**Pathway to Environmental Resilience: Analyzing Financial Dimensions to Curb Energy Security Risks**

## Abstract

Given the importance of environmental sustainability, energy security risk in ensuring stable energy supply, minimizing business risks and costs, and supporting long-term investment and sustainable growth, and the examination of the energy security risk and financial development in terms of strategic business aspect is crucial in academic literature. For this, the current study establishes the quantile-dependent association between business development indicators and the environmental sustainability in broader sense. Precisely, this study investigates the role of energy security risk (ESR) and its four sub-indices, i.e., geopolitical (GEPR), economic (ECOR), environmental (ENVR), and reliability risk (RELR) with diverse measures of firm's financial performance in the United States from 1970 to 2020. The novel Wavelet Quantile Correlation (WQC) methodology is selected to obtain the study results. The outcomes of the wavelet quantile correlations expose the non-linear behavior of the variables chosen, acknowledging the method's utility. Regarding the connectedness of financial development with energy security risk indices, the overall results reveal that the banking and stock market sector negatively correlates with the energy security risk at various bearish and bullish market conditions in the short and medium run. With the geopolitical risk, the banking sector is negatively affected, while stock market variables possess an escalating impact. Similarly, the reliability risk is negatively knotted to the quantile association with the bank sector and positively tied to stock market variables. Also, the environmental risk has an increasing negative impact on financial development indicators at various bearish, stable, and bullish quantiles, specifically in the short and long run. In light of the outcomes, policies regarding the enhancement of business strategy development and eliminating the impact of environmental risks in developed countries like the USA have been furnished.

**Keywords:** Financial and Business Models, Geopolitical Risk, Environmental Risk, Economic risk, Reliability Risk.

## Introduction

Indeed, sustainable business growth is achievable with the implementation of adequate financial strategies. In this regard, financial development is pivotal in driving economic growth by efficiently shaping the business strategies, mobilizing savings, providing credit, and facilitating investments, which are essential for firms economic and financial progress (Frishammar et al., 2025; Estrada et al., 2010). In developing the business strategies and understanding the depth of financial protocols, financial development of business firms is termed as a key indicator. It enhances the firm’s ability to utilize the efficient sources of low budgeted capital, empowering firm’s investment decision, and improve their capital structure augmented with their strategic aims (Garcia- Torres.,2024). A well-developed financial sector ensures that resources are channeled into the most productive avenues, allowing businesses to implement effective strategies, cultivate the innovative business environment, and create employment opportunities (Adelakun, 2010; Zhuang et al., 2009). This, in turn, leads to increased productivity, improved living standards, and significant poverty reduction. The growth of the financial sector is often tied to a country's ability to integrate into the global economy and maintain stable energy supplies, as conventional energy sources like oil, gas, and coal continue to support industrialization and economic activities (Fotio et al., 2022; Ahmad & Zhang, 2020). In this regard, energy security significantly influences financial development by providing the stability needed for a healthy economy as well as the financial markets (Reitmaier et al., 2025; Paravantis & Kontoulis, 2020). When a nation secures its energy resources, it creates an environment conducive to investment, developing both domestic and foreign investor confidence, essential for financial sector growth. Stable energy supplies underpin industrial and economic activities, leading to increased lending, investment opportunities, and enhanced financial services (Simsek & Umee, 2020). Moreover, energy security minimizes risks associated with energy shortages or price volatility, which helps stabilize financial markets and promotes sustainable economic growth (Aslantuk & Kiprizli, 2020). This stability allows financial institutions to manage risks more effectively, allocate resources efficiently, and support long-term development projects, all of which are vital for advancing financial development (Ozili & lorember, 2024).

In the current energy mix of economies, the majority in the global world extensively rely on traditional, fossil-based energy sources as the pillar of their industrial and economic structure. For instance, in the United States, the contribution of fossil-based energy sources is 84 percent of total primary energy production in 2023, highlighting its dominant contribution in driving the country’s advancements. In general, the reliance of economies on conventional energy sources carry extensive energy security risks owing to their finite nature and dependence on politically unstable regions for supply, each of which can lead to shortages and price instability. In other words, the heavy reliance on conventional energy sources like coal, petroleum and natural gas, can expose a country's financial system to global price fluctuations and geopolitical tensions, potentially leading to economic and financial instability (Lee et al., 2022a).

When energy security is compromised, the effects on financial development can be severe from multiple channels. High energy security risks, such as volatile energy prices or supply disruptions, can deter investment and financial attractiveness (Jewell, 2013). For instance, according to Zhang et al., (2019), if the price of oil or gas fluctuates wildly, businesses may be hesitant to invest in new projects because of the uncertainty about future energy costs. This can slow financial development, as fewer businesses seek loans, issue bonds, or invest in new ventures. Moreover, uncertainty in energy insecurity can lead to increase the cost of capital.

When energy prices are unpredictable, lenders may see this as a risk and demand higher interest rates to compensate (Dabrowska et al. 2021). This makes borrowing more expensive for businesses, which can hinder financial development. Additionally, rising energy costs due to insecurity can lead to inflation, prompting higher interest rates across the economy (Yusuf and Mohd, 2023). These higher interest rates discourage investment and borrowing, further slowing financial development. Economic instability resulting from energy security risks can also further instigate financial market volatility (Khan et al., 2023). When energy supplies are disrupted or prices spiked, this instigate uncertainty, investors may become nervous and pull their money out of financial securities, leading to market downfall. This slowdown financial development, as businesses struggle to raise the capital they need to grow and innovate (Authers, 2012).

In addition, as the world shifts toward renewable energy sources, countries that are overly dependent on fossil fuels may also find it challenging to attract investment in their financial markets, as investors increasingly prioritize sustainability and environmental, social, and governance factors (Jinga. 2021). To mitigate these risks, it is suggested that countries need to diversify their energy sources and invest in renewable energy (Zhu et al., 2020). By doing so, they can reduce their dependence on fossil fuels, minimize exposure to global energy price fluctuations, and create a more resilient financial system. Renewable energy investments also offer new opportunities for financial development, as they require significant capital and create demand for a wide range of financial services, including project finance, green bonds, and carbon trading (Shahbaz et al., 2021). However, in some stances, a switch to clean energy could lead to enhanced energy security risks. This can happen if renewable energy infrastructure is not fully established or if energy sources that depend on the weather, like solar and wind, are excessively given reliance. Furthermore, there may be risks associated with the transition process itself, particularly if it results in to lesser financing into conventional energy infrastructure before the formation of green energy-based structure. Thus, given the sporadic and transitory nature of alternative energy sources, the transition to green energy can sometimes cause supply delays if improperly managed, leading to create threats to energy security. Furthermore, supply chain vulnerabilities may also result from green technologies' reliance on rare earth elements and key resources and thereby requires a major infrastructural change that could enhance financial costs in the process. Hence, the heavy dependence of the economies on traditional energies, as well as a forced and mismanaged transition to renewable energies, can both augment energy security risks, leading to cause instable financial development. This triggers the need of a detailed investigation of both energy security and financial development domains.

In the light of the above, the current study aims to perform an extensive examination of energy security and financial development link by investigating how the dimensions of energy risks can influence financial development indicators like banking and stock market domains. The notion behind analyzing this dynamic is to underscore the importance of effective energy management in driving financial development (Khan et al., 2021). Energy management strategies that emphasize sustainability, diversification, and efficiency are essential to ensure that energy security positively impacts financial development, supporting both immediate economic needs and long-term financial stability (Fu et al., 2021). The ability of a country to ensure a steady supply of energy resources is directly related to the resilience and growth of its financial markets; however, greater risks associated with energy security can result in disruptions in production, higher prices, and unpredictability in economic activity, all of which can destabilize markets and hamper financial development. In advanced economies like the United States, this interdependence is more evident (Li, 2005). The U.S. has a mature financial sector that supports significant investment in energy infrastructure and technological innovation, particularly in renewables and energy efficiency. This makes the country more vulnerable to stability in energy security as large portion of this reliance drives its long-term economic growth (Moe, 2010).

Therefore, this research contributes to the policy by exploring the complex relationship between security risk, geopolitical, environmental, and reliability risks, and seven measures of financial development (deposit money bank assets, liquid liabilities, private credit, and domestic credit, market capitalization, total value added, and turnover) in the US. Unlike traditional evaluations, this study offers a more thorough comprehension of how a particular energy security issue interacts with a variety of financial growth aspects. With an emphasis on the US economy, a key player in international energy and financial markets, this study offers a deeper understanding that may have wider ramifications, particularly for other developed nations, amid a time of heightened geopolitical unrest, environmental difficulties, and the pressing need for energy transitions. Furthermore, the application of Wavelet Quantile Correlation as our methodological framework also enables us to capture the dynamic and non-linear interactions between energy security risks and financial development across different time zones and quantiles. This advanced econometric allows a more interesting approach and refined analysis, revealing the way these relationships evolve with time and under changing market conditions. The findings can help decision making in identifying weaknesses and develop focused risk management strategies by examining how fluctuations in energy security, such as geopolitical or economic concerns, affect financial indicators like investment stability and market confidence. This understanding helps to create balanced policies that support sustainable growth, guarantees that investments are made in resilient infrastructure and technology, and informs decisions regarding the distribution of resources and investment priorities. It also facilitates efficient scenario planning and readiness for increasing environmental challenges, resulting in stronger and more flexible economic systems.

## 2. Literature Review

### 2.1. Theoretical linkage

The relationship between energy security and financial development is complex, yet crucial for understanding how economies can grow and remain stable. Energy security ensures a stable and reliable energy supply, vital for sustaining economic activities and attracting investment (Cherp et al., 2012). When a country has a secure energy supply, businesses can operate smoothly, investors feel confident, and the economy can grow without significant disruptions (Le & Nguyen, 2019). A stable and reliable energy supply allows businesses to operate efficiently, which in turn attracts investment and promotes economic growth. When businesses know they can rely on a steady energy supply, they are more likely to invest in expansion, innovation, and new technologies. This drives financial development by creating a need for more sophisticated financial products, thereby attracting loans, investment funds, and insurance (Uduma et al., 2010). Moreover, improved energy security can develop financial stability, creating a feedback loop (Blum & Legey, 2012). When a country invests in energy infrastructure, diversifies its energy sources, and implements effective energy policies, it stabilizes energy security. This, in turn, creates a stable environment for businesses to operate and invest, which attracts financial advancements. This virtuous cycle is more evident in advanced economies, where technological advancements in energy production have significantly improved energy security. Innovations such as fracking and renewable energy technologies have assisted these economies to be made less dependent on foreign energy sources and more resilient to supply disruptions (Jaffe, 2021). At the same time, the sophisticated financial markets provide advanced hedging instruments that allow businesses to manage energy price volatility effectively. This interplay between energy security and financial development ensures long-term economic stability and growth (Jarrett et al., 2019).

However, when energy security is threatened, it can have a significant negative impact on financial development and economic stability (Banna et al., 2023). In economies with poor energy security and underdeveloped financial markets, the risks can reinforce each other, creating a cycle of insecurity (Cherp et al., 2012). When a country lacks a stable energy supply, it can struggle to attract investment, which hinders financial development. Without a developed financial sector, it may be difficult to fund the energy infrastructure needed to improve energy security (Mineh & Yang, 2018). Governments facing energy insecurity also often spend heavily on subsidies or infrastructure to stabilize the situation. While these measures may be necessary to ensure a reliable energy supply, they can strain public finances (Brown & Sovacool, 2011). When a government diverts large amounts of money to energy subsidies or infrastructure, it may have less to invest in other areas, such as financial sector development. This can limit the growth of financial markets and hinder overall economic development (Bhattacharya et al., 2015). This can further worsen the existing energy insecurity and financial underdevelopment. However, with proper management, even in these challenging situations, there can be opportunities for growth and innovation. High energy risks can sometimes act as a catalyst for change, prompting investment in alternative energy technologies and more sophisticated financial instruments for risk management (Hoang et al., 2021). Effective policy responses and energy sector reforms driven by these risks can enhance financial stability and spur economic growth (Zhuang et al., 2009). While energy insecurity can pose significant challenges to financial development, it can also create opportunities for innovation and growth. Thus, understanding and addressing energy security challenges can be key to unlocking financial development and long-term economic stability.

### 2.2. Empirical Studies

To ensure long-term economic upgradation, the energy sector plays a pivotal role, impacting every facet of society from economic stability to government resilience. Achieving energy security is not just a matter of supply; it requires a holistic approach that considers institutional frameworks, environmental sustainability, and behavioral dynamics. Financial conditions are equally critical, as the modernization and maintenance of energy infrastructure necessitate continuous investment in cutting-edge technologies, new equipment, and forward-looking research and development (Pimonenko et al., 2022). Hence, stable energy sources are essential for a country’s economic growth, public services, and overall safety, making them a key part of national security. To reduce energy security risks, several factors need to be studied that could mitigate the energy security risk (Billah et al., 2019). In this regard, Chen et al. (2024) used a cross-sectional augmented autoregressive distributed lag model to analyze how natural resource profits, financial development, and the quality of institutions affect energy security risks. From the results, it was observed that in the long run, earnings from natural resources, financial growth, and strong institutions like good governance and low corruption, could help in the reduction of energy security risks. In the short run, only financial development was found to affect the energy security. Additionally, while factors like GDP and trade can increase energy security risks, advancements in ICT can help lower these risks over time. In this regard, Doğan et al. (2023), while evaluating the energy security effect on environmental assessment in newly industrialized countries using common correlated effects mean group estimation approached, found that insecurity in energy results in more carbon emissions, while environmental quality was found to be negatively affected by the technological innovations, and financial development since, during economic uncertainty, or financial crisis, there are chances of more emissions due to reliance on cheaper non-renewable energy resources.

A stable environment for businesses to operate and invest attracts financial advancements. Stability in financial development results in enhanced investments (Hermes & Lensink., 2003) and economic efficiency by encouraging entrepreneurship and boosting innovations (Qamruzzaman & Jianguo., 2018). In support of that context, Le and Nguyen. (2019) highlighted the effect of energy security on growth by observing panel data from 2002 -2013 of 74 countries using the Cobb-Douglas function. From the results, it was found that reliable energy security enhances economic growth across various countries thus financial development, regardless of their income level. Energy insecurity reflected by high energy use relative to economic output and increased carbon emissions dampens economic growth. The impact of energy security on growth varies by region and income level but is consistently positive. Another study by Lee et al. (2022a) studied the factor of income inequality in terms of energy security and financial development. For this purpose, they collected the data from 68 countries (2001 to 2018). The results depicted that energy security affects financial development by influencing income inequality and economic growth. In early development stages, poor energy security can worsen income inequality, creating instability that hinders financial development. As countries develop energy security, improvement in income distribution occurs, with enhanced financial development benefits, and with more people accessing financial services. Additionally, past income inequality exacerbates financial challenges in less developed countries but has less impact in more developed ones.

Financial development can affect the energy sector since, it is a foundation for growth in terms in terms of national, economic, and social stability (Majeed & Mazhar 2019). Feng et al. (2023) conducted a study on 60 countries to determine how financial development can affect energy security. For this purpose, they utilized the functional data analysis technique to analyze the data collected over a period of 1995 to 2019 and observed a different pattern of the impact of financial development on energy security. The impact was found to be improving from 2010 to 2015, while a negative impact was observed from 2013 to 2017. However, the impact was found to be determined by the region and economic stability of the region, with more pronounced effects in America, Europe, and Asia Pacific while less effect in middle-income and developing countries.

Shifting to renewable energy contributes significantly to financial development by increasing firms stability (Kassi, 2020), attracting global capital by allowing global investors to increase foreign direct investment (Sarkodie et al., 2020), and reducing dependency on fossil fuels (Holechek et al., 2022) which can decrease the financial risks associated with economic instability (Cheng & Wu 2024). So, to determine whether shifting to renewable energy affects energy security, (Aslam et al., 2023), conducted a panel study on 41 countries that are involved in the Belt and Road Initiative BRI. The data for this study was taken from a period of 1995 to 2018. From the results, they found that shifting the economy toward renewable energy contributes significantly to reducing the energy security risk and makes the economy more secure in terms of energy supply. Thus, they suggested that BRI countries should focus on policies that increase investment in renewable energy and reduce reliance on non-renewable energy which can reduce their energy security risks in the long term.

Similarly, Anton and Nucu (2020) determined the effect of renewable energy consumption through financial development and hence the impacts on energy security by studying 28 EU countries from 1990 to 2015. The results were analyzed through the panel fixed effects model and found that financial development positively impacts renewable energy consumption across three dimensions: the banking sector, bond market, and capital market. This means that as these financial sectors grow, they support increased use of renewable energy, which enhances energy security as mentioned by (Ainou et al., 2023). However, in new EU Member States, capital market development does not affect renewable energy consumption. So, while financial development generally boosts renewable energy use, its impact varies depending on the specific financial sector and regional context.

On the other hand, Sadorsky, (2011) also studied the same effect in Central and Eastern Europe. The results of the study revealed that financial development, particularly through the banking sector, positively impacts energy consumption. As banking grows, energy consumption increases, which can influence energy security by potentially leading to higher energy demand. While stock market variables have a less consistent impact, stock market turnover significantly boosts energy consumption. Understanding these relationships could balance financial growth with energy security, ensuring that increased consumption does not compromise energy stability and sustainability.

Information and communication technology (ICT) is another factor that affects financial development by making online financial services accessible (Alshubiri et al., 2019), and making the financial markets more efficient through automated processes (Nabi et al., 2023). ICT also affects energy security. Lee et al. (2022b) conducted a panel study on 66 countries. The data was collected from 1996 to 2019. From the results, an influencing impact of ICT was observed on energy security through the moderating effect of financial development through technological advancements. However, generally, a negative impact on energy security is observed by ICT. Additionally, no effect of ICT was observed on energy security through the moderating role of human capital (skills and Knowledge). In cases of low economic risk, improvement in energy security was observed by ICT but in cases of increased economic risk beyond the threshold level, no significant positive impact was observed on energy security through ICT. Moreover, an upward trend was observed with the fluctuating effect of ICT on energy security.

Similarly, Lee et al. (2022a) also studied the role of financial development and energy nexus. For this purpose, they conducted a study on 30 Chinese provinces. By observing the results obtained from 2000 to 2018 by using the fixed effect model, they found that financial development and technological innovation significantly enhance energy security in China. Financial development, such as improved access to funding and financial services, primarily boosts energy security by encouraging technological advancements like new energy technologies. According to Zhang et al., 2022, these innovations help ensure a more reliable energy supply. However, the impact of financial development on energy security is not uniform across regions. Coastal areas and regions with lower capital experience different levels of technological innovation, which affects how much financial development can improve their energy security. This highlights the need for region-specific strategies to enhance energy security through financial and technological improvements.

Wang et al. (2022) explored a panel study on different newly industrialized countries and analyzed the data yearly data using the CS-ARDL model. The data was collected from 2000 to 2018 and observed the impact of technological advancements on energy security in the understudied economies within this time frame. It was observed that with the advancements in technology, the risks related to energy security lowered in the long run. However, the uncertainty in global and economic instability increased energy security risk. In contrast, financial development and globalization were found to have a negative effect on energy security, possibly due to greater exposure to global market fluctuations. A bidirectional relationship between these factors was found which suggested that improvements in one area could affect the others. So, focus on technology is necessary while managing the risks from global uncertainty and economic factors (Iriani et al., 2024).

Apart from advancements, the role of digitalization in maintaining energy security was determined by Wang & Ullah., (2024). They conducted a panel study on a group of most energy-consuming countries and collected their data from 2003 to 2021. The data was analyzed through GMM estimates and found that energy security has a negative effect by the ICT in developed countries, however, the environmental trade and financial development were found to have a reduced effect on the risks associated with energy security in both types of economies with mitigating effect of ICT, GDP and carbon emissions along with the production of renewable energy. So, for a stable energy future, financial institutions, businesses, and governments should work in collaboration.

Since immense actions are being taken the reduce dependence on fossil fuels, for clean energy production, the need for energy security is quite evident due to the increasing energy crisis and financial development can maintain energy security (Kanwal et al., 2022). Hence, Kartal et al. (2024), analyzed the association between the two understudied variables by using the cross-quantilogram approach. For this purpose, they conducted a study on the Korean economy, which is heavily dependent on fossil fuels, throughout 1980 to 2018. From the results, they identified that, the financial health of a country can be a good indicator of a secure energy supply. The financial markets like stock markets, were also observed to have a greater impact on energy security risk than financial institutions. The impact was observed to be dependent on the economic conditions (or quantile).

In conclusion, growth theory emphasizes the importance of the energy sector for future development and stability. To ensure proficient energy security, it is essential to address institutional, environmental, and behavioral factors, along with financial conditions. Investments in new technologies and infrastructure are vital for maintaining and modernizing energy systems. Studies reveal that financial development enhances investments and economic efficiency, boosting energy security by promoting renewable energy and technological advancements. However, the impact of energy security on financial development varies by sectors and level of advancements. Overall, a coordinated approach in adapting energy management to curtail energy insecurity is pertinent with the coordination of financial institutions, governments, and technological innovation for safeguarding long term financial sustainability.

## 3. **Materials and Methods**

In this section, the data description, their sources, and methodological framework will be discussed in detail.

### ***3.1 Data Description and Sources***

The present study considers the annual data from 1970 to 2020 for the USA. The study aims to enumerate the quantile-dependent association between energy security risk and its sub-indices with various financial development indicators in the USA. The secondary data points of energy security risk (ESR) have been obtained from the Global Energy Institute's online source. This index is constructed with the help of four sub-indices, i.e., geopolitical (GEPR), economic (ECOR), environmental (ENVR), and reliability risk (RELR). The four sub-indices are formulated using 29 metrics encompassing various aspects of energy security risk, including energy production capacity, supply, operations, energy consumption, and emissions. These sub-indices are then aggregated using their respective weights to create a comprehensive energy security risk index. The energy security risk index aims to improve our comprehension of the fluctuations in energy security risk inside a country and the variations in energy security risk compared to other countries (Iyke.,2024). Similarly, the explanatory variable financial development is measured through the USA's banking and stock market sectors. In the banking sector, deposit money bank assets (DMBA), liquid liabilities (LQLI), private credit by deposit money banks (PCDB), and domestic credit to the private sector (DCPS) are included. Deposit money bank assets can be explained as total assets held by deposit money banks as a share of GDP. Assets include claims on the domestic real nonfinancial sector, which includes central, state, and local governments, nonfinancial public enterprises, and the private sector. Deposit money banks comprise commercial banks and other financial institutions that accept transferable deposits, such as demand deposits. Liquid liabilities are defined as the Ratio of liquid liabilities to GDP. Liquid liabilities are also known as broad money or M3. They are the sum of currency and deposits in the central bank (M0), plus transferable deposits and electronic currency (M1), plus time and savings deposits, foreign currency transferable deposits, certificates of deposit, and securities repurchase agreements (M2), plus traveler’s checks, foreign currency time deposits, commercial paper, and shares of mutual funds or market funds held by residents. Similarly, private credit by deposit money banks is Private credit by deposit money banks and other financial institutions to GDP. Lastly, domestic credit to the private sector refers to financial resources provided to the private sector. Moreover, stock market capitalization (SMCA-total value of all listed shares in a stock market as a percentage of GDP), stock market total value added (SMVT-total value of all traded shares in a stock market exchange as a percentage of

GDP), and stock market turnover (SMTO-Total value of shares traded during the period divided by the average market capitalization for the period) is taken under the caption of the banking sector. This segmentation of the financial development indicators is consistent with the study of Chiu & Lee (2020). Data related to all financial development sectors are retrieved from the web source of Global Financial Development.

### *3.2 Method*

The novel methodology of Wavelet Quantile Correlation (WQC) is deployed for formal empirical analysis. The background of the WQC is based on the quantile correlations formally introduced by Kumar & Padakandla (2022). The quantile correlation estimator was mathematically proposed by Li et al. (2015) and Percival & Walden (2006), and WQC is the extended version of these estimators. The potential benefits are associated with the WQC framework in analyzing the connectedness of time series variables. For instance, it offers to capture the association between the variables on the time scale and over various quantile frequencies (Kumar & Padakandla., 2022). Similarly, at various time dimensions, this innovative model allows for the capture of the tail structure dependence of the variables. Further, the asymmetric behavior and possible presence of outliers are well-captured by distributing the outliers into different quantiles. Due to its exceptional data handling, this technique is also called a semi/nonparametric technique and has become a widely acknowledged framework among economic and financial academicians (Chishti et al.,2023). The partial wavelet correlations are calculated by the following;

$$\rho\widehat{(x,y)} = \frac{COV(\widetilde{\widetilde{Z}}y,jt,\widetilde{\widetilde{Z}}y,jt)}{\sqrt{VAR(\widetilde{\widetilde{Z}}y,jt),VAR(\widetilde{\widetilde{Z}}y,jt)}} \qquad (1)$$

Where the L.H.S $\rho(x,y)$ is referred to as an unbiased estimator of the coherence between energy security, geopolitical, economic, reliability, and environmental risks with financial development $\widetilde{\widetilde{Z}}\,y,jt$ .

## 4. Results and Discussion

The analysis is started to analyze the initial characteristics of the variables by retrieving the descriptive statistics (**Table 1**). The summary includes mean, skewness, kurtosis, standard deviation, and Jarque-Bera test. On average, the stock market variables are exposed to more extremes than the banking sector. The variables associated with risks hold asymmetric, while negatively skewed behavior of financial development is observed in analyzing the skewness and kurtosis. Among the sub-indices of the USA, the economic risk is riskier with a high standard deviation (3.033) than aggregate energy security risk (1.973). Moreover, the stock market sector is exposed to more risk than the banking sector in the USA. The J-B statistics of all variables are highly significant, indicating the non-normal attitudes of selected time series variables.

| **Table 1: Outcomes of Descriptive Statistics** | | | | | |
|---|---|---|---|---|---|
| **Variables** | **Mean** | **Skewness** | **Kurtosis** | **Std. Dev.** | **J-B Stats** |
| ENSR | 21.133 | 0.381 | -0.892 | 1.973 | 13.404*** |

| | | | | | |
|---|---|---|---|---|---|
| GEPR | 20.912 | 0.272 | -1.043 | 2.192 | 15.707*** |
| ECOR | 18.8471 | 0.591 | -0.830 | 3.033 | 14.351*** |
| RELR | 22.037 | 0.639 | -0.073 | 2.432 | 21.937*** |
| ENVR | 23.990 | -0.453 | -0.583 | 2.064 | 21.479*** |
| DMBA | 15.394 | -0.280 | -1.142 | 1.180 | 31.002*** |
| LQLI | 17.506 | -0.375 | -0.678 | 1.159 | 22.282*** |
| PCDB | 34.542 | 0.095 | -1.678 | 9.895 | 15.903*** |
| DCPS | 34.655 | 0.120 | -1.642 | 10.046 | 13.338*** |
| SMCA | 22.346 | 0.244 | -1.557 | 10.890 | 15.539*** |
| SMVT | 27.322 | 0.536 | -1.131 | 24.336 | 15.028*** |
| SMTO | 25.233 | 1.527 | 3.392 | 19.303 | 40.906*** |
| Note: The asterisk ***, **, and * represent significance levels at 1%, 5%, and 10% respectively. | | | | | |

**Table 2** presents the correlations of all variables. A positive correlation has been observed between ESR and DMBA, LDLI, SMVT, and SMTO. Similarly, the correlation becomes negative with PCDB, DCPS, and SMCA. Hence, the simple correlation provides a mix of outcomes related to the associations of financial development with energy security risk. The correlation between geopolitical risk and financial development also turned positive for DMBA, LDLI, SMVT, and SMTO, and negative for PCDB, DCPS, and SMCA. Further, the economic risk is positively related to all financial development indicators except SMCA. The reliability risk is connected with positive correlations for all financial development indicators. Lastly, environmental risk is negatively associated with LQLI, PCDB, DCPS, SMCA, SMVT, and SMTO, while a positive association is observed with DMBA.

| **Table 2: Outcomes of Correlations** | | | | | |
|---|---|---|---|---|---|
| Variables | ENSR | GEPR | ECOR | RELR | ENVR |
| DMBA | 0.378 | 0.423 | 0.375 | 0.185 | 0.089 |
| LQLI | 0.124 | 0.240 | 0.288 | 0.133 | -0.578 |
| PCDB | -0.016 | -0.028 | 0.073 | 0.304 | -0.546 |
| DCPS | -0.005 | -0.018 | 0.080 | 0.310 | -0.533 |
| SMCA | -0.203 | -0.230 | -0.127 | 0.142 | -0.487 |
| SMVT | 0.191 | 0.170 | 0.243 | 0.478 | -0.452 |
| SMTO | 0.307 | 0.313 | 0.355 | 0.513 | -0.416 |

**Figure 1 (i-iv)** depicts the quantile correlations between energy security risk and financial development. The banking sector indicators are used in these figures to explore the possible association between energy security risk and financial development. The x-axis of the graph presents the quantiles of financial development defined as low (bearish), middle (normal), and high (bullish) quantiles. The y-axis cracks the quantiles into three-time measures, i.e., 1970-1976, 1977-1990, and 1991-2019. These time measures about corresponding quantiles are termed short, medium, and long-run associations between the variables. Further, the strength of the relationship is portrayed by the color bar on the right side of each graph. Out of many colors, the jet-black color presents negative quantile-based correlations, while the deep yellow color signifies positive associations between two variables.

The left-corner **Figure 1(i)** has been drawn to explain the association between deposit money bank assets and energy security risk. The graph depicts the accelerating impact of ENSR on DMBA from short to medium and long run. Observing the effects of energy security risk on the bearish condition of deposit money bank assets, the positive correlation pertains from the short to medium and long run. It shows that when market conditions are not good, the energy security risk helps to stabilize the energy sector and reduce the bank defaults in the USA. Similarly, reliable energy security can act as a safeguard, reducing the impact of losses and maintaining the value of banking assets. Further, when the market condition is normal (middle quantiles), the positive correlation is evident in short and medium runs. However, the energy security risk does not impact deposit money bank assets in the long run. In the short run, no correlation is evident in the bullish scenario, while from the medium to long run, a positive correlation is observed between ENSR and DMBA. This outcome has several implications in the context of the USA. For instance, solid energy security enhances economic development, causes corporate profits to increase, and amends the features of banking assets. Also, in extreme market conditions, the positive correlations between energy security risk and deposit money bank assets reduce the risk of default in banking sectors. It escalates the investors' confidence and provides a diversification arena for investors. **Figure 1 (ii)** illustrates the quantile correlations between LQLI and ENSR. In the short and medium run, a negative correlation is observed between the bearish and bullish conditional quantiles of LQLI and ENSR. This outcome has several implications. For instance, in the bearish market, the hedging risk is managed by increasing the liquid liabilities of the banks. Similarly, the asset companies grasp more liquid assets, so the volatility in the energy sector may be reduced. On the other hand, in the bullish market, the positive market tendencies provide hedging assets by protecting energy security issues. This may also open more venues for investors in terms of diversification. Conversely, in the long run, the correlation is not evident in bearish and normal conditions. At the same time, a negative and low to moderate association is observed between LQLI and ENS at extreme quantiles. This graph also depicts the relationship between LQLI and ENSR in several dimensions. The fluctuations in the escalating impact of energy security risk on liquidity at various quantiles acknowledge the asymmetric relationship. **Figure 1 (iii)** depicts the overall negative association between PCDB and ENSR. In the short run, the negative correlations are evident at all quantiles of private credit by deposit money banks; however, the connection is somehow weak. The maximum value of connectedness reaches -0.15. In the short run, this association may result from reduced credit demand, Snugger banking lending rules, and a reduction in risk premium. Low to high correlations are observed in bearish and normal market conditions in the medium run. Looking at the long-run dynamics, the negative correlations are observed in stable and bearish market conditions, and at extreme market conditions, the correlation possesses an eliminating effect. The USA's structural and economic financial flows may result in a persisting negative impact of private credit by deposit money banks with long and medium-run energy security risks. **Figure 1 (iv)** has been presented to investigate the quantile-dependent associations between DCPS and ENSR. Overall, negative correlations have been observed between domestic credit to the private sector and energy security risk. In the short run, harmful and accelerating connectedness is observed at bearish, stable, and bullish market conditions. It can be seen that moving from lower to higher quantiles, the energy security risk obtained has an escalating impact on domestic credit to the private sector. In the medium run, the negative but decreasing impact pertains to bearish and average market conditions. However, this impact diminishes in the bullish market scenario. Similarly, in the long run, the bearish market condition of domestic credit to the private sector possesses a decreasing effect on energy security risk, and this impact is retained in stable and extreme quantiles. The bullish quantiles indicate the asymmetric and eliminating effect with oscillating correlations. These outcomes are consistent with the study of Kartal et al. (2024), who examined the same association between energy security risk and financial development in South Korea.

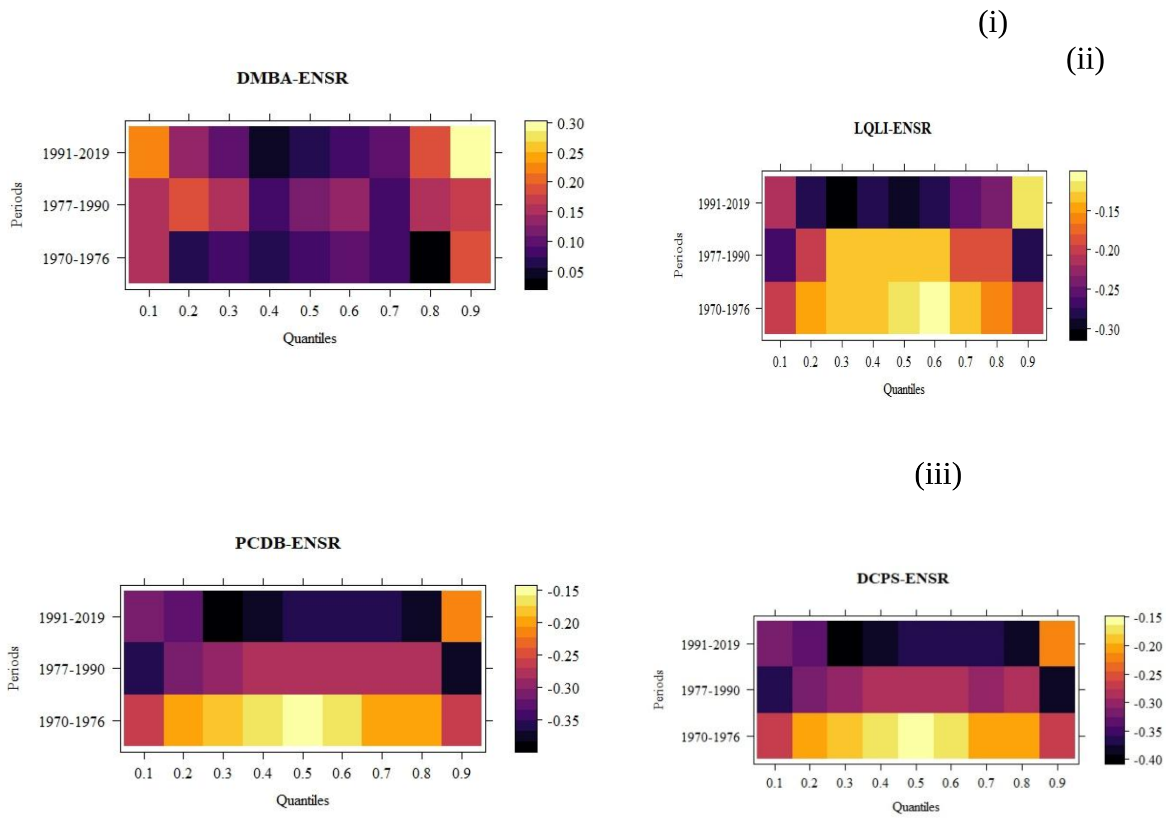
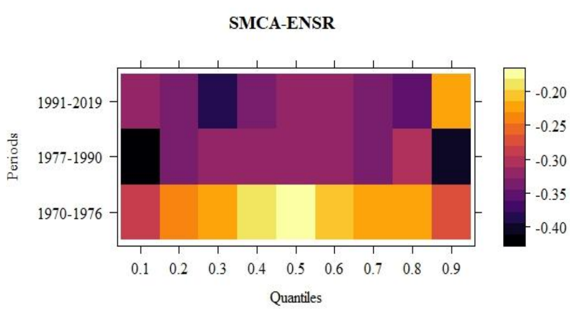



Figure 1: Quantile Correlations between Energy Security Risk and Financial Development (Banking Sector)

**Figure 2** explores the association between stock market indicators and energy security risk. The top left corner of **Figure 2 (i)** depicts the correlations between SMCA-ENSR. The graph's color bar scheme highlights the negative correlations, indicating the negative association between the total value of all listed shares in a stock market as a percentage of GDP and energy security risk. In the short run, the correlations increase from lower to higher quantiles. It means that connectedness between the variables from bearish (low) to the bullish (high) scenario, the relationship tied in grip. The situation has drastically changed in the medium run as the impact of energy security risk is eliminated in bearish and bullish conditions. In contrast, some connections are evident in medium quantiles. Similarly, in the long run, negative and low correlations are apparent in all market conditions. **Figure 2 (ii)** depicts the positive and non-linear association between SMVT and ENSR. In the short run, the impact of energy security risk is moderate to low at bearish quantiles. In contrast, in medium and bullish quantiles, the energy security risk is not associated with the stock market total value added. This means that energy stocks are traded separately when the market conditions are good. In the medium run, the association is strengthened by observing the increasing impact from low to higher quantiles. In the bearish market condition, the relationship between the stock market total value added and energy security risk is comparatively low compared to the other market scenarios. Conversely, the association attains strength in bearish, stable, and bullish market conditions in the long run. The maximum value of correlations reaches 0.4 in the extreme market condition of the stock market total value added. **Figure 2 (iii)** portrays the correlations between SMTO-ENSR. Similar to the stock market total value added, a positive association is observed between the total value of shares traded during the period divided by the average market capitalization for the period and energy security risk. In the short run, moderate correlations are observed that vanish in medium quantiles. However, the connection becomes stronger at bullish conditions. In the medium run, an escalating impact is observed in the bearish to bullish market conditions. At lower quantiles in the medium run, the maximum correlation of 0.46 is observed, which underlies various implications of the total value of shares traded during the period divided by the average market capitalization and energy security risk. In the long run, a positive and increasing impact has been observed between the variables at all market conditions.

(i)

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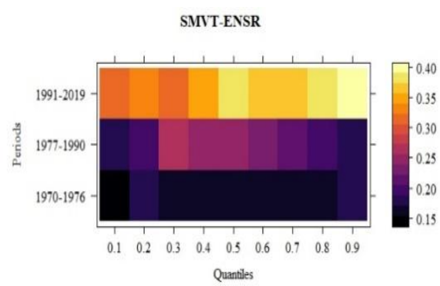


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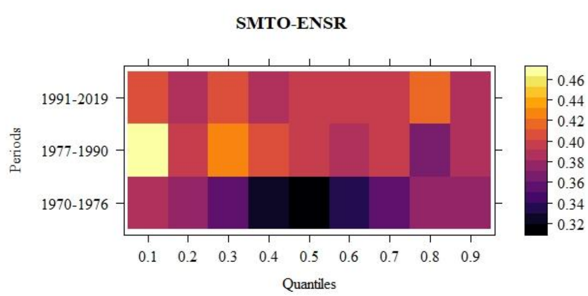
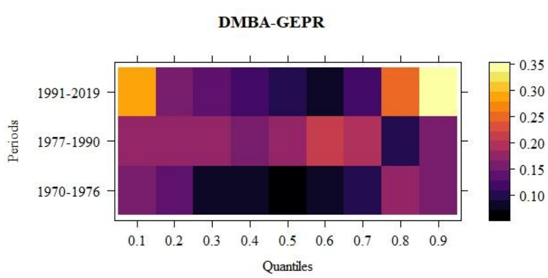


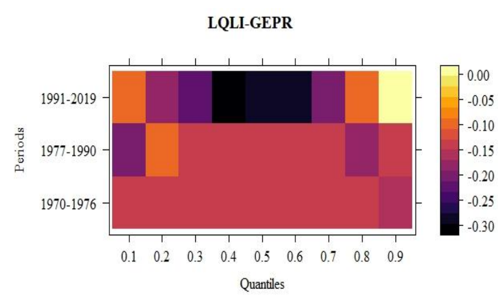

Figure 2: Quantile Correlations between Energy Security Risk and Financial Development (Stock Market Sector)

**Figure 3 (i-iv)** depicts the quantile correlations between geopolitical risk and financial development. This graph is plotted for the four banking sector indicators of the USA. The top left of **Figure 3 (i)** shows the possible correlations between DMBA and GEPR. The associations between the variables are observed, and positive connectedness is observed between them. Statistically, it indicates that with the increase in geopolitical risk, the deposit money bank assets also increase, and vice versa. In the short run, positive correlations are observed, and this pattern is everlasting till the bearish market scenario. Likewise, low to moderate correlation is observed in all market conditions in the medium run.  In the long run, a positive correlation is observed in the bearish market scenario. However, this connection increases to high correlations in bullish market conditions. It shows that in the long run, the relationship between geopolitical risk and the deposit money bank assets becomes strong during good market conditions. **Figure 3 (ii)** reveals the negative correlations between LQLI-GEPR. Moving from the low (bearish) to high (bullish) quantiles, the improved negative correlations are observed in the short and medium run. Similarly, in the long run, the impact is negative and accelerating in the bearish market scenario, while it vanishes in the bullish condition.  **Figure 3 (iii)** shows the negative and increasing effects of geopolitical risk on private credit by deposit money banks. Observing deeply, in the short run, the connectedness of PCDB-GEPR is improving from bearish to bullish market conditions. Meanwhile, the negative impact is also observed from lower to higher quantiles. The bullish market scenario shows negative associations in the long run. **Figure 3 (iv)** has been drawn to investigate the connectedness between DCPS-GEPR. Moderate and significant correlations between bearish (lower) and bullish (extreme) market conditions are evident. In the medium run, a negative association is observed at all quantiles. Similarly, in the long run, the bearish market condition strengthens the association between domestic credit to the private sector and geopolitical risk in the USA. This negative correlation aligns with the study by Lu et al. (2020) performed for emerging countries, which finds negative associations between geopolitical risks and financial development. Moreover, the asymmetric semiparametric association is also evident in the long run. The associated negative correlations between the financial development indicators and geopolitical risk in the USA are comprised of various reasons. For instance, with the increase in geopolitical risk, investors' confidence weakens, resulting in low financial development. Similarly, the rise in geopolitical risk causes an increase in economic uncertainty after the failure of financial planning. Lastly, financial institutions are more risk-averse in adverse geopolitical risk scenarios.

(i)

(ii)




(iii) (iv)

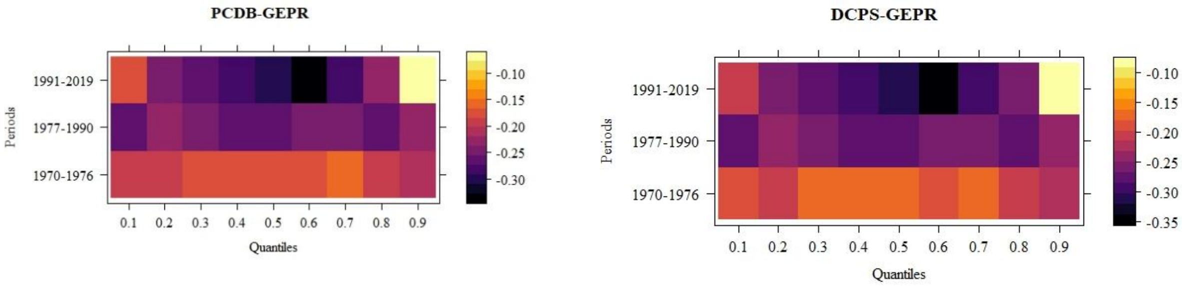
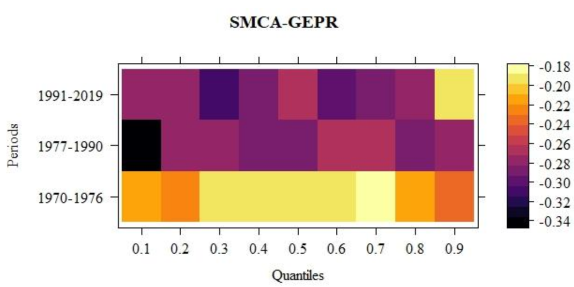
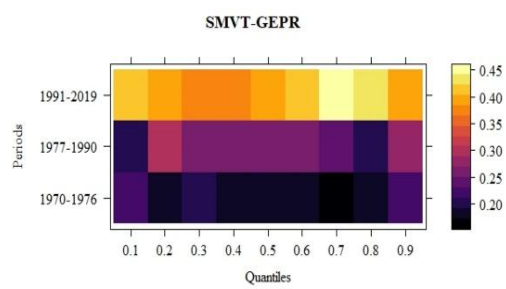



Figure 3: Quantile Correlations between Geopolitical Risk and Financial Development (Banking Sector)

**Figure 4 (i-iii)** has been plotted to explore the possible connectedness between stock market indicators and geopolitical risk in the USA. The top left graph **Figure 4 (i)** depicts the negative correlations between SMCA-GEPR. Out of all runs, the short-run association is more evident, possessing high values of correlations from lower to higher quantiles of the stock market as a percentage of GDP. In the long run, significant negative correlations are observed in the bullish market scenario. **Figure 4 (ii)** indicates the positive correlations between SMVT-GEPR. In this graph, the short and medium runs illustrate the non-linear behavior of the stock market total value added with the geopolitical risk in the USA. Unlike the short and medium run, a negative and significant association is observed in the long run. This strength of the relationship is evident in all quantiles, i.e., in all market conditions. **Figure 4 (iii)** presents the positive association between SMTO-GEPR. The graph shows that if the total value of shares traded during the period divided by the average market capitalization increases, then geopolitical risk also increases. This connectedness is evident in the short run (bearish condition), medium run (bearish and bullish conditions), and the long run (bearish conditions). Developed countries like the USA have several implications for these outcomes. Interestingly, it indicates that geopolitical risk is enhanced with the increase in the trading of shares that directly impact the country's economic growth.

(i)

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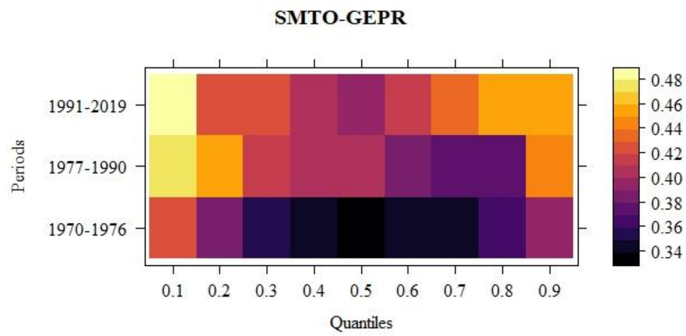



Figure 4: Quantile Correlations between Geopolitical Risk and Financial Development (Stock Market Sector)

**Figure 5 (i-iv)** illustrates the quantile-based wavelet correlations between economic risk and financial development in the USA. The banking sector, which represents the financial development of the USA, is used in these figures. Figure 5 (i) portrays the association between DMBA-ECOR and the color scale, pointing to the positive correlation between the two variables. Among various runs, only in the long run has the significant and escalating impact of economic risk been apparent. This association is also held when the deposit money bank assets are in bearish condition. The maximum correlation reaches 0.4, indicating that when economic risk increases, the deposit money bank assets also increase, specifically in good market conditions. This outcome is well-suited for the developed nations like the USA. **Figure 5 (ii)** depicts the connectedness between LQLI-ECOR. A negative correlation is observed in the short run between liquid liabilities and economic risk at several quantiles of LQLI. It asserts that in the short run, the economic risk decreases with the increase in liquid liabilities, and liquid liabilities will increase as the economic risk decreases. In the medium run, the non-linear impact of economic risk and liquid liabilities is observed from bearish to bullish scenarios as the correlation alters from negative to positive. Similarly, in the long run the bearish market condition portrays the positive and increasing impact of economic risk on liquid liabilities. These results are of utmost importance for investors to diversify their assets. In the long run, the investors can shift to long-term investment projects, increasing the country's financial development. **Figure 5 (iii)** has been plotted to depict the correlations between PCDB-ECOR. The graph observes the overall negative correlation; however, the dynamics of the connections is varied in various market conditions. In the short run, low to high correlations are observed moving from lower to higher quantiles. Under the bearish conditions of private credit by deposit money banks, the economic risk is negatively and significantly correlated with the economic risk. This situation is highlighted in the long run. These results have several implications in terms of the practical financial market. For example, the negative association, in the long run, increases the lending confidence of the banks. The higher the economic risk, the higher the private credit will tend to be. By reducing the economic risk, the default risk will be low; thus, private credit will also accelerate. Moreover, this negative association holds in the long run; thus, economic stability will be guaranteed in the USA. All these aspects will improve the financial development of the USA. Likewise, the other banking indicators, the DCPS, pose a negative connection with the economic risk (**Figure 5 (iv)**). Statistically, the negative association shows that with the increase in economic risk, the domestic credit to the private sector tends to decrease. In the short and long run, the minor negative impact of economic risk is evident. However, the correlation dimensions vary, portraying asymmetric associations between economic risk and domestic credit to the private sector. In the long run, the bearish market conditions support the negative connection of DCPS-ECOR. In conclusion, it can be seen that accelerating economic risk tends to decrease domestic credit for the private sector in the USA.

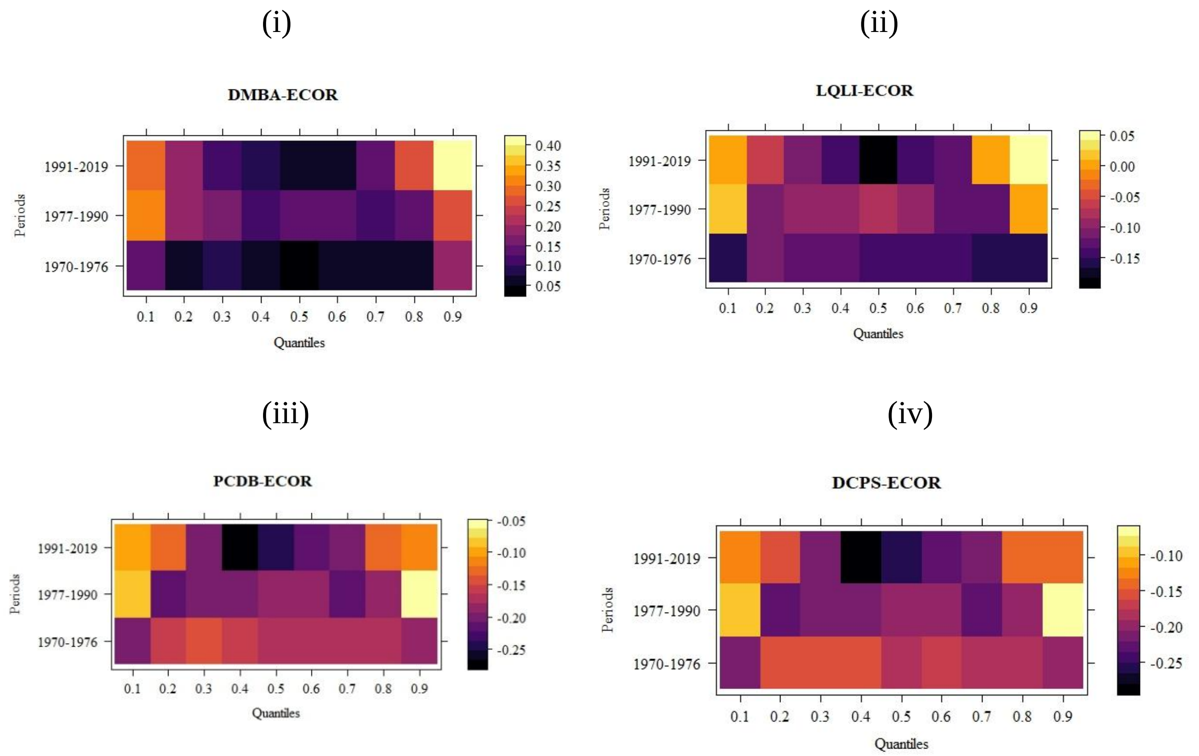



Figure 5: Quantile Correlations between Economic Risk and Financial Development (Banking Sector)

**Figure 6 (i-iii)** depicts the wavelet quantile correlations between stock market variables and economic risk. The negative association is evident at various quantiles of SMCA with economic risk in the USA (**Figure 6 (i)**). In the short run, the negative association depicts bearish, stable and extreme quantiles of the total value of all listed shares in a stock market as a percentage of GDP. The correlations are static across the various market conditions in the medium run. Similarly, in the long run, the correlation is evident with weak strength. Overall, the negative association shows that an increase in economic risk causes a decrease in the total value of all listed shares in a stock market as a percentage of GDP. This outcome indicates that investors will turn their attention to other asset portfolios that provide them more profit, and the market will need hedging assets. **Figure 6 (ii, iii)** shows the negative relationship between SMVT and SMTO with ECOR. It holds several interpretations. The negative association asserts that an increase in economic risk will cause a decrease in stock market total value added and stock market turnover. It holds specifically in the developed market of the USA because the economic risk will not attract investors to invest their wealth in the businesses of the respective country. Hence, increased economic risk causes a decrease in the financial development in the USA.

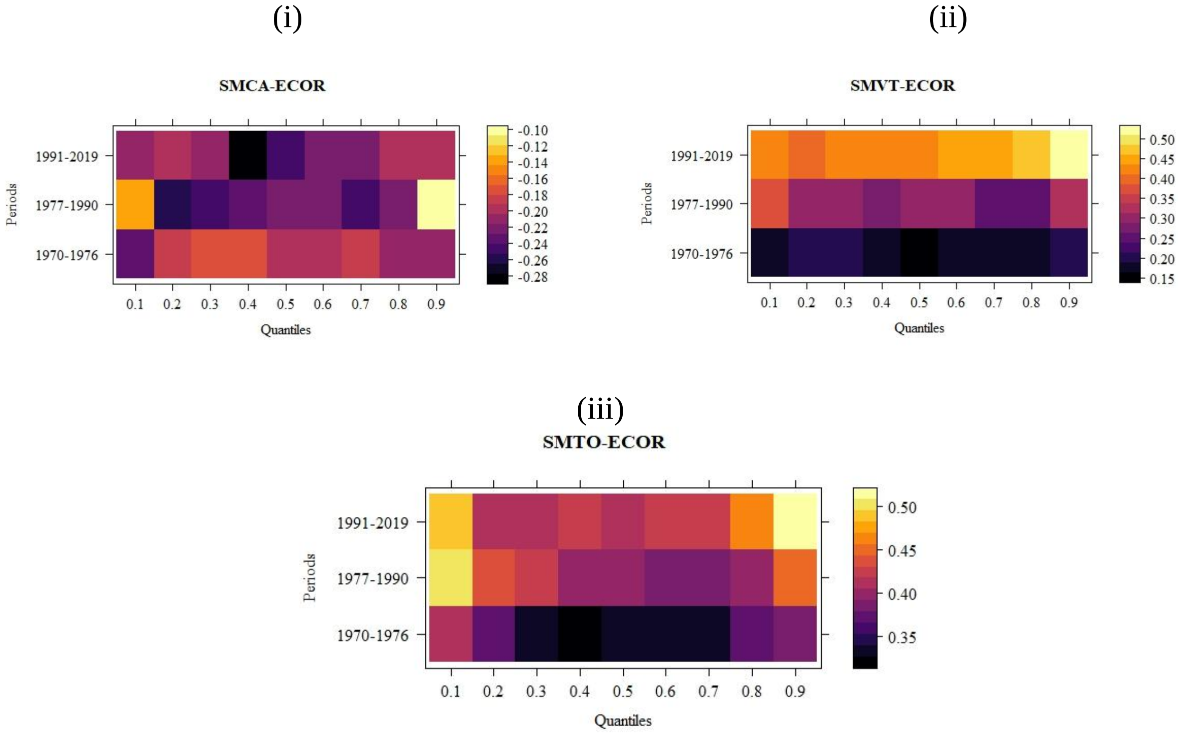
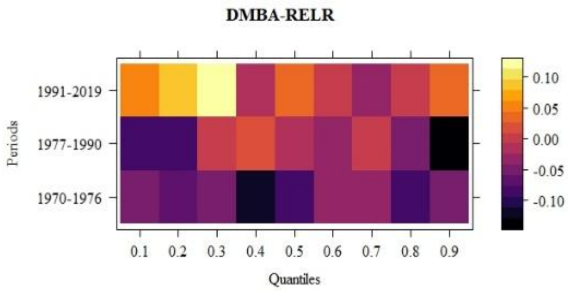


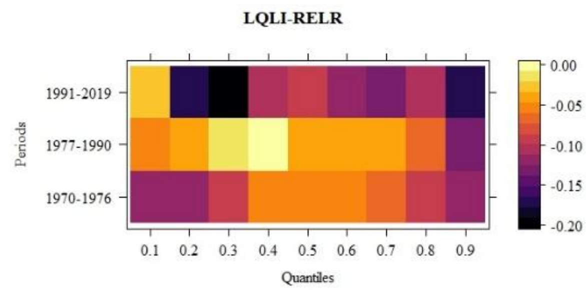

Figure 6: Quantile Correlations between Economic Risk and Financial Development (Stock Market Sector)

**Figure 7 (i-iv)** describes the wavelet quantile associations between financial development (banking sector variables) and reliability risks. Figure 7 (i) shows the increasing impact of reliability risk on deposit money bank assets in the short to long run. In the short and medium run, the negative correlation is possessed in bearish conditions. It shows that when the market condition is not good, the increasing reliability risk causes a decrease in the deposit money bank assets. In the long run, this association altered under bad market conditions (bearish) and found a positive association between DMBA-RELR. Similarly, positive to negative correlations are evident in the long run from bearish to bullish scenarios. These patterns strongly recommend the non-linear associations between financial development and reliability risks. **Figure 7 (ii)** portrays the negative association between LQLI-RELR. It asserts that an increase in liquid liabilities causes a decrease in the reliability risk and vice versa. Overall, the strength scale shows the color scheme from 0 to -0.20, indicating strong evidence of a negative relationship between liquid liabilities and reliability risk. This mechanism of increasing negative impact holds at various bearish and bullish conditions of liquid liabilities while moving from short to medium and long run. **Figures 7 (iii) and 7 (iv)** illustrate the negative associations between PCDB and DCPS with RELR. The negative connectedness shows that an increase in reliability risk causes a decrease in the deposit money banks and domestic credit to the private sector. Reliability risk is associated with the infrastructure and supply chain management of the country; the outcomes of our study are justified accordingly, and if investors are not satisfied with the country's reliability index, the financial projects will not be financed by foreign investors. Hence, reliability risk poses the adverse impact on the financial development of the USA.

(i)

(ii)

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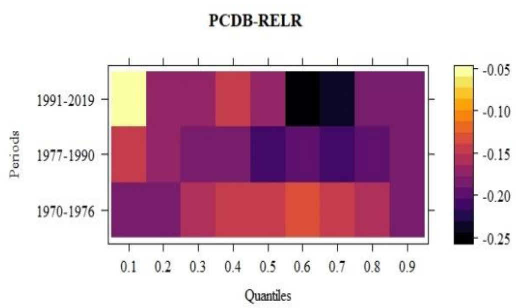


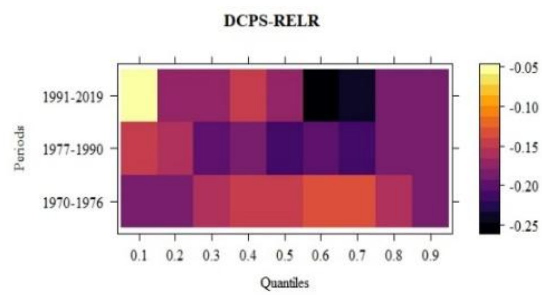
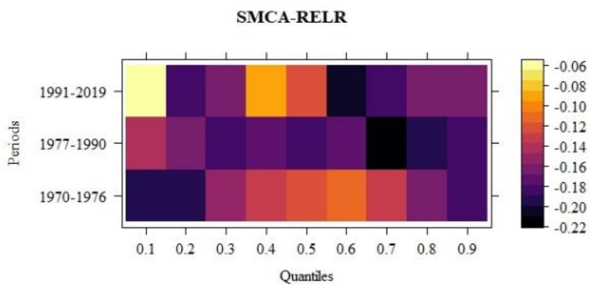




Figure 7: Quantile Correlations between Reliability Risk and Financial Development (Banking Sector)

**Figure 8 (i-iii)** expresses the correlations between stock market variables and reliability risk. A negative association is observed between SMCA-RELR (Figure 8(i)) in the short to medium and in the long run. However, the negative impact of SMCA is accelerating from bearish to bullish scenarios. In terms of the investor's point of view, this negative association asserts that accelerating reliability risk sets it apart from investment in local projects. Unlike SMCA, the escalating positive impact of reliability risk is predicted on SMVT and SMTO (**Figure 8 (ii, iii)**). It indicates that if reliability risk increases, the stock market activities also increase. For the USA, it can be predicted from the retrieved outcomes that fluctuations in reliability risk may not impact the investor's sentiments in the short to long runs. The reliability risk indicator does not merely damage the stock market investments in developed nations like the USA.

(i)

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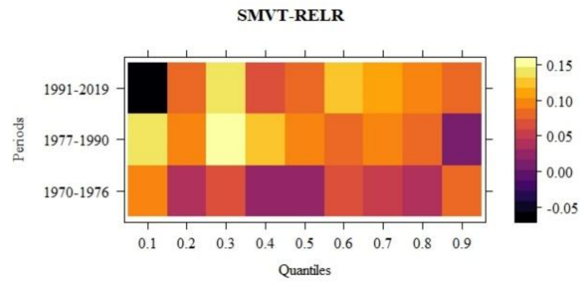


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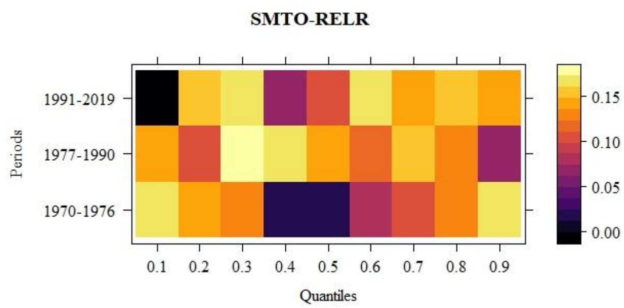
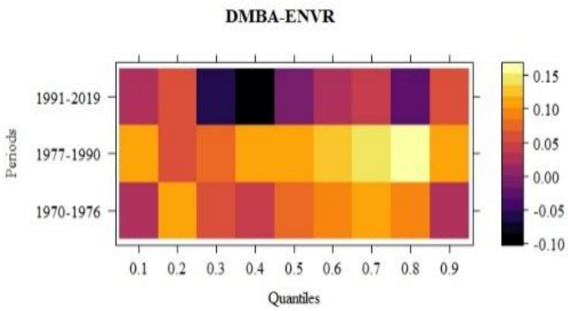



Figure 8: Quantile Correlations between Reliability Risk and Financial Development (Stock Market Sector)

**Figure 9 (i-iii)** depicts the wavelet quantile correlations between stock market variables and environmental risk. The top left **Figure 9 (i)** has been drawn between DMBA-ENVR. The escalating impact is depicted in the short to medium and long run at various market conditions. Observing the nature of the relationship, the positive association dominates more than negative correlations in the bearish to bullish market scenarios of DMBA. The result suggests that an increase in environmental risk, i.e., extreme changes in the policies or laws related to the ecology in the USA, cause an increase in the deposit money bank assets. On the contrary, the negative association is observed in the long run from bearish to bullish market scenarios. This variation in the positive and negative associations affirms the non-linear behavior of the variables. **Figure 9 (ii, iii, iv)** illustrates the negative association between LQLI, PCDB, and DCPS with ENVR. This association leads to the result that in the short run, from bearish to bullish conditions, the banking sector variables LQLI, PCDB, and DCPS are negatively associated with the ENVR. Overall, the outcomes show that an increase in environmental risk causes a decline in financial development in the USA, and an increase in financial development tends to decrease environmental risk. This relationship may arise because, in developed countries, the ecological rules are stringent, and financial markets are restricted from following them in the manufacturing and investment industries. This situation also increases investment opportunities as diversification is essential for financial investors.

(i)

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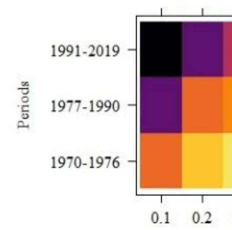


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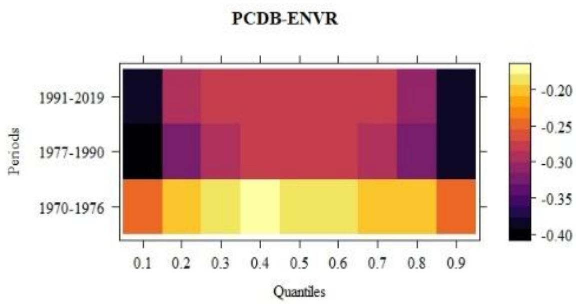


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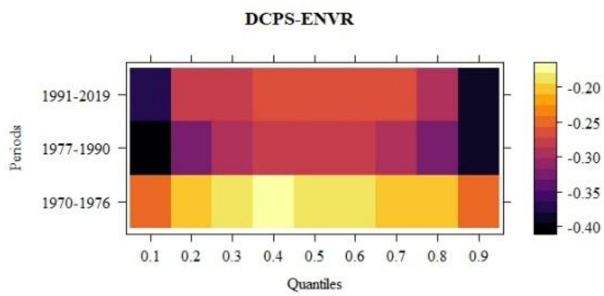
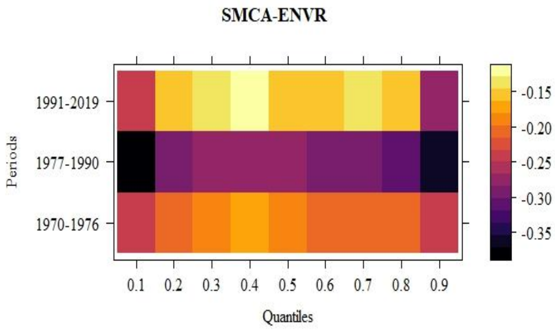



Figure 9: Quantile Correlations between Environmental Risk and Financial Development (Banking Sector)

**Figure 10 (i-iii)** presents the wavelet quantile correlations between stock market indicators and environmental risk. **Figure 10 (i)** depicts the negative correlations between stock market capitalization and environmental risk. Negative and persistent associations are observed from bearish to bullish quantiles in the short run. In the medium run, environmental risk does not impact the stock market capitalization in the USA. The negative and deep association is evident in the long run, specifically in stable and bullish market conditions. **Figure 10 (ii)** explains the relationship between SMVT-ENSR in the USA. Moving from the short to long run, the escalating impact of environmental risk is evident in the stock market value added. This positive impact shows that as the environmental risk increases, investors are more interested in trading activities. This situation encourages the investors to hedge their assets, and diversification of the asset is also implanted in the market. In the long run, the correlations are positive in bearish, stable, and bullish market conditions, indicating that environmental risk tends to increase stock market trading regardless of market conditions. Moreover, the non-linear behavior is also prominent in the figure as correlations are relatively posing the negative to positive associations depending on the market conditions. **Figure 10 (iii)** shows the positive association between stock market turnover and environmental risk. This outcome clarifies that in the USA, the escalating impact of environmental risk causes an increase in the stock market turnover. It also shows the positive involvement of the investors in the local stock market activities.

(i)

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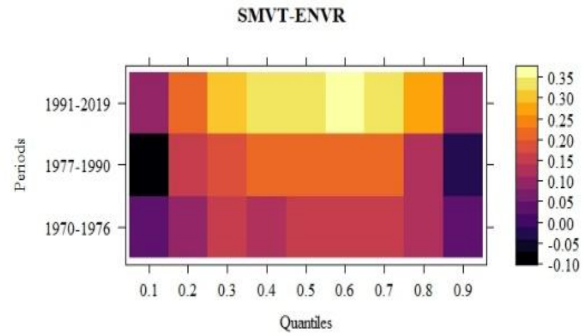


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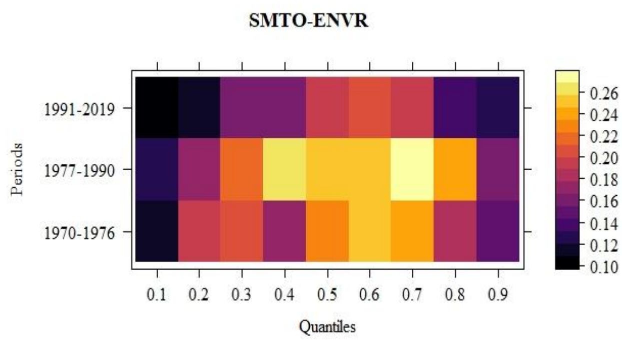


Figure 10: Quantile Correlations between Environmental Risk and Financial Development (Stock Market Sector)

## 5. Conclusions and Policy Suggestions

This section covers the brief results of the study with policy suggestions and future implications.

The study explores the quantile-dependent association between energy security risk and its sub-indices and financial development indicators. The USA case study was used to accomplish the required objectives, and annual time series data on the selected risk indices and financial development indicators were obtained. The data ranges from 1970-2020. For empirical analysis, the novel econometric framework of Wavelet Quantile Correlations (WQC) is utilized. The study results are discussed according to the banking and stock market sectors (used as financial development indicators) and their associated relationship with energy security risk and sub-indices. The key outcomes of the study are as follows. The quantile-dependent correlations between DMBA-ENSR are positive at various quantiles, while LQLI, PCDB, and DCPS negatively correlate with ENSR. DMBA, LQLI, PCDB, and DCPS are respective banking sector indicators. Further, the quantile-dependent association of energy security risk with the stock market indicators portrays the negative association with SMCA and SMVT. At the same time, SMTO appears to be positively associated with ENSR in various bearish, stable, and bullish market conditions. Moving to the quantile-dependent associations of financial development with geopolitical risk. The DMBA-GEPR is positive, while LQLI, PCDB, and DCPS correlate negatively with GEPR. Along with this, the quantile correlations of SMCA-GEPR are negative. However, SMVT and SMTO are positively associated with GEPR. Similarly, DMBA-ECOR has positive associations with bearish to bullish market conditions. On the contrary, the LQLI-ECOR depicts the positive and negative correlations in the short, medium, and long run corresponding to low and high quantiles. However, the non-linear behavior is evident in establishing the association. The PCDB-ECOR and DCPS-ECOR are negatively correlated overall. Regarding the stock market variables, the SMCA-ECOR appears hostile, while SMVT and SMTO correlate positively with ECOR. LQLI, PCDB, and DCPS are negative for reliability risk, while DMBA shows both associations at various epochs of run corresponding to each quantile. Moreover, the SMCA-RELR is negative, SMVT-RELR is both, and SMTO signifies only positive associations at multiple quantiles. Lastly, the association with ENVR at various quantiles of DMBA, LQLI, PCDB, and DCPS is positively and negatively associated. The stock market variables like SMCA-ENVR present negative, SMVT-ENVR possess negative and positive both, and SMTO-ENVR is positively associated with ENVR at bearish, stable, and bullish market conditions in the short, medium, and long run, respectively.

Given the above empirical outcomes, the following policy recommendations are suggested. First, it is vital to boost the resilience of the banking segment against energy security risks, especially in changing market conditions. In this regard, establishing risk management frameworks and encouraging banks towards portfolio diversifications could mitigate the adverse influence detected in both short and medium runs. This could include encouraging investments in green bonds, clean energy and renewable technologies, which can further facilitate long-term energy security. Overall, there is a need to encourage investments in green products such as green bonds and energy security-linked derivatives, to hedge against energy security risks and provide investment opportunities that align with energy security goals. Moreover, more specific measures are required, such as, establishing a devoted energy risk management unit in banks to focus exclusively on crafting and implementing strategies to assess and mitigate energy risks, supply disruptions and price volatility. Moreover, proper energy management measures, such as conducting scenario analysis and stress tests that specifically evaluate the impact of severe energy security crises on banks financial stability is needed to be emphasized in policy directives.

As for the capital markets, federal institutions should necessitate companies to disclose their exposure to energy security risks in their financial reporting, enabling investors to assess the potential impact on stock valuations, as well as companies' financial performance and strategic responses. Guidelines for revealing how businesses are mitigating these risks through their investment and operational strategies should also be included of this framework. To further enhance investor protection, there is a need to create a certification program for financial products that prioritize energy security and sustainability, making sure that these products adhere to strict risk management and environmental guidelines.

Moreover, regulations compelling financial institutions to include environmental risk measurements in their investment decision-making processes are desperately needed, given the detrimental effects of environmental risks on financial development indices. This could entail establishing thresholds for acceptable levels of environmental risk and requiring that investment portfolios be evaluated for their impact on the environment and risk exposure. In order to formulate and carry out best practices for addressing environmental hazards, financial institutions should be encouraged to work with conservation groups.

Also, establish a structure for early warning systems that keep an eye on macroeconomic trends and send out immediate warnings about possible threats to financial stability in order to handle the conflicting effects of economic risk on financial development. In this regard information from numerous sources, such as macroeconomic indicators and business firms-specific trends, should be integrated by this system along with establishing economic stabilization funds as well. This can be used as a safety net for the banking sector and as a means of preserving economic stability during times of extreme economic turbulence. The U.S. financial industry may improve its capacity to handle the difficulties presented by energy security threats, especially those associated with environmental effects and economic instability, with the help of the deduced conclusions and suggested regulations. The financial sector can both mitigate short-term risks and create a strong foundation for long-term stability and growth by putting targeted measures like sophisticated risk management frameworks, increased transparency in risk disclosures, and strategic investments in sustainable practices. By allowing the industry to adjust to changing risks with greater proficiency, these regulations will increase sustainability and resilience in the face of unanticipated future uncertainties.

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