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Social Contribution of Agricultural Sector toward Green Economy by using Quantile ARDL Model Approach

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A green economy is not only a low-carbon economy, that ensures adequate production, and resource efficiency but also promotes a socially inclusive economy. This means that the economy employs all resources to remove poverty and confirms the availability of food at low cost and other infrastructural facilities, to improve the lifestyle of the inhabitants. The present study considers key social determinants that impact the progression of a green economy in the agricultural sector. Govt expenditures on agriculture, food availability, Foreign Direct Investment (FDI) in agriculture, access to energy, and agricultural Infrastructure, are taken as exogenous variables whereas a green economy Index is developed with 20 variables as endogenous variables. A nonlinear relationship is tested using Panel QARDL for 80 developed and developing countries during the 2000-2020 time. ECM is significant and negative at all quantiles as required for the stability of the model. Govt expenditures and FDI are found to be significant and negative in the long run indicating that the expenditures and investment for a green economy need the right direction from govt and private investors not to invest in areas that deplete the natural resources. All exogenous variables are significant at higher quantiles in PQARDL. The study concludes with a policy suggestion that for a socially inclusive and resilient green economy, equal access to energy for smart practices, and availability of food for all, are valuable in the agricultural sector for moving toward sustainability and a green economy.

1. Introduction

The perception of a green economy is characterized by an economic framework in which income and employment growth are tied to sustainable investments. Importantly, the green economy should be inherently inclusive, ensuring its growth benefits all sectors of society, and leaves no one behind. It should create opportunities for income generation and employment that should extend to diverse populations, addressing social equity concerns while fostering sustainability (Jezierska-Thöle et al., 2022; Musvoto et al., 2018).

UNEP has recommended that in nurturing an inclusive green economy, it is imperative to catalyze and support transformative investments through a range of targeted public expenditures, policy reforms, and regulatory changes that mutually create the necessary "enabling conditions" (Levidow, 2018; Ramzy, 2013; Victor & Jackson, 2012). To increase the welfare of the agriculture sector government expenditures are necessary for the green economy that emphasizes sustainability, reduction in carbon emissions, and environmental protection.

The purpose behind these practices is to decrease soil degradation, reduce the use of chemical inputs, and lower the carbon footprint of agriculture, public funding can be directed towards research and development initiatives driven by sustainable agricultural technologies and on infrastructure development in the agriculture sector. Investments not only increase food production but also keep water resources and relieve the environmental stress caused by excessive use of water. Governments can give subsidies and incentives to farmers who adopt environmentally friendly practices, e.g. organic farming, reforestation efforts, or transitioning to renewable energy tracks for farm developments. Healthy soil is vital for sustainable agriculture and carbon confiscation (Zou & Li, 2022).

A socially inclusive green economy is intrinsically linked to achieving global food security, ensuring adequate supplies of food and agricultural commodities to sustain growing populations. Projections indicate that the world's population is expected to increase by approximately 2.3 billion people between 2010 and 2050, primarily in developing countries. While it is expected that the proportion of undernourished individuals in developing countries will decline from the current 17% to 11% by 2015, aligning with poverty reduction goals (Fanzo & Pronyk, 2010; Zou & Li, 2022). It's crucial to acknowledge that progress in reducing the total number of undernourished people is advancing at a slower pace. Achieving this reduction depends on two critical factors, enhancing agricultural productivity to produce more food and agricultural commodities efficiently. This includes investing in innovative farming techniques, technologies, and sustainable practices to increase yields and reduce food loss.

FDI in Agriculture plays a pivotal role in curbing rural poverty and promoting well-being in developing countries. Approximately 75% of the world's impoverished individuals reside in rural areas, relying on the agricultural sector for their livelihoods. Agricultural growth holds the potential to empower poor countries, regions, and households by increasing employment opportunities and income levels. By bridging the rural-urban income divide and alleviating rural poverty, agriculture serves as an important connection between rural communities and broader economic development. Despite its modest share of total employment, agriculture's reliance on acquired inputs and provision of raw materials, and food to other sectors is imperative for employment and overall economic activity (Unay-Gailhard & Bojnec, 2019; Yue et al., 2016).

Adopting energy-efficient and environmentally friendly techniques, and access to electricity in agriculture is fundamental for advancing toward a green economy. Electric-powered irrigation, machinery, and renewable energy supplies like solar pumps promote sustainable farming practices, decreasing greenhouse gas emissions and dependence on fossil fuels. This approach not only improves productivity, reduces production costs, and assists the availability of goods and services at low prices but also the incorporation of renewable energy into the agricultural sector, with the principles of a green economy (Falchetta, 2021; Wright, 2012).

Investment in the agriculture sector is important not only for the acquisition of advanced infrastructure but also for addressing the gradual wear and tear or consumption of fixed capital (CFC) of physical assets used in agricultural production. This includes maintenance of buildings, repair of machinery, investment in efficient irrigation systems, and other capital-intensive components necessary to sustain the long-term productivity of agricultural operations (Abrosimova et al., 2020; Kumar, 2017).

The primary objective of this study is.

- To empirically investigate the emerging concept of a green and sustainable economy, particularly concerning the agricultural sector.
- To provide insights into the subtle relationships between social aspects of agricultural activities and their influence on the green economy.
- To assess the social contribution of the agriculture sector by relating how these initiatives fit with the SDGs.

The purpose of this research is to fill the gap of limited availability of empirical work on the green economy by introducing novel ideas related to the social contribution of agriculture toward the green economy. The study elaborates on the quantiles at low to medium, medium to high, and high to highest levels for all explanatory variables across 80 cross-sections from developed and developing countries. The selection of variables is uniquely determined for this study as Chi (2022) established an empirical model defensible within Confirmatory Factor Analysis and verified using Covariance-based Structural Equation Modeling. Lv et al. (2023) discovered the mechanisms in which green finance influences ANSP, having the objective of green transformation and more availability of food in agriculture. Unay-Gailhard and Bojnec (2019) focused on labor use and the availability of green jobs in agriculture for the development of the green economy.

The novelty of this research lies in the introduction of the exogenous variable, the green economy by generating an Index using 20 economic, environmental, and social variables by using PCA. This study employs five unique endogenous variables that majorly contribute to monitoring the social contribution of the agricultural sector by using Panel Quantile ARDL

(Q1, Q2, and Q3) for the period 2000-2020, which is rare in the existing literature.

The remaining organization of the paper is as follows in the second section literature review is reviewed to find the gap related to the topic. In the third section, there is a discussion about data and methodological techniques. Results have been discussed in section the fourth section. In section five concluding remarks with some policy suggestions stipulated.

2. Literature Review

This research focuses on evaluating the progress of the green economy by implementing social participation in the agricultural sector, a sector of immense importance in the socioeconomic advancement of every nation. Beyond conventional agricultural practices, the worth of rural areas are increasingly becoming hubs for modern industrial facilities, a range of services, tourist destinations, recreational areas, and housing development projects.

Zhang et al. (2022) highlighted the implication of the green economy as a keyframe for developed and developing nations. This aim is to extract insightful implications by explaining an inclusive investigation of the relationship related to globalization, the green economy, and the challenges set by climate change to improve sustainable infrastructure. It also investigates how the economic structure of a nation can plays a crucial role in mitigating environmental issues, boosting production efficiency, fostering the growth of the green economy, and facilitating the adoption of environment-responsive technologies. Furthermore, this study sheds light on the significance of improving admittance to a healthy and safe environment, particularly for vulnerable populations, while simultaneously enhancing human safety by providing natural resources i.e., land, water, and food.

Ma et al. (2022) focused on Green Economic Efficiency, which is an inclusive index used to assess economic, social, and environmental development. The research utilized the Slack-Based Measurement (SBM) directional distance function and the Luenberger productivity indicator to evaluate both static Green Economic Efficiency and dynamic Green Total Factor Productivity within China’s inner-city groups. To gain an expert comprehension of the components influencing GEE and GTFP, the study introduced the concept of Economic Policy Uncertainty (EPU) as a contributing factor. The findings indicated a positive correlation between EPU and both GEE and GTFP. This proposes that market mechanisms play an essential part in enhancing GEE and GTFP. Considering these results, the study recommended that policymakers should leverage the government's macro-control functions to effectively harness the potential of market mechanisms in environmental governance.

Q. Jiang et al. (2022) investigated empirically the critical question of whether the digital economy can efficiently facilitate agricultural green expansion, a key component for achieving agricultural rural modernization. They analyzed panel data from 30 Chinese regions over the period from 2011 to 2020. The study reveals that China's green agriculture proved to be directly related to digitalization but with regional heterogeneity, with the dividends being particularly higher in the eastern and vital regions compared to the western region and its role in promotion is nonlinear with rising “marginal effect." It also demonstrated a spillover effect indicating that its impact encompasses around. Overall, the research work contributes to a deeper understanding of how the digital economy facilitates agricultural green development, highlighting both its spatial dynamics and nonlinear effects. The findings provide valuable theoretical insights and practical recommendations for improving digital infrastructure development.

Jezierska-Thöle et al. (2022) investigated the economic, environmental, and social characteristics of the green economy in Poland. The research aimed to recognize the proportions of the quality of life-related to the environment, economy, and society while considering agricultural factors to indicate improvement in the adoption of the green economy doctrine. The study also examined the relationship between the achievement of execution of a green economy and the use of environmental funding offered by the Common Agricultural Policy by using an index of 19 variables. Pearson's correlation coefficient test is used to find the strength of the correlation between green economy and green payments. Furthermore, the study highlighted that spending on agri-environmental-climate measures per hectare exhibited the strongest correlation with the economic measurement of the quality of life, emphasizing the significance of such measures in promoting economic sustainability in rural areas.

Ren et al. (2022), conducted a study within the social framework of encouraging a low-carbon economy to address the challenge of achieving sustainable growth in Chinese agribusiness while aligning with current social development requirements. The research aimed to investigate the procedures inducing the sustainable growth of Chinese agriculture and improving decision-making processes within the agribusiness sector. This study developed a decision support system by integrating various statistical models. The research found a correlation among the dependent variables i.e. debt supporting indicators, environmental management, and the financial sustainability of agricultural companies in China.

Caffaro and Cavallo (2019) recognized that Smart Farming Technologies increase the chances of sustainability and agricultural productivity. The research observed the effect of sole farming, farm size, education, and professed barriers on the adoption of SFTs in North-West Italy. The study found after a survey of 310 farming operators via questionnaire that lower education and working alone on the farm harmed the implementation of SFTs. Whereas farm size was found to be directly associated with SFTs. The study ends with the conclusion that well-designed policies and training sessions intended for the agricultural sector improve the usage of Smart Farming Technologies.

Heshmati (2014) examined the activities, objectives, and structure of significant social executors in the movement toward the green economy, besides the thought of green citizenship. These components play a decisive role in developing the dimensions for green practices and their successful execution. The survey stressed that to achieve energy independence emphasis should be on the green hydrogen economy. Green Innovation, Industries, and regions in the green economy are described by a particular focus on connecting the potential of Information and Communication Technology (ICT)-based innovations to initiate economic retrieval and encourage environmentally friendly practices. Furthermore, the study accentuated the implication of green finance as an exceptional development in modern financial institutions, highlighting its implications for sustainable economies.

Hezri and Ghazali (2011) explored the intersections of technology, economics, politics, and morality from the perspective of the green economy and its complex shift towards sustainability, this shift necessitates the convergence of social, environmental, and economic objectives. The paper proposed that a critical component of transitioning to a green economy should involve seeking growth through environmental investments that specifically target impoverished communities. The study also highlighted that many beneficiaries of green initiatives remain ignorant of their technological and technical It is emphasized that Malaysia must work towards enhancing the five identified conditions to integrate social, economic, and environmental dimensions for sustainable development.

The present study tries to fill the gap in the existing literature by defining the unique proxy of the green economy and finding the social impact of the agriculture sector on the green economy.

2.1 Methodological Framework

2.2 Description of the Data and Variables

To observe the social contribution of the Agricultural sector to a green economy, the data of exogenous variables has been collected from miscellaneous sources, including the Agricultural share of Govt expenditures (LASHGEX), Agricultural Food Production (LFOODP), Agricultural Foreign Direct Investment (LFDIA), Agricultural Access to electricity, rural (LEACCA), and Agricultural Consumption of fixed Capital (LCONFC) is taken as control variable. Data of all exogenous variables are obtained from FAOSTAT. Moreover, the study also considers all independent variables as the leading factors contributing toward a green economy.

The endogenous variable, the Green Economy Index, is derived from twenty distinct economic, environmental, and social factors that are crucial for sustainability with Principal Component Analysis (PCA). Data for these twenty variables have been assembled from a range of reputable sources, including WDI (World Development Indicators), WB (World Bank), Eurostat, Our World in Data, and ILO (International Labor Organization). The present study used proxies such as Good Governance, Green Investment, Green Innovation, Organic Agriculture, Sustainable Consumption, Renewable Energy, Water Use Efficiency, Energy Efficiency, Material Use efficiency, Low carbon Zero Waste, Air Quality, Poverty Alleviation, Investment in Human Capital, Subjective Well-being, Intra generational equity, Intergenerational equity, Biodiversity and Eco System Protection, Green Trade and Meeting basic needs to create an exogenous variable over twenty years. The data employed in this research covers the period from 2000 to 2020 and encompasses 80 countries from both the developed and developing world. To ensure equivalence of the results, the data has been logarithmically transformed. All the sources and descriptions of variables are mentioned in Table 1.

Table No 1: Sources & Description of the Variables

Variable (Symbol)	Definition	Source
Green Economy (INDEX)	INDEX of 20 Variables	WDI, WB, EUOROSTAT
Agricultural share of Govt expenditures (LASHGEX)	Agriculture Share of Govt Expenditures percentage of GDP.	FAOSTAT
Agricultural Food Availability (LFOODP)	Food production index (2014-2016 = 100)	FAOSTAT
Agricultural Foreign Direct Investment (LFDIA)	FDI inflows to Agriculture, Forestry, and Fishing percentage	FAOSTAT
Agricultural Access to Electricity, (LEACCA)	Access to electricity, in rural (% of rural population)	FAOSTAT
Agricultural Consumption of Fixed Capital (LCONFC)	Consumption of fixed Capital (% of total population)	FAOSTAT

Source: Author's Construction

3. Methodology

The Quantile Autoregressive Distributed Lag (QARDL) model represents an advanced iteration of ARDL, which explores both cointegration and short-term dynamics amongst independent and dependent macroeconomic variables across different sections of the conditional distribution of these variables. The QARDL approach (Afshan & Yaqoob, 2022; Anwar et al., 2021; Aziz et al., 2020; Baek, 2021; Gangopadhyay et al., 2023; Mensi et al., 2019; Shahzad et al., 2021; Sharif, Afshan, et al., 2020; Sharif, Baris-Tuzemen, et al., 2020; Van Song et al., 2022) is utilized to investigate the effect of the Agricultural share of Govt expenditures (LASHGEX), Agricultural Food Production (LFOODP), Foreign Direct Investment in agriculture sector (LFDIA), Access to electricity, rural (LEACCA), and Consumption of fixed Capital's (LCONFC) impact on the green Economy.

This method creates awareness of non-linear associations, providing thorough information involving location-based asymmetry by using numerous quantiles. (Cho et al., 2015; Sahin & Sahin, 2023). Based on the above-mentioned descriptions within the context of this existing study, the QARDL method stances as a suitable methodology for estimating the non-linear relationships related to the policy variables and the control variables. Nevertheless, the Wald test, often referred to as the Wald Chi-Squared test, is also employed to evaluate the impact of the demonstrative variables in the short and long run (Sharif, Godil, et al., 2020).

In addition, the time-changing incorporation link is considered using the Wald test to verify the stability of integration coefficients across different quantiles. This analytical approach helps in assessing both long and short-run regularities. The following explanation is the ARDL model equation for the stated variables:

$$GE_{2-t} = \alpha + \sum_{i=1}^{l} \phi_i \, GEI_{2t_{-i}} + \sum_{i=0}^{m} \text{ω}_i \, LASHGEX_{t-i} + \sum_{i=0}^{n} \text{Л}_i \, LFOODP_{t-i} + \sum_{i=0}^{o} \Theta_i \, LFDIA_{t-i} + \sum_{i=0}^{p} \text{ƴ}_i \, LEACCA_{t-i} + \sum_{i=0}^{q} \text{¥}_i \, LNCONFC_{t-i} + \epsilon_t \quad \epsilon q \qquad (1)$$

In Equation 1 the Error term is mentioned as $\boldsymbol{\epsilon}_t$ identified as $EI_{2t} - E\ [\ GEI_{2t}\ /\ \sigma_{t-i}\ ]$. The smallest field $\boldsymbol{\sigma}$ of variables are as $\boldsymbol{\sigma}$ = [GEI_{2t}, $LASHGEX_t$, $LFOODP_t$, $LFDIA_t$, $LEACCA_t$, and $LCONFC_t$] and characters l, m, n, o, p and q mean the lag order of Schwarz information criteria (SIC) 2016. The variable employed in equation 1 is the symbolic interpretation of green economy as $GEI_{2t_{-i}}$ stands for, preceding green economy value, Agricultural share of Govt expenditures (LASHGEX), Agricultural Food Production (LFOODP), Foreign Direct Investment (LFDIA), Access to electricity, rural (LEACCA), and Consumption of fixed Capital (LCONFC) is taken as control variable respectively. Furthermore, in the expansion of Equation 1, the QARDL model formulates quantile approximations as follows:

$$QGE_{\square} = \alpha(\tau) + \sum_{i=1}^{l} \phi_i(\tau)\, GEI_{2t_{-i}} + \sum_{i=0}^{m} \text{ω}_i\,(\tau)\, LASHGEX_{t-i} + \sum_{i=0}^{n} \text{Л}_i\,(\tau)\, LFOODP_{t-i} + \sum_{i=0}^{o} \Theta_i\,(\tau)\, LFDIA_{t-i} + \sum_{i=0}^{p} \text{ƴ}_i\,(\tau)\, LEACCA_{t-i} + \sum_{i=0}^{q} \text{¥}_i\,(\tau)\, LNCONFC_{t-i} + \epsilon_t(\tau) \quad \epsilon q \quad (2)$$

Where $\boldsymbol{\epsilon}_t\ (\boldsymbol{\tau})$ = GEI_{2t} - Q_{GEI2t} ($\boldsymbol{\tau}$/vt-1) and 0 > $\boldsymbol{\tau}$ < 1 correspond to quantile (Kim & White, 2003). Due to the expected serial correlation equation 2 transformed into equation 3.

$$Q\Delta GE_{2t} = \alpha + \rho GEI_{2t_{-1}} + \partial_{LASHGEX} LASHGEX + \partial_{LFDIA} LFOODP_{t-i} + \partial_{LFOODP} LEACCA_{t-i} + \partial_{LEACCA} LNCONFC_{t-i} + \sum_{i=1}^{l-1} \phi \Delta\, GEI_{2t_{-i}} + \sum_{i=0}^{m-1} \text{ω}_i \Delta\, LASHGEX_{t-i} + \sum_{i=0}^{n-1} \text{Л}_i \Delta\, LFOODP_{t-i} + \sum_{i=0}^{o-1} \Theta_i\, \Delta LFDIA_{t-i} + \sum_{i=0}^{p-1} \text{ƴ}_i\, \Delta LEACCA_{t-i} + \sum_{i=0}^{q-1} \text{¥}_i\, \Delta LNCONFC_{t-i} + \epsilon_t(\tau)\epsilon q \qquad (3)$$

Though rendering to the QARDL method offered by Cho. Et al. (2015) the quantile error correction model can be restated as under:

$$Q\Delta GE_{2t} = \alpha(\tau) + \rho(\tau)\big(GEI_{2t_{-1}} - \beta_{LASHGEX}(\tau) LASHGEX_{t-1} - \beta_{LFOODP}(\tau) LFOODP_{t-1} - \beta_{LFDIA}(\tau) LFDIA_{t-1} - \beta_{LEACCA}(\tau) LEACCA_{t-1} - \beta_{LNCONFC}(\tau) LNCONFC_{t-1}\big) + \sum_{i=1}^{l-1} \phi(\tau)\Delta\, GEI_{2t_{-1}} + \sum_{i=0}^{m-1} \text{ω}_i(\tau)\Delta\, LASHGEX_{t-1} + \sum_{i=0}^{n-1} \text{Л}_i(\tau)\Delta\, LFOODP_{t-1} + \sum_{i=0}^{o-1} \Theta_i\,(\tau)\Delta LFDIA_{t-1} + \sum_{i=0}^{p-1} \text{ƴ}_i\,(\tau)\Delta LEACCA_{t-1} + \sum_{i=0}^{q-1} \text{¥}_i\,(\tau)\Delta LNCONFC_{t-1} + (\tau)\epsilon q \quad (4)$$

The delta procedure is applied to investigate the accumulative short-term effect of the previous Green Economy on the current Green Economy. The delta approach is shown as $\phi_i = \sum_{i=1}^{l-1} \phi_j$ However, the aggregate short-run influence of the preceding and existing levels of LASHGEX, LFOODP, LFDIA, LEACCA, and LCONFC are examined as $\text{ω}_i = \sum_{i=0}^{m-1} \text{ω}_i$ by $\text{Л}_i = \sum_{i=0}^{n-1} \text{Л}_j$ by $\Theta_i = \sum_{i=0}^{o-1} \Theta_j$ by $\text{ƴ}_i = \sum_{i=0}^{p-1} \text{ƴ}_j$ by $\text{¥}_i = \sum_{i=0}^{q-1} \text{¥}_j$ Correspondingly. The ρ coefficient of the error correction measure (ECM) given in Equation 4 is expected to be both negative and statistically significant. The coefficients concerned the long run for agriculture Govt expenditures, agriculture food availability, agriculture Foreign Direct investment, agriculture access to electricity, and rural population are estimated as under:

$\boldsymbol{\beta}_{GEI^*} = -\boldsymbol{\beta}_{GEI^*/\rho}$, , $\boldsymbol{\beta}_{LASHGEX^*} = -\boldsymbol{\beta}_{LASHGEX^*/\rho}$, $\boldsymbol{\beta}_{LFOODP^*} = -\boldsymbol{\beta}_{LFOODP^*/\rho}$, $\boldsymbol{\beta}_{LFDIA^*} = -\boldsymbol{\beta}_{LFDIA^*/\rho}$, $\boldsymbol{\beta}_{LEACCA^*} = -\boldsymbol{\beta}_{LEACCA^*/\rho}$, $\boldsymbol{\beta}_{LNCONFC^*} = -\boldsymbol{\beta}_{LNCONFC^*/\rho}$

Wald test

The current study considers the asymmetric effect of LASHGEX, LFOODP, LFDIA, LEACCA, and LCONFC on the green economy in the short and long term by using the Wald test. To analyze the test, the stated null hypothesis is as below:

H_0: $\boldsymbol{\sigma}_*(0.1) = \boldsymbol{\sigma}_*(0.2) = \ldots\ldots\ldots\ldots\ldots = \boldsymbol{\sigma}_*(1.0)$

Alongside the below-mentioned alternate.

H_0: Ʒ i ≠ j / $\boldsymbol{\sigma}$ (i) ≠ $\boldsymbol{\sigma}$ (j)

Analogous relationships are applied for LASHGEX, LFOODP, LFDIA, LEACCA, and LCONFC on green economy factors and precise lags by ϕ_i , ω_i , $Л_i$, Θ_i , ƴ, and $¥_i$ of short-term factors.

4. Results and Discussion

4.1 Descriptive Statistics

A descriptive investigation of all variables is presented in Table 2. The mean, minimum, and maximum values of all the variables show a mix of positive and negative results, i.e., INDEX (-0.001, -5.88, 4.5), LASHGEX (1.54, -1.58, 4.05), LFOODP (1.28, -3.00, 3.51), LFDIA (1.26, -1.17, 3.33), LEACCA (-0.22, -3.91, 3.29) and LCONFC (3.38, 0.65, 4.45). The Jarque-Bera test has been employed to assess the normality of the data. The results indicate the rejection of all null hypotheses testing for normality. This suggests that the assumption of normality is not met, providing impetus for researchers to progress towards QARDL analysis. (Ali et al., 2021; Godil et al., 2020; Song et al., 2022) and it also specifies that all these particular variables of the time series data do not follow a normal distribution, hence justifying the use of quantile regression analysis for the selected dataset.

Table 2: Results of Descriptive Statistics

Variables	Mean	Min	Max	Std. Dev.	JB Test	P-Value
INDEX	-0.000718	-5.886296	4.583323	2.424865	51.92900	0.000000
LASHGEX	0.534704	-2.407946	2.850707	0.968835	25.65927	0.000003
LFOODP	91.76365	42.38000	181.5100	14.72947	232.9630	0.000000
LFDIA	-0.467791	-7.759787	4.294486	1.682401	21.76226	0.000019
LEACCA	4.303884	-0.458132	4.721281	0.616713	16207.42	0.000000
LCONFC	8.957541	2.209153	19.09934	3.154767	113.9334	0.000000

Source: Authors' Estimation

4.2 Variance of Inflator

Along with descriptive statistics, we also calculated the Variance Inflation Factor amid all independent variables in Table 3 showing the magnitude of VIF amongst all the independent is less than 10. It also has a threshold beyond which the problem of multicollinearity exists between independent variables. Values greater than 10 show the significant existence of the problem of multicollinearity in the variables. We can see from the VIF matrices that there is no problem with multicollinearity because all the values are less than 10 (Rehman Khan et al., 2023).

Table 3: Variance Inflation Factor (VIF)

	INDEX	LAGREM	LENVT	LIAWAT	LFER	LPEST
INDEX	-					
LASHGEX	1.37682	-				
LFOODP	1.119138	1.03963	-			
LFDIA	1.037894	1.011339	1.000002	-		
LEACCA	1.729452	1.109965	1.143156	1.002643	-	
LCONFC	1.007291	1.024891	1.000031	1.009173	1.001343	-

Source: Authors' Estimation

4.3 Cross-Sectional Dependence

Before taking steps toward panel data and quantile data analysis needs to identify the cross-sectional interdependence of the countries. Cross section dependence (CD) test is also crucial to decide the appropriate unit root test (Pesaran, 2004; Zhong et al., 2022). This investigation uses three panel CD tests owning the same null hypothesis that "cross-sections are independent". The significant p-values acknowledge to reject the null hypothesis and found dependence of all cross sections on each other as shown in Table 4. Our results are similar to (Chen et al., 2022; Pesaran, 2004).

Table No 4: Cross-Sectional Dependence Test

Test	Statistic	Probability
Breusch-Pagan LM	15271.19***	0.0000
Pesaran scaled LM	152.3451***	0.0000
Pesaran CD	9.683233***	0.0000

Source: Authors' Estimation

Note: ***, **, and * symbolize the significance level at 1%, 5%, and 10%, correspondingly.

4.4 Unit Root Test

The unit root test is a commonly utilized method for examining the stationarity of variables. As the cross-sections are dependent on each other, tested from CD test, each variable's order of integration is searched by applying second-generation unit root tests, CIPS, and CADF to cover the impact of cross-sectional dependence and heterogeneity (Iqbal et al., 2023; Tufail et al., 2021; Zaidi et al., 2021). These tests can manage heterogeneity and cross-sectional dependence more effectively than the first-generation unit root tests (Pesaran, 2021). Unit root tests are essential for assessing the presence of trends and stationarity in time series data.

Identifying these characteristics is crucial because they can significantly impact the statistical analysis of time series data, affecting the validity of statistical inferences (Cai et al., 2021; C. Jiang et al., 2022; Song et al., 2022). The outcomes of CIPS and CADF confirm that there is a mixed order of integration at I (0) & I (1) all the data is stationary at a 5% or 10% level of significance. A mix of order of Integration is recommended for Panel ARDL and Panel Quantile ARDL co-integration technique. The null hypothesis of CIPS and CADF panel unit root tests is that "data series is non-stationary". Table 5 contains the results of both tests.

Table 5: Results of Unit Root Tests CIPS and CADF

Panel Unit Root test	**CIPS**			**CADF**			
Variables	**Level**	**First difference**	**Decision**	**Level**	**First difference**	**Lags**	**Decision**
LASHGEX	-2.36***	-	I (0)	-1.631	-2.23***	1	I (1)
LFOODP	-2.60***	-	I (0)	-1.536	-1.88***	1	I (1)
LFDIA	-3.18***	-	I (0)	-2.20***	-	1	I (0)
LEACCA	-2.78***	-	I (0)	-1.739	-3.30***	1	I (1)
LCONFC	-1.556	-2.343*	I (1)	-1.377	-1.473*	1	I (1)
INDEX	-2.19***	-	I (0)	-1.606	-2.38***	1	I (1)

Source: Authors' Estimation

Note: ***, **, and * symbolize the significance level at 1%, 5%, and 10%, correspondingly.

4.5 Co-integration Test

If dependence is approved, the established co-integration tests offer deceptive results. Therefore, this research directs a second-generation panel co-integration test as given in Table 6 (Westerlund, 2005). The test's null hypothesis is "no co-integration" among chosen variables. The statistically significant probability value permits us to reject the null hypothesis and reveal that long-run co-integration occurs between the selected variables. Our results are like (Khalid et al., 2023; Rehman Khan et al., 2023).

Table No 6 Westerlund's Cointegration Test

Panel	**Statistic**	**Probability**
80 Developed and Developing Countries	-1.6910**	0.0454

Source: Authors' Estimation

Note: ***, **, and * signify the significance level at 1%, 5%, and 10%, correspondingly.

Table 7: Panel ARDL and Panel Quantile Long Run and Short Run Estimates

Variable	Coefficient	t-Statistics	Prob.
LASHGEX	-0.945***	-18.92057	0.0000
LFOODP	0.018***	6.281524	0.0000
LFDIA	-0.166***	-5.986593	0.0000
LEACCA	1.99***	10.96528	0.0000
LCONFC	-0.108***	-9.471777	0.0000
C	-8.866***	-9.673457	0.0000
DLASHGEX	0.011992	-0.767833	0.4427
DLFOODP	0.0024***	3.207307	0.0014
DLFDIA	0.047073	0.024131	0.9808
DLEACCA	0.002094	0.837872	0.4023
DLCONFC	0.005166	0.546556	0.5848
ECM	-0.00583**	-1.920459	0.0550

Source: author's calculation
Note: ***, **, and * denote the significance level at 1%, 5% and 10%, correspondingly.

4.6 Results Discussion of Panel Quantile ARDL

In Panel QARDL the first variable, the agricultural share of Govt expenditure is inverse and significant at a 1% level of confidence in the green economy as depicted in Table 7. An increase in the degree of fiscal decentralization of government spending is correlated with a decline in economic growth at the provincial level described by (Devarajan et al., 1996; Zhang & Zou, 1998). It is often said that Agricultural Financial Expenditure can significantly affect the social, economic, and environmental aspects of agriculture through investments in water infrastructure, farmland, scientific input, and support of agriculture by giving subsidies. Chen et al. (2018) employed a vector autoregressive (VAR) model and determined that agricultural fiscal expenditure is useful in reducing rural poverty instead of advancing general agricultural development.

At times ineffective or very small fiscal support to farmers hinders the adoption of modern technologies. Funding constraints may reduce R&D efforts to find innovative solutions for the reduction in greenhouse gas emissions and optimal resource utilization for sustainability. With low funding, farmers might not only be deprived of the skills and knowledge of organic agroforestry but also there is a lack of motivation, which is required to transition to greener farming methods and give benefit to the environment.

Food availability in a socially inclusive economy is presented as the Food Production Index which is a positive and significant. A one percent rise in food production will enhance the social efficiency of the inclusive green economy. Food production and its availability to consumers in the agricultural sector is a cornerstone of the socially inclusive green economy, embodying sustainability, and environmental stewardship. By embracing agroecological practices, organic farming, and reduced chemical usage, agriculture can minimize its ecological footprint while ensuring food security. Localized, diversified food production and distribution systems can reduce transportation emissions and promote community resilience. Additionally, regenerative farming practices can seize carbon, enhance soil health, and preserve biodiversity. A sustainable food production approach not only addresses hunger and nutrition but also contributes significantly to achieving sustainable development goals, and an ecologically balanced, and environmentally conscious economy.

In Panel QARDL Foreign Direct Investment (FDI) in the agriculture sector is significant and inversely related to the green economy in Panel Quantile ARDL. In empirical research, the dual performance of FDI has been observed in the agriculture sector, with positive shocks, leading to increased inflows of foreign direct investment. Conversely, negative shocks **to** FDI in the agricultural sector may be inversely related to the green economy when profit-driven agricultural practices are prioritized over sustainability. Intensive farming methods may give rapid returns to investors, more use of chemical inputs, and extensive use of monoculture, all of which can have negative environmental impacts. FDI Hinder green growth was found by Ofori et al. (2023). The degree of openness in an economy inversely affects FDI inflows into the agricultural sector. A higher degree of economic openness implies lower levels of agricultural protection against foreign trade and imports, consequently reducing the incentive for FDI inflows into the agricultural sector of the economy (Zeytoonnejad Mousavian et al., 2023).

Access to electricity shows a positive and significant association of the agriculture sector toward the green economy in long-term analysis. As Bridge et al. (2016) advocated households' access to electricity has a substantial impact on income, educational attainment, and agricultural productivity. Electricity, as a form of energy, plays a significant part in enhancing the economic growth of a country, by increasing social well-being and life quality, in all the sectors with the severe production of sustainable electricity (Maxim, 2014; Rehman et al., 2018). According to Byaro and Mmbaga (2022), the result of sub-Saharan Africa demonstrates that agricultural productivity improves food protection by increasing access to electricity in the agricultural sector is a cornerstone of the green economy, altering farming practices and sustainability.

Consumption of fixed capital (proxy of Infrastructure) in the agriculture sector is significant and inversely related to the green economy in Panel Quantile ARDL. In the context of the agricultural sector, consumption of fixed capital occurs as farmers and agricultural businesses use these assets in their daily operations. The process involves accounting for the decrease in value of these assets over their useful life, considering factors like depreciation, repairs, and replacements. Proper management of this consumption is crucial for maintaining a productive and efficient agricultural operation. Upgrading or replacing aging assets with more efficient and environmentally friendly ones is a key aspect of sustainable agricultural practices, contributing to a greener economy.

Table No 8: Results of Quantile Autoregressive Distributed Lag (QARDL) Social Contribution of the Agriculture Sector

Quantiles (τ)	Constants α∗(τ)	ECM ρ∗(τ)	LLASHGEX βOIL(τ)	LLFOODP βGP(τ)	LLFDIA βGPR(τ)	LLEACCA βEPU(τ)	LLNCONFC ∂1(τ)	DLASHGEX θ0(τ)	DLFOODP κ0(τ)	DLFDIA ψ0(τ)	DLEACCA ω0 (τ)	DLCONFC ω1(τ)
0.10	-13,1***	-0.014**	0.0203	-0.002***	-0.0047	-0.014	-0.444105	0.043***	0.006	-0.013	0.025	0.0068
	(0.00)	0.0366	0.2484	0.0000	0.2130	0.8313	0.0000	0.0000	0.5980	0.0017	0.3817	0.1698
0.20	-13.4***	-0.0007	0.031**	-0.0016**	-0.0039	-0.011	-0.236489	0.033*	0.001	-0.011	0.040	0.0042
	(0.00)	0.7307	0.0550	0.0449	0.3520	0.79	0.0002	0.0116	0.1177	0.0131	0.4896	0.5231
0.30	-11.6***	-0.001	0.0236	-0.001	0.002	0.001	-0.091316	0.024	0.002**	-0.003	0.028	0.0007
	(0.00)	0.7029	0.2196	0.3870	0.9435	0.9981	0.0718	0.1183	0.0307	0.3796	0.6759	0.9071
0.40	-10.8***	-0.0015	-0.0016	0.0011	0.0018	0.032	0.002493	0.014	0.003***	-0.004	0.042	0.0024
	(0.00)	0.6193	0.9460	0.8690	0.6894	0.216	0.9664	0.5671	0.0044	0.4169	0.5020	0.5428
0.50	-8.86***	-0.0052**	-0.0184	0.001	0.0063	0.026	0.055195	-0.015	0.003***	0.001	0.047	0.0021
	(0.00)	0.0550	0.4089	0.2584	0.1225	0.293	0.0064	0.4427	0.0014	0.9808	0.4023	0.5848
0.60	-7.11***	-0.0059**	-0.0178	0.0016**	0.007*	0.038**	0.134249	-0.026	0.004***	0.002	0.059	0.0027
	(0.00)	0.0372	0.3909	0.0631	0.0639	0.053	0.0326	0.1216	0.0002	0.6101	0.3485	0.3969
	-	-0.0045	-0.048**	0.003***	0.011***	0.039**	0.280582	-0.020	0.005***	0.0074	0.068	-0.0002

0.70	6.42***											
	(0.00)	0.1103	0.0279	0.0005	0.0087	0.0080	0.0003	0.1560	0.0000	0.1550	0.3552	0.9383
0.80	-6.27***	-0.0082***	-0.046***	0.0036***	0.008**	0.031**	0.557994	-0.03**	0.01***	0.0068	0.08***	0.00016
	(0.00)	0.0012	0.0010	0.0000	0.0121	0.0298	0.0000	0.0458	0.0000	0.1448	0.0028	0.9423
0.90	-6.25***	-0.0088***	-0.071***	0.004***	0.011***	0.103	0.950442	-0.06***	0.075***	0.08**	0.115**	-0.0008
	(0.00)	0.0001	0.0000	0.0000	0.0006	0.1395	0.0000	0.0001	0.0000	0.0290	0.0373	0.7867

Note: The table reports the quantile estimation results. The p-values are between brackets. *, ** and * indicate significance at the 1%, 5% and 10% levels, respectively.**

Source: Authors' Estimations

4.7 Results Discussion of Panel Quantiles

In this analysis, Government expenditure, Food Production Index, Foreign Direct Investment (FDI), access to electricity, and consumption of fixed capital are indeed important social variables that have been discussed that influence the agricultural sector's role in transitioning towards a green economy. Here's how they contribute to sustainability in agriculture. Likewise, it is envisioned that the coefficients are heterogeneous within quantiles and different in statistical significance.

Table 9 shows the output for the quantile ARDL estimation both in the long and short run with the help of coefficients at different levels of quantiles varying from lower to higher levels, respectively (Godil et al., 2020). The results obtained from the long-run estimation reveal a significant and negative speed of adjustment coefficient for variable 'p.' Moreover, the Error Correction Model provides the desired outcomes, demonstrating the significance and a negative relationship across all quantile levels. The first long-run variable is the Agricultural share of Govt expenditures considering utilization of public funds towards sustainable agricultural practices, research and development, infrastructure improvement, and policy support are vital for steering the agricultural sector toward environmentally friendly practices. Well-directed government expenditure can incentivize and facilitate the whole sector because individual interests are different from public interests they hesitate to adoption of green technologies and sustainable farming methods, So Govt take steps to subsidize this sector but in our study, it is evident that results are insignificant from (0.10-0.60) quantiles except 2nd quantile and from (0.70-0.90) it becomes significant but inversely related.

The inverse relationship between government expenditures and the green economy often stems from the allocation of resources within government budgets. Governments often allocate a significant portion of their budgets to sectors that are considered traditional economic drivers, such as industry, infrastructure, and defense. These sectors may receive substantial financial support to stimulate immediate economic growth, create jobs, and address necessary issues. However, such allocation patterns may inadvertently divert resources away from investments in the agriculture sector toward the green economy.

Even the low fiscal expenditures from Govt in the agricultural sector can indeed hinder its contribution to the green economy. A "green economy" typically refers to an economy that is environmentally sustainable, resource-efficient, and low-carbon. Agricultural resources and significant part of achieving a green economy due to their potential to relieve climate change, preserve natural resources, and encourage sustainable practices. However, if fiscal expenditures (government spending) in the agricultural sector are low, it can result in several challenges that impede its contribution to a green economy and regrettably, the percentage of GDP is always low in developing nations.

The Food Production Index is used to see the availability of food to all inclusively. This index reflects the growth and efficiency of food production. Improving this index in an environmentally sustainable manner involves focusing on enhancing productivity without compromising on natural resources. Results of the current study indicate that quantile (0.10-0.20) is statistically significant but inversely related to a green economy because of the ignorance of some crucial practices such as sustainable farming techniques, crop diversification, reduced chemical usage, and efficient resource management in achieving a green economy within the agricultural sector.

From (0.30-0.50) the results of quantiles are insignificant and after that (0.60-0.90) the outcomes positively significantly contribute to the green economy. In the short run this variable is insignificant at first quantile and from (020-0.90) quantiles it is positively contributing toward a green economy. Monitoring food production helps assess a region's ability to meet its food needs, ensuring food security and addressing nutritional requirements. Food production is linked to social development, especially in agrarian economies by creating employment opportunities, enhancing income levels for farmers, alleviating poverty in rural areas with environmentally friendly techniques, and reducing negative environmental impacts. It helps assess whether policy measures are effective in promoting agricultural growth and ensuring food sufficiency.

In the present study, the quantities of Foreign Direct Investment from (0.10-0.50) are insignificant and from (0.60-0.90) these are positive and significant. Foreign Direct Investment (FDI) can play a role in supporting sustainable agricultural practices. When foreign investments are directed towards eco-friendly technologies, renewable energy integration, efficient irrigation systems, and responsible land use, they can contribute positively to the green conversion of the agricultural sector.

Foreign Direct Investment (FDI) plays a crucial role in promoting inclusive green total factor productivity in China. However, environmental pollution during the FDI process represents a significant obstacle that hampers the advancement of inclusive green total factor productivity (Zhu & Ye, 2018). FDI has demonstrated a significant role in fostering economic growth by elevating a country's technological capabilities, generating new employment opportunities, and providing a vital source of external capital for developing nations. Empirical evidence indicates a positive correlation between the FDI inflows-to-GDP ratio and the real GDP growth rate However, this impact is not statistically significant for lower-middle-income countries (Piabuo et al., 2023). Inward foreign direct investment (IFDI) positively contributes to the development of green innovation in China, supporting the "Pollution Halo hypothesis." Conversely, outward direct investment (OFDI) exerts a reverse green technique effect on China's green innovation (Luo et al., 2021).

The same behavior is observed for access to electricity, Quantiles from (0.10-0.50) are insignificant and from (0.60-0.90) these are positive and significant. Reliable and widespread access to electricity is a fundamental enabler for adopting modern, energy-efficient farming practices. It supports the implementation of precision agriculture, the use of renewable energy, and the electrification of equipment, reducing the sector's carbon footprint and enhancing its overall sustainability.

The last variable agricultural Consumption of Fixed Capital is used as the control variable. It is a proxy state of Infrastructure of the agricultural sector such as roads, bridges, buildings, machinery, and other long-term capital assets that are subject to wear and tear over time. Results indicate that the first three quartiles are significant but inversely related to the green economy, the fourth quantile is insignificant and from (0.50-0.90) these are significantly positively related to the green economy. Efficient management of fixed capital, considering depreciation and obsolescence, is critical for sustainable agricultural operations. Reinvestment in newer, more efficient assets that align with green practices ensures that the agriculture sector operates in an environmentally responsible and resource-efficient manner. By leveraging these variables effectively and aligning them with sustainable and green principles, the agricultural sector can significantly contribute to building a greener and more sustainable economy.

Table No 9: Wald Test Normalized Restriction

Summary Long-Term Effect			**Summary Short-Term Effect**		
F-statistic	282.7416	0.0000	F-statistic	2.541563	0.0189
Chi-square	1413.708	0.0000	Chi-square	15.24938	0.0184
Normalized Restriction	**Value**	**Std. Err.**	**Normalized** Restriction	**Value**	**Std. Err.**
LASHGEX	-0.945592	0.049977	**DLASHGEX**	-0.015216	0.019817
LFOODP	0.018634	0.002966	**DLFOODP**	0.002443	0.000762
LFDIA	-0.166451	0.027804	**DLFDIA**	0.000116	0.004805
LEACCA	1.994183	0.181863	**DLEACCA**	0.047073	0.056181
LCONFC	-0.108729	0.011479	**DLCONFC**	0.002094	0.003831
C	0.00	0.00	**ECM**	-0.005166	0.002690

Source: Authors' Estimations

4.8 Wald Test

The Wald test serves as a tool to assess the stability of parameters in both the short and long run, to detect any asymmetric relationships among the explanatory variables. In Table 9, we present the results of the Wald test. Based on these findings, it becomes evident that the dependency coefficient holds statistical significance. Consequently, we must reject the null hypothesis suggesting linearity in the speed adjustment coefficient, which means the green economy is jointly affected in the long run by all independent variables. (Ali et al., 2021; Godil et al., 2020; Luqman et al., 2021)

The results obtained from the Wald test indicate that in the long run, there exist asymmetric

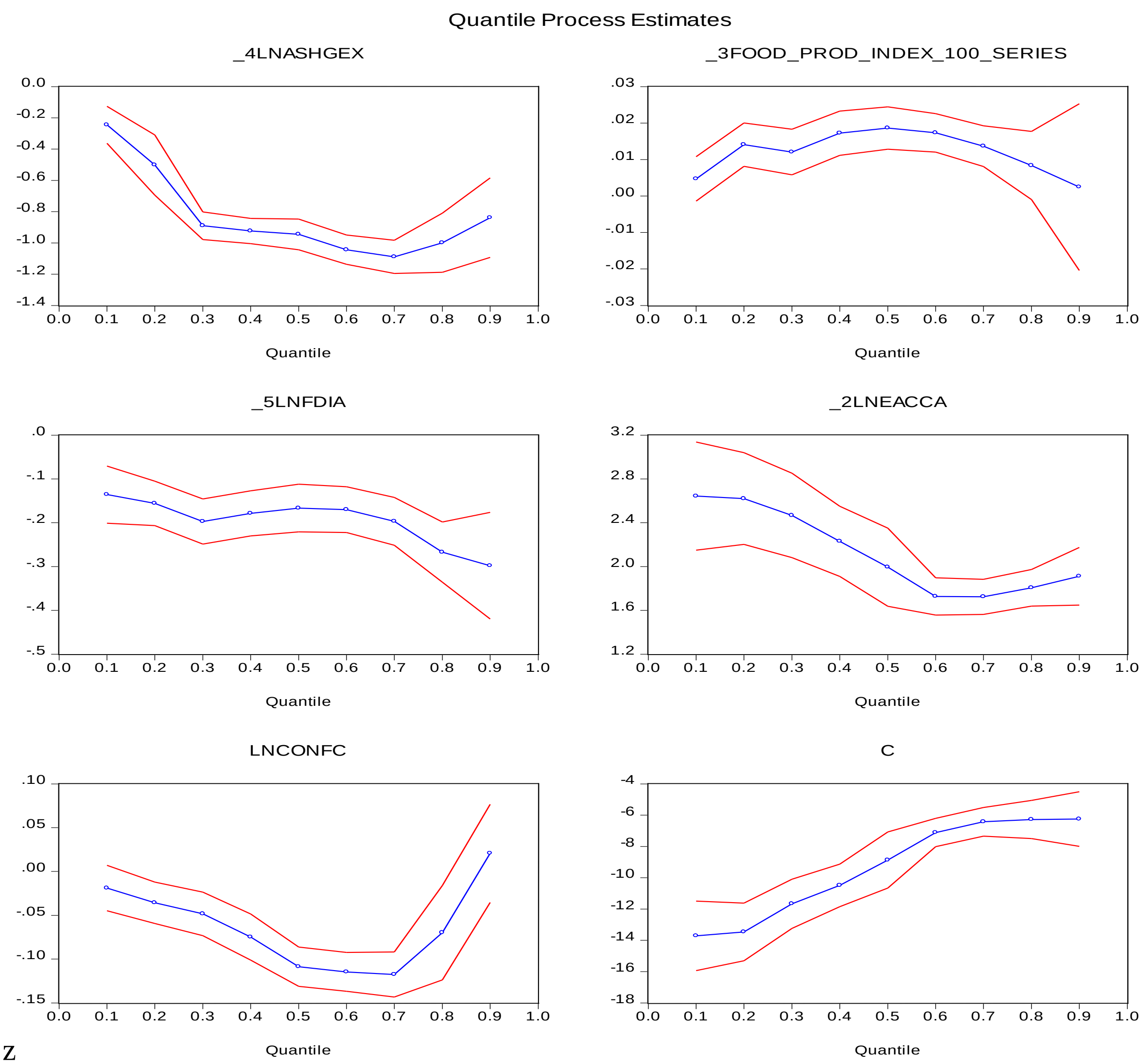
Journal of Social & Organizational Matters

Vol 3 No 3 (2024): 14-39

relationships linking all the exogenous factors including LASHGEX, LFOODP, LFDIA, LEACCA, and LCONFC toward the green economy. These outcomes are reflected in the statistical significance of all the long-term parameters. Although, LASHGEX, LFOODP, LFDIA, LEACCA, and LCONFC are significant at a 95% level and LEACCA is insignificant in this model. The reliability of parameters for short-term relationships was also rejected, given that all short-term coefficients exhibit significance except. When focusing on short-term dynamics, the findings highlight that the cumulative prior experience of the green economy significantly impacts current progress toward a green economy. Additionally, the significance of LEACCA contradicts the null hypothesis of a symmetric association connecting LEACCA and the green economy in the short run.

4.9 Quantile Parameter Estimates

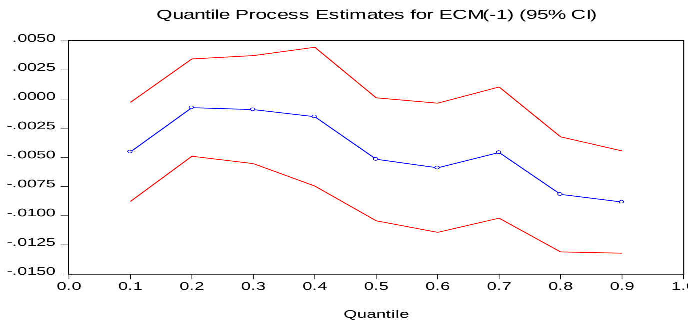
Figure No 1: Quantile Process Estimates for the Long-run Model



Z

The plot in Figure 1 indicates the probable parameter for all the quantiles 0.1, 0.2, 0.9, and 1.0 with a 95% confidence interval (outer shaded area) on the vertical axis (blue solid line). Figure 2 shows the stability of the Model. All blue lines are within the red lines. (Shahbaz et al., 2018). The graph for ECM also shows the stability of the overall model.

Figure No2: Quantile Process Estimates for Convergence Coefficient



5. Conclusion and Suggested Policy Measures

The social contribution of the agricultural sector toward the green economy ends up with a comprehensive conclusion that green transformation is not only the subject of sustainable environment and productivity, but it also deals with social inclusion. A socially Inclusive economy may achieve SDGs 1 & 2 by providing food security and eliminating Poverty. The present study empirically found the impact of selective independent variables like govt expenditures in agriculture, availability of food, FDI in agriculture, access to electricity, and gross fixed capital formation on green economy i.e., the self-generated Index with the help of 20 inclusive variables for 80 cross sections from developed and developing nations of the world.

This study used nonlinear Panel QARDL due to the rejection of the normality hypothesis of the Jarque Bera test. The QARDL is an extension of classical least square estimation for the conditional mean, it is notable for its robustness in the presence of outliers. Second generation unit root test yielded mixed order of integration results and the Westerlund test confirmed cointegration among the variables. All the variables are significant towards the green, Govt expenditures and Foreign Direct Investment are inversely related, rest of all are positively related to the green economic index. In some cases, government expenditures may prioritize short-term economic goals, which can conflict with the longer-term objectives of building a green and sustainable economy.

FDI in agriculture may prioritize short-term economic gains at the expense of the planet's well-being and future agricultural sustainability. The collective long- and short-term effect of all variables is symmetrical on the green economy as indicated by the Wald test. All the variables are insignificant at lower to middle quantiles and after that it becomes significant. In QARDL, the value of ECM also has been applied to the annual data from 2000-2020, the outcome is according to theory that is significant and negative at all quantiles from (0.10-0.90).

The concept of a green economy has garnered significant attention in recent years due to various concurrent global crises, including the 2008 financial and economic downturns, as well as crises related to climate change, biodiversity loss, food, fuel, and water. These crises, though diverse in their origins, share a common core cause: the misallocation of capital, particularly towards non-renewable sources of energy, perpetuating a "brown economy" rather than fostering a sustainable "green economy."

The findings indicate the contribution of the study that access to electricity primarily yields immediate impacts on both food availability and utilization, with only a minor portion of the effects being mediated by income. This insight could guide policymakers to prioritize investments in off-grid electricity, especially near vulnerable households. Implementing small-scale and household-level electricity systems in rural areas may effectively enhance food security by promptly influencing local and subsistence food production, conservation, and preparation.

5.1 Limitations and Future Research

Based on the findings, the study recommends the following actions. Firstly, the government should formulate and implement policies aimed at boosting agricultural productivity. This could involve initiatives such as enhancing seed quality for farmers and providing modern mechanized tools, aligning with expert opinions. (Anderu & Omotayo, 2020; Ezeh et al., 2022). Secondly, the study recommends that the government should enhance agricultural FDI, because it is crucial not only to improve spending on critical infrastructure that can expedite the transportation of agricultural produce to various destinations such as markets and industrial zones but also to actively seek Foreign Direct Investment to support these essential purposes. (Anderu & Omotayo, 2020)

Three key strategies can facilitate the movement to a green economy:

- Transforming investments
- Promoting resource efficiency
- Prioritizing social and human well-being.

By redirecting investments towards low-carbon, waste-reducing, clean, resource-efficient, and ecosystem-enhancing activities, we can significantly enhance resource efficiency and, in the medium to long term, anticipate a net increase in income and job opportunities (Zeb et al., 2014). The study is limited to only one aspect of inclusive economy i.e. social contribution, in future researchers may study other aspects of an inclusive green economy with other important variables.

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