3

Unit Root Test

Variables	ADF Test		PP-Test	
	Level	First Difference	Level	First Difference
REC	-1.423	-4.1000**	-1.423	-4.093
TNR	-2.346	-6.158***	-2.200	-6.294***
CPOL	-2.225	-4.448**	-2.249	-4.448*
ETARR	-1.289	-3.759**	-1.289	-6.632***
FT	-3.209	-4.515**	-2.454	-4.516**
GB	-3.762**	----------	-3.749**	----------

The findings in the Table 4 provide the long run effects of the selected variables on REC. The results postulate that carbon policy impacts REC negatively in the long run. The concerned coefficient is statistically significant and negative at 10 %. The magnitude of the impact shows that one percent increase in environmental tax there will lead to 1.954 percent decrease in REC. The plausible argument can be drawn with such evidence that recent development in market-based instrument in order to support environmental taxes is quite a critical scenario which is difficult to be achieved to establish positive impact on renewable energy consumption. Environmental regulations to energy usage calls for more regulations in the form of environmental reforms (Bashir, Ma, Bashir, Radulescu, & Shahzad, 2022). These outcomes show further policy adjustment is required for making the environmental policies or taxes effective in promoting REC. Studies by Bashir et al. (2022), Dogan et al. (2023) and Degirmenci and Yavuz (2024) validate the findings of present study.

Table 4

Long Run and Short Run DARDL Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
L(REC)	0.509	0.735	0.69	0.503
L(ETARR)	3.411**	1.612	2.12	0.058
D(ETARR)	0.646	1.802	0.36	0.727
L(CPOL)	-1.954*	0.931	-2.10	0.064
D(CPOL)	-0.930	0.988	-0.94	0.367
L(GB)	1.96e-09**	8.62e-10	2.28	0.044
D(GB)	8.32e-10	5.20e-10	1.60	0.138
L(TNR)	0.187	0.140	1.34	0.208
D(TNR)	0.002	0.092	0.03	0.979
L(FT)	0.245	0.534	0.46	0.655

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(FT)	4.860*	2.358	2.06	0.060
R-squared	0.911			
Adjusted R-squared	0.822			
F-statistic	10.24			
Prob(F-statistic)	0.0003			

Secondly, the effect of energy tariffs on REC is found to be statistically significant and positive in the long run. A one unit increase in ETARR increases REC by 3.411 percent according to the magnitude of the coefficient. One of the potential reasons for this finding can be the decrease in energy demand due to increase in its price resulting from the imposition of the ETARR (Albatayneh, Juaidi, Abdallah, Pena-Fernandez, & Manzano-Agugliaro, 2022). Research findings by Jenner, Groba, and Indvik (2013) and Saad, Ramli, Mohd Arshad, and Mohayiddin (2022) support the present study's findings.

Third, the coefficient of green bonds is positive and significant in the long run. Ceteris paribus, for a unit increase in green bonds, REC increases by 1.96 units in the long run. The finding implies that green bonds are securities that seek to raise cash and finance to support efforts aimed at developing green environment (Ye & Rasoulinezhad, 2023). Green financing may help with the development of new technologies, the funding of environmentally friendly projects, and the expansion of the green economy. It is therefore a major force behind the growth of the green economy and the restructuring of the industrial sector (Adedoyin, Bekun, & Alola, 2020; Fang, Liu, & Putra, 2022). The results are considered to be consistent with Mclnerney & Bunn (2019) who posited that green bonds play a major role in energy efficiency as they tend to enhance the participation of private investors. Similarly, the findings are also consistent with Sreenu (2024), who argued that green bonds have contribution to energy initiatives. However, contrary to the argument of Pineiro-Chousa et al. (2021) who argued that green bond markets are not considered efficient due to inconsistent standards, thus, cannot be viewed as efficient energy indicator to maximize green projects.

According to the outcomes of the long run estimation, TNR have insignificant but positive impact on REC. The positive impact of TNR on REC is consistent with Ahmadov and Van Der Borg (2019) and (Liu & Lu, 2023) who argued that mineral resources are critical to foster renewable energy consumption. Similarly, FT has no significant impact on REC in the long run.

As far as the short run results are concerned, Table 4 highlights that the effects of TNR, CPOL, GB is insignificant in the short run. However, increase in FT is responsible for increasing REC. as far as the magnitude of the coefficient is concerned, for a unit increase in FT, REC increases by 4.86 percent in the short run. The findings of Croutzet and Dabbous (2021) support the outcomes of the present study by arguing that FT is a significant contributor to REC by impacting energy investment, consumption and saving decisions. Likewise the investigation made by Vo, Pham, Tran, and Vu (2023) favour these findings who argued that FT development is a source of new forms of risk management and capital funding, and FT startups create an environment for green projects and REC. R square value 0.911 indicates that the model is a good fit, as 91 % explanation in dependent variable is explained by the independent variables.

Conclusion and Policy Recommendations

Adopting net-zero emission objectives necessitates the utilisation of green energy resources to mitigate climate change. The idea behind a net-zero supply chain is to reduce emissions into the atmosphere to slow down global warming by bringing the temperature of the atmosphere down.

Many studies have been conducted to assess the energy transition towards net-zero objectives. The successful transition to net zero emissions relies heavily on low-cost, emission-free power. In this regard, the goal of the current study is to evaluate the effects of implementing net zero supply chain management techniques in the energy system and to ascertain the significance of energy tariffs, green bonds, mineral resource utilisation, carbon policy, and fintech in this regard. For this purpose, secondary data spanning over 2000 to 2023 period has been empirically analysed using DARDL estimation approach. According to the research, carbon policy, green bonds impact renewable energy consumption positively and significantly, but FT impacts renewable energy consumption significantly only in the short run. Natural resources do not effect renewable energy consumption significantly in the short and the long run both.

Thus, the findings conclude that if carbon prices are successfully implemented, companies will be held accountable for their actions and any environmental harm they produce. When there is a fair carbon pricing, renewable energy sources become more competitive when compared to high carbon energy supply, encouraging investors to invest in clean technologies. Moreover, according to the current study, environmental compliance is essential to enforce laws pertaining to environmental taxes. Therefore, in order to guarantee a sustainable and moderate use of natural resources, businesses must demonstrate that they are in accordance with these requirements.

Implications of the Study

This study explores the complex interaction between energy tariffs, green bonds, carbon policy, natural resource use and renewable energy consumption. Policymakers, company executives, and other stakeholders may find our results useful if they use net zero supply chain management techniques in the energy system. Several worthy policies in this regard are given as follows: Firstly, with financial support and other incentives, policymakers should prioritise the use of renewable energy sources and sustainable resource management. It is essential to implement environmental regulations, involve stakeholders, and

enhance environmental governance. Secondly, green funding should be made feasible which would increase the use of renewable energy. Green finance efforts speed up the adoption of renewable energy sources for the carbon awareness by promoting increases in the percentage of renewable energy in the fuel supply. Green bonds and better resource management might lead to the growth of green financial markets, which could help governments reduce the world's dependency on fossil fuels.

Moreover, policies should be established and implemented to reduce the exploitation of natural resources. In this regard, the current natural resource tax laws should be implemented in China to create policies that support new initiatives and eliminate the rent-seeking behaviour towards natural resources. It is imperative for China to put into practice net zero supply chain management strategies in energy system initiatives that cater to underprivileged and marginalized the mineral resource usage. The study also suggests that China's government should establish independent and strong institutions to manage and monitor natural resources. Since, transparency and accountability are the two major themes detected in value chain of natural resources, thus, it is crucial to be aware that natural resource rents are linked to sustainable growth. Besides, independent institutions all over the world should show support for Chinese government in imposing tax obligations on natural resources that are extracted by foreign nations.

In addition, the modernization and expansion of financial sector, the upgrading of national efficiency benchmarks, and the creation of a market for long-term carbon awareness are major elements which should promoted by the government. In order to meet energy transition that is a requirement of carbon neutrality target, China is advised to develop a power system based on renewable energy and monitor renewable production and consumption in smart grid and energy storage. China should also make changes in current incentive system to refine the mechanism. Besides, it is also suggested to build renewable market mechanism.

Limitations and Future Direction

Though the current study has developed useful results about the adoption of net zero supply chain management techniques in the energy system, it is vital to highlight the study's limitations in order to assure the authenticity and trustworthiness of its findings. The study's shortcomings might assist identify paths and ideas for future studies. The present study acquired secondary data whereas future research can use first hand qualitative data to compare and contrast the findings. Moreover, the present study has focused on the data related to China, therefore, its findings may not reflect the scenario of resource management in other world economies. Future studies can focus on some major world economies and draw a comparison between the supply chain management in major economies and that in China. This can present a complete picture of policies established to secure environmental quality all over the world. In addition, the present study is focused on the role of the role of mineral resource usage, energy tariffs, green bonds, carbon policy, and carbon awareness in promoting eco-friendly energy system. There are several other factors, which may have a significant impact on net-zero supply chain management strategies in energy system. However, it is not possible to analyze the impact of every relevant factor in a single study. Thus, more research should be conducted to discover other determinants of net-zero supply chain. As adopting net zero supply chain management strategies in energy system is a flourishing field, more studies should be conducted to reaffirm its significance in the context of the emerging world economies.

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