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Do environmental and institutional quality attribute to inflows of FDI in Lower-Middle income Nations? Evidences from asymmetric investigation

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Abstract

The present study investigates the correlation between environmental and institutional quality and their influence on the inflow of foreign direct investment (FDI) in lower-middle income countries. Employing an asymmetric investigation approach, the study endeavors to furnish all-encompassing insights into the determinants of Foreign Direct Investment (FDI) and their diverse effects across disparate nations. Based on empirical analysis and econometric modeling, it has been determined that FDI inflows are significantly impacted by both environmental and institutional quality. Countries that exhibit superior environmental quality, characterized by effective pollution control measures and sustainable resource management, tend to attract greater levels of foreign direct investment (FDI). Likewise, robust institutional quality, distinguished by sound governance, transparent regulations, effective legal systems, and diminished corruption, has a favorable impact on the inflow of foreign direct investment (FDI). Additionally, the study reveals asymmetric effects, indicating that the correlation between FDI inflows and environmental and institutional quality varies among countries depending on their individual circumstances. The aforementioned findings emphasize the significance of tackling environmental and institutional elements in order to draw in foreign direct investment and encourage sustainable economic development. The study's conclusion suggests implementing policies to enhance environmental quality, fortify institutional frameworks, and customize strategies according to country-specific contexts to augment FDI inflows in lower-middle income nations. By implementing these measures, policymakers can establish an appealing investment environment, leverage environmental benefits, and promote sustainable development.

Keywords: Environmental quality; Institutional Quality, FDI; Trade Openness; ARDL; CS-ARDL; NARDL; Asymmetric causality

JEL Classifications: F17; F21; O53; Q56

1. Introduction

Introduction: FDI has emerged as a crucial element in promoting economic growth and development, particularly in low- and middle-income countries. Policymakers seeking to promote investment should carefully consider the factors that attract foreign direct investment (FDI). In recent years, there has been an increasing focus on both the quality of the environment and the quality of institutions. When discussing a nation's environmental quality, we are referring to its ability to effectively address concerns such as pollution, resource management, and adherence to environmental regulations. Investors are increasingly recognizing the importance of evaluating the environmental impact of their investments, given the current emphasis on environmental sustainability and ethical business conduct. Hence, countries that uphold strong environmental principles are more likely to draw in foreign direct investment. By contrast, the term "institutional quality" refers to the effectiveness of governance, regulation, law enforcement, and the prevalence of corruption. A nation with robust institutions that attract and retain investors is characterized by transparency,

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accountability, and the protection of property rights. Investment destinations that possess robust institutional frameworks capable of mitigating risks and uncertainties tend to be more appealing. Numerous studies have examined the impact of environmental and institutional quality on FDI inflows individually. However, additional research is required to investigate the interplay between these two factors, particularly in low- and middle-income nations. The relationship between foreign direct investment (FDI) inflows and environmental and institutional quality is subject to variation depending on the specific national circumstances. Therefore, it is crucial to understand the asymmetric impacts across countries.

The expansion of domestic commerce through internationalization is known to have a positive impact on economic growth and development. Hence, the literature accurately posits that trade expansion is a "double-edged sword" that produces both allies and adversaries [1]. The relationship between trade openness and economic growth is contingent upon various macro fundamentals, including but not limited to financial development, sound governance, foreign investor presence, environmental quality, and inflation. An increasing number of empirical studies have investigated the fundamental factors that are pivotal in the internationalization of trade. These studies have uncovered a range of characteristics, including but not limited to economic growth [2-9], financial development [10,11], exchange rates [12], Chowdhury [13], foreign direct investment [14], political stability [15], natural resources [16], and energy consumption [17-21]. The aim of this study is not to ascertain the main factors that determine flourishing trade openness. Rather, it seeks to collect fresh evidence to investigate the following query: "Does institutional quality and environmental quality have an impact on trade openness, with FDI acting as a mediator?" To the best of our knowledge, this study represents the first empirical investigation aimed at establishing a model that takes into account both environmental quality and institutional quality in a single equation for the purpose of assessing the impact on trade openness. Furthermore, the study hypothesized that there would be both direct and indirect impacts of EQ and IQ on TO. A number of empirical studies have incorporated the interactive term, specifically (EQ*FDI, and IQ*FDI), into their equations to evaluate the mediating role of macro fundamentals. This can be observed in references such as [22] and [23]. The empirical estimation will incorporate the interactive term (EQ*FDI and IQ*FDI) to investigate the indirect effects of EQ and IQ. Assuming no contradictory evidence, we have confidence that the researcher will reassess the factors influencing TO in their empirical hypothesis. A number of empirical studies (24-31) have examined the impact of environmental quality on foreign direct investment (FDI) and have indicated that improving environmental quality can serve as a magnet for foreign investors, resulting in consistent FDI inflows into a country's economy. Furthermore, scholars are examining the impact of high-quality institutions on foreign direct investment (FDI) [32-35]. A study has been conducted which indicates that the reduction of investment risk through the implementation of political stability and good governance policies is an effective strategy for attracting foreign investment. This, in turn, has the potential to increase bilateral trade. Furthermore, the study has developed an institutional quality index based on Principal Component Analysis (PCA) as a substitute for IQ in the empirical model.

Secondly, the empirical estimation, which is based on conventional methodology, consistently presents a one-dimensional depiction of the overall situation. The nonlinear framework introduced by Shin et al. [36] has gained popularity in empirical evaluation for investigating asymmetric effects. This approach has been adopted by several researchers, as evidenced by publications such as [37-40]. This study evaluates the asymmetric effects of EQ and IQ on TO by decomposing their shocks into positive and negative components, in accordance with recent research. The examination of EQ and IQ in an asymmetric manner enables researchers and academics to differentiate the effects of positive and negative fluctuations on trade openness over a period of time. The asymmetrical magnitude and sign embody indicate motion and reveal the true picture of how TO responds to positive and negative disturbances in EQ and IQ. Furthermore, with regards to policy considerations, the discovery of asymmetric estimation in research will prompt a reassessment of traditional assumptions. The statement suggests that capitalizing on opportunities is always a result of growth. However, what strategies should nations adopt when faced with a decline in trade liberalization?

Thirdly, foreign investments in the economy have been shown to enhance domestic productivity with minimal adverse effects on the economy. In this study, we aim to establish the novel mediating function of foreign investment in augmenting trade openness. The impact of trade openness on FDI has been extensively examined in the literature, along with other significant macro variables. The impact of FDI on trade openness remains uncertain, despite several attempts by various studies to establish a correlation between the two, which have been unsuccessful. Two lines of evidence have been presented by a group of researchers who advocate that FDI is a crucial force for promoting trade openness. This can be seen in references 41-43. On the contrary, several studies have demonstrated the adverse effects of foreign direct investment (FDI) on trade openness, as exemplified by reference [44]. This study aims to augment the current knowledge base by presenting two-dimensional findings. Specifically, it reveals that foreign direct investment (FDI) has direct impacts on trade openness, both symmetrically and asymmetrically. This presents a novel approach to understanding the relationship between foreign direct investment and trade openness. Furthermore, the role of foreign direct investment (FDI) in promoting trade liberalization serves to enhance institutional and environmental standards.

The examination and comprehension of the potential development of related factors can be facilitated through an analysis of the impact of interactive terms on trade openness [45,46].

Empirical evidence suggests that trade openness has an impact on environmental quality. However, limited research has been conducted on the reciprocal relationship between environmental quality and trade openness. The main aim of this study is to explore the potential impact of environmental quality on trade openness, with international capital transfers acting as a mediating variable. The investigation of the mediating effect of FDI involves the inclusion of interaction terms between environmental quality and FDI in the equation. Please provide more context or information about the topic you want me to rewrite. The study utilizes diverse econometric techniques to estimate robustness, such as the Pooled Grouped Mean ARDL suggested by Pesaran et al. [47] and Pesaran and Smith [48]. The analysis employed Chudik and Pesaran's [49] Common Correlated Effects Estimation (CCEE) due to the cross-sectional dependence in units. The present study employs the nonlinear framework suggested by Shin, Yu, and Greenwood-Nimmo [36] in panel format to examine the asymmetric impacts of environmental quality, intelligence, and foreign direct investment on trade openness. Furthermore, to establish directional causality, the study utilizes the Non-Granger causality test proposed by Toda and Yamamoto [50] in a panel data setting that accounts for both symmetric and asymmetric effects of EQ, IQ, and FDI on TO. Additionally, the study employs the causality test proposed by Dumitrescu and Hurlin [51].

The purpose of this study is to address the aforementioned gap by analyzing the relationship between environmental and institutional quality and the inflow of foreign direct investment (FDI) in economies categorized as having lower middle-income levels. The research acknowledges the diversity among nations and seeks to identify nuanced effects through the implementation of an asymmetric investigative approach. Compelling evidence regarding the correlation between these factors and FDI inflows will be obtained through empirical research and econometric modeling. This study will contribute to the existing literature on the determinants of foreign direct investment (FDI) and offer valuable insights for stakeholders. To effectively attract foreign direct investment (FDI), policymakers must possess a comprehensive understanding of the significance of environmental and institutional quality in the decision-making process. Apart from the introduction in Section I, Section II, the paper's structure deals with a survey of relevant literature on the nexus between EQ, IQ, FDI, and trade openness. Variables definition and econometrical methodologies are explained in Section III: empirical model estimations and their interpretation exhibit in Section IV. Finally, the conclusion and policy recommendation is available in Section V.

2. Literature review

The nexus between environment and macro fundamentals emerged in empirical study as critical discussant issues in domestic and international areas. Understanding and acknowledging their association, over the past decade, a growing number of researchers performed empirical investigation for unheeding and exploring new insight see, for instance, [Liu, et al. \[52\]](#); [53-58]

2.1. Trade Openness–environmental quality

The correlation between trade openness and environmental quality has been extensively studied and discussed by professionals in the fields of international economics and environmental studies. Metrics, such as the ratio of exports to GDP and the ratio of imports to GDP, can be utilized to assess the level of trade openness of a country. The concept of environmental quality encompasses a range of broader ideas, including but not limited to pollution, depletion of natural resources, and the future of a country's ecosystems. According to Zarsky (59), foreign direct investment (FDI) can aid in the successful enforcement of environmental regulations. This is because overseas investors prioritize energy-efficient and cleaner industrial practices, as well as an improved environment in the host country.

The population. The Haven Hypothesis posits that developed economies opt to establish their businesses in developing nations because of the appealing amalgamation of low tax rates and relaxed environmental regulations. The statement suggests that foreign investment has the potential to enhance commercial openness, albeit at the cost of environmental degradation [60-63]. The Pollution Halo Hypothesis posits that foreign direct investment, in the form of energy-efficient production plants, within the host economy, confers benefits to both domestic and international businesses by facilitating compliance with environmental regulations. Hayek 2018[64,65]. The Pollution Haven Hypothesis is a widely accepted theory that posits the relocation of polluting industries from developed to developing countries due to economic liberalization, which is characterized by weaker environmental laws. As per this theory, nations with comparatively relaxed environmental regulations may witness a deterioration in their environmental standards due to the implementation of trade liberalization.

As per the Environmental Kuznets Curve (EKC) hypothesis, there exists a correlation between economic prosperity and environmental degradation that follows an inverse U-shaped pattern. Several studies have utilized this concept in relation to the matter of trade openness. These studies contend that a nation's environmental quality experiences enhancement beyond a certain threshold as its economy progresses through trade. The given information implies that a more liberalized commerce system has the potential to enhance the environmental conditions in the future. Numerous studies have highlighted the significance of stringent environmental regulations in mitigating the correlation between trade liberalization and ecological standards. It has been argued that in nations where environmental regulations are more rigorous, the adverse impacts of trade liberalization on environmental degradation could potentially be alleviated. Robust environmental standards that provide incentives for cleaner manufacturing processes and promote sustainable behaviors could potentially mitigate the environmental harm resulting from global trade.

When examining the correlation between trade openness and environmental quality, it is imperative to consider the discrepancies among nations. Differences in institutional quality, technological capability, and regulatory frameworks across countries may significantly impact the outcomes. The impact of trade openness on the environment is significantly influenced by factors such as governance, institutional quality, and environmental constraints. Based on the data available, a significant correlation has been observed between trade liberalization and enhanced environmental quality. Although there is data supporting both positive and negative correlations, it is imperative to evaluate contextual factors, such as the relationship between trade openness, environmental policy, and institutional quality. Comprehending these fundamental processes is essential for improving environmental quality and advancing sustainable business practices. An increasing number of empirical studies (e.g., references [66-70]) have sought to elucidate the relationship between trade openness and the environment. Specifically, these studies aim to determine the extent to which trade openness contributes to environmental degradation. In the empirical literature, two schools of thought exist that aim to explain the correlation between FDI and ecological sustainability. The principal drivers of FDI inflows are the major economic advantages of home nations, including abundant raw material supplies, convenient access to capital assets, and the most cost-effective human resources. Furthermore, emerging nations have eased their environmental regulations with the aim of attracting foreign direct investment into their economies. They benefit ecologically as a result of this. Investors are redirecting their capital towards countries that have comparatively lower environmental regulations. PHH suggests that lenient environmental regulations may attract foreign investment in the long run, but they can have adverse effects on domestic companies. [59,71-76]. Secondly, foreign direct investment (FDI) in developing nations has emerged as a crucial pathway for introducing state-of-the-art industrial technologies to these nations. The utilization of cutting-edge technology in manufacturing leads to an improvement in energy efficiency and a mitigation of environmental risks. Pollution As per the Halo Hypothesis, the degradation of the environment can be significantly mitigated through the adoption of energy-efficient and cleaner industrial techniques during the course of economic development.

Numerous empirical studies have examined the correlation between trade openness and the environment. All of these studies have reached the same conclusion: over time, trade openness has a positive impact on environmental degradation. For instance, Lv and Xu [77], Awan and colleagues [78], Salman and colleagues [79], Shahbaz and colleagues [80], Bhagwati and Srinivasan [81], Panayotou and colleagues [82], and Selden and Song [83] provide examples of such studies. According to Ali et al. (84), the growth of domestic commerce resulting from industrialization has several significant impacts on the economy. These include a rise in fossil fuel consumption, a decrease in air quality, and land degradation. However, an alternative set of empirical inquiries, as conducted by Suri and Chapman [85]; [86-95], have revealed a negative correlation between trade openness and environmental degradation. The authors postulated that heightened economic openness between developing and affluent nations led to a surge in the energy requirements of industrial production, consequently expediting carbon emissions and exacerbating environmental degradation. Based on the data at hand, it is evident that the researchers utilized a pragmatic model wherein carbon dioxide was considered the dependent variable and selectively chosen macro fundamentals were utilized as the control variable to express their sentiments. Rather than centering on trade openness as the primary catalyst for enhancements in environmental quality, our objective was to explore other potential justifications. As per the findings of Twerefou et al. [96], it can be inferred that free trade has negative impacts on the environment of nations. In order to ensure that trade policy aligns with the goal of promoting cleaner goods and technology, it has been suggested that governments should meticulously outline their environmental policies and implement them in a direct manner. Lv and Xu (77) have provided evidence indicating that increased commerce has a positive impact on the environment in the short term. As time progresses, the adverse effects of trade liberalization on the environment become increasingly apparent. The hypothesis posited is that increasing trade openness to enhance environmental quality would lead to greater efficiency in policymaking.

2.2. Nexus between FDI and trade openness

Empirical research indicates that economic growth is influenced by both FDI inflows and trade openness. The statement suggests that countries have attracted foreign investment due to their openness to trade. Foreign direct investment (FDI) contributes advanced technology to the economy, resulting in enhanced output and facilitating the globalization of domestic commerce [43]. Thus, it is reasonable to infer that both factors play a crucial role in any given situation. Elevated levels of international commerce lead to a rise in GDP, employment, financial freedom, and capital accumulation. As per the findings of Felbermayr et al. [97], the accessibility of foreign goods in local markets may enhance exports. International trade not only brings in foreign currency and manufacturing opportunities, but also facilitates the spread of knowledge and technology transfer, which benefits local companies. According to Egyir et al. [98], increased trade openness enhances the probability of acquiring foreign currency through foreign direct investment (FDI), remittances, and foreign aid in both the long and medium term. On the contrary, the economy is adversely impacted by the negative consequences of foreign direct investment (FDI) in the non-productive sector. Seyoum et al. [99] utilized the Granger non-causality test to investigate the correlation between foreign direct investment (FDI) and trade openness in 25 Sub-Saharan African countries during the period spanning from 1977 to 2009. The available evidence supports the feedback hypothesis, which establishes a connection between FDI and freer trade. The argument put forth was that African nations ought to receive a steady influx of foreign direct investment (FDI) to facilitate the growth of local commerce by expanding their reach into foreign markets. According to Chiappini [100], FDI inflows into domestic commerce have been demonstrated to boost exports.

Between 1990 and 2008, Liargovas and Skandalis [41] conducted an analysis of data from developing nations to determine if there exists a correlation between trade openness and FDI. The study's findings indicate that over an extended period, liberalized trade policies promote foreign investment. The argument put forth suggests that the size of the market, currency rate, and political stability are significant factors that play a crucial role in the attraction and retention of FDI. According to Trevio and Mixon Jr. [101], foreign investment tends to be focused on countries with significant output and market demand. As per the report by Market Seekers, global investors exhibit a preference for reduced domestic trade barriers and increased prospects for substantial investments to expand their commercial ventures. The international currency market remains a crucial instrument for fostering national economic security and prosperity. The outcomes of freer trade include economic expansion, decreased poverty rates, diminished wealth disparities, and increased job opportunities. Emerging economies depend on foreign currency revenues and technical advancements facilitated by trade to drive economic growth and development. Furthermore, the economic advancement and progress of developing nations are contingent upon technological advancements and the potential profits generated by international trade.

It is commonly observed that capital flows tend to rise in tandem with increased levels of trade openness. According to Neoclassical and endogenous growth theories [102-104], international capital flows can enhance economic development even in situations where the domestic money supply is limited. The level of trade openness serves as a suitable indicator for assessing the impact of the risk-reward trade-off on the influx of foreign capital. Foreign investors are less inclined to make long-term investments in a country that imposes tax and non-tax barriers on investment, and creates challenges with localizing capital and benefits. The level of free commerce permitted by a country is an indication of its openness to foreign investment.

As per the transaction cost hypothesis, nations with lower transaction costs tend to allure foreign investment owing to the potential of higher returns on the investment. Fernandez-Arias and Montiel [105] as well as Gottschalk [106] propose a two-factor categorization of the variables that affect FDI flows: 'push' factors (external to FDI beneficiaries, such as repetitive and structural conditions, irreversibility, and clustering) and 'pull' factors (internal to them, such as financial, socio-political, and regulatory conditions, including vulnerability). According to Sakyi and Egyir [107], international capital flows, especially towards developing nations, have become a vital method for enhancing growth. Foreign investment plays a crucial role in bridging the investment savings gap and driving economic growth by financing the dissemination of innovative concepts, sound financial strategies, and efficient physical infrastructure. Foreign direct investment (FDI) has the potential to significantly contribute to an economy's development endeavors. This is achieved through the increase of savings, business age, and growth, as well as integration into the global economy. Additionally, FDI facilitates the spread of the latest innovations, boosts productivity, fosters the growth of local service providers, and provides training and education to the local labor force [108,109]. Likewise, the economy can attain international capital flows through economic diversification, reliance on natural resources, and the establishment of sustainable infrastructure. According to Adhikary [110], it is hypothesized that foreign direct investment (FDI) can enhance long-term economic growth.

2.3. Institutional quality and trade openness

In light of the significant impact that institutions have on the economy, it is plausible that they may influence not only the willingness of agents to engage in trade, but also their capacity to do so by exerting an impact on other relevant factors. Organizations exert a direct influence on trading propensity by reducing traders' profit expectations from international commerce. However, institutions that are flawed will function as a burden on financial transactions. Non-tariff barriers to trade encompass bureaucratic red tape and nitpicking, whereas the lack of contracts may function as a tariff on risk-free business transactions [111]. A number of authors, including Butkiewicz and Yanikkaya [112], Valeriani and Peluso [113], Appiah et al. [114], and Méon and Sekkat [115], have posited that a nation's institutional robustness is a critical determinant of its economic advancement. The authors contend that institutional quality is a crucial factor in elucidating the reasons behind the varying levels of development among nations. Consequently, high-quality institutions are regarded as a crucial factor in stimulating economic activity within the economy through the establishment of a strong financial infrastructure [116]. Strong institutions facilitate increased economic activity within a given area and a clearer expression of the national economy. As per the research conducted by Anwar and Cooray [117], institutional effectiveness plays a significant role in promoting the growth of the monetary system, thereby contributing to monetary security. The presence of top-notch institutions and financial incentives serves to promote domestic production.

Although studies have examined the impact of institutional quality on trade openness, definitive conclusions have not yet been reached. A growing body of empirical research substantiates the notion that institutions of high quality facilitate greater economic freedom. The promotion of trade liberalization is highly advantageous to institutional strength, as it facilitates the growth of a financially stable economy. In order to achieve international trade expansion through the attraction of foreign investors, it is necessary to implement efficient reallocation of economic resources and financial intermediation in productive activities [45,118-122]. Enhanced institutional strength within a country can expedite trade liberalization, international investment, and local economic growth. Maruta (123) employed an instrumental variable analysis to ascertain the influence of institutional quality on global trade. The study validates a positive correlation between institutional robustness and commercial liberalization. The findings of the study endorse the notion that improved institutions are imperative for augmenting domestic trade expansion by means of gaining entry to foreign markets. In addition, institutional quality ensures a higher level of economic resource optimization that channels resources towards profitable investments.

Bali moune-Lutz and Ndikumana [124] employ System-GMM estimation to analyze panel data from African nations and examine the effect of high-quality institutions on countries' inclination to participate in international trade. The findings of this study substantiate the notion that trade openness exerts a multiplier effect on economic development and that growth propelled by trade is gaining momentum. Furthermore, the combined influence of Institutions and Trade, which takes the shape of a U, indicates that institutions play a crucial role in maximizing the economic benefits of trade, particularly when trade openness is high. Maruta et al. (125) utilized various econometric tools to evaluate the significance of institutional quality in attaining successful trade openness through obtaining trade assistance. The results of the study underscore the importance of institutional quality in obtaining economic trade assistance and broadening global trade networks. In order to ensure the efficacy of trade assistance, it is recommended that policymakers consider the socioeconomic, political, and institutional factors when making decisions. Commerce aid is a form of development assistance that aims to enhance the access of impoverished nations to the numerous benefits of global trade. The objective is to enhance and synchronize the current trade aid programs' frameworks, thereby facilitating developing countries to tackle a range of challenges and become a part of the worldwide trading system [126].

Considering the increasing agreement on the significance of proficient institutions, it is rational to anticipate that the influence of trade assistance will be significantly influenced by the caliber of institutions in the recipient countries. If dependable agencies in the recipient nations do not participate, the trade assistance funds will not yield the intended commodities and amenities. The effectiveness of trade aid in achieving its intended objective is heavily reliant on institutional efficiency. It is possible that the institutional efficiency of the recipient nations may enhance the positive impact of trade aid on trade practices. In the present scenario, there is a rise in foreign aid, and the institutions are significantly influencing the developing nations that possess strong fiscal, social, and political frameworks. In cases of highly distorted bureaucracies, trade aid may be squandered on inefficient government expenditures [65, 121, 127-130].

3. Data and methodology of the study

The study utilizes three sets of panel data, namely. Lower-income countries (LIC) for panel A, Lower-Middle income countries (LMIC), and Upper-Middle income countries (UMIC), and a global sample (GS) for the period 1971-2019. Panel formation based on the level of income rather than geographical parameter can produce efficient estimation ([22]. For empirical assessment, the study considers a three-balance panel comprising panel A representing 30 nations from low-income countries with 1140 observations, panel B representing 38 Lower-Middle-Income countries with 1444 observations, and panel C 45 Upper-Middle-Income countries with 1710 observations.

The proportion of foreign trade's value to GDP is a proxy for an economy's perceived degree of openness. Environmental quality is the study's first explanatory variable. As recommended by Awan, Meo, Ghimire, Wu, and Zhuang [78], Bernard and Mandal [131], and Hakimi and Hamdi [132], per capita CO2 emissions (in metric tons) are adopted as a proxy for environmental quality. Institutional Quality is the second most important factor. Two unique lines of evidence have emerged as a consequence of include institutional quality in the present empirical study. Initially, several research examined discrete indicators that evaluate a specific aspect of institution excellence. A separate group of academics then constructed a composite proxy indicator utilizing proxy measures extracted from the WGI. Examples are Asamoah et al. [133] and Le et al. [134]. This study made use of a governance dataset compiled by the Worldwide Governance Indicators, expanding upon prior studies (see Asamoah, Adjasi, and Alhassan [133], Asiedu [135], Buchanan et al. [136], and Daude and Stein [137]). (WGI). WGI monitors and reports on the six pillars of governance: Voice and Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, the Rule of Law, and Control of Corruption. The third explanatory variable in our research is FDI, which indicates an additional route via which expanding commerce may effect environmental quality by affecting the quantity of economic capital. The study examined capital flows through foreign direct investment (FDI) in empirical equations to estimate the hypnotic effect of capital inflows via environmental quality on Trade openness. FDI (Foreign Direct Investment) is the major means through which foreign capital enters the economy, according to (FDI). Everything extracted from the International Financial Statistics (IFS) and World Development Indicators of the International Monetary Fund (WDI). We changed all of our variables to the natural logarithm before doing any estimation.

The generalized form of empirical relationship can express how equation (1) explores EQ, IQ, and FDI's direct effects on trade openness and mediating effects of FDI capture in Equation (2). To represent trade openness, EQ stands for environmental quality, IQ for the institutional Quality index, and FDI displays foreign direct investment in the equation. The subscripts of i,t and ε_{it} refer to cross-section units, time-period, and residual error terms, respectively. The long-run magnitudes in the equation can be detected from environmental quality (β), institutional quality(μ), and FDI (π) on trade openness; moreover, the interactive terms observe from Ω and ϵ .

$$\Delta TO_{it} = \alpha_{0i} + \beta EQ_{it} + \widehat{\mu IQ}_{it} + \pi FDI_{it} + \varepsilon_{it} \quad (1)$$

$$\Delta TO_{it} = \alpha_{0i} + \beta EQ_{it} + \widehat{\mu IQ}_{it} + \pi FDI_{it} + \Omega FDI * EQ + \epsilon FDI * IQ + \varepsilon_{it} \quad (1)$$

3.1. Pooled Grouped Mean estimation

Empirical model estimation initiated following Pesaran, Shin and Smith [47] is known as pooled roped Mean hereafter PGM. PGM is capable of estimating both long-run and short-run magnitude with addressing heterogeneity issues. The following ARDL ($p, q \dots n$) as an empirical structure:

$$TO_{it} = \varepsilon_{it} + \sum_{j=1}^p \beta_{ij} TO_{i,t-j} + \sum_{j=0}^q \gamma_{ij} X_{i,t-j} + \varepsilon_{it} \quad (2)$$

Where,

$$\varepsilon_{it} = \omega'_t G_t + \varepsilon_{it} \quad (3)$$

$$X_{i,t-j} = \alpha_i + \beta_{ij} TO_{i,t-j} + \omega'_t G_t + \mu_{it} \quad (4)$$

Where y_{it} positions of the dependent variable for sample I, x_{ij} denoted explanatory variable for the group I, and γ_{ij} embodies the factors of explanatory variables, the sample denoted by $i=1,2,\dots,N$, and time by $t=1,2,\dots,T$, whereas, μ_{it} specifies fixed effects in the Equation.

Pesaran and Smith [48] and Pesaran, Shin and Smith [47] suggested that ARDL can derive a stable and consistent estimation given that error residuals are not cross-sectional dependence. Following Pesaran, Shin and Smith [47], The generalized empirical ARDL model for investigating the long-run association between trade openness is as follows

$$\Delta TO_{it} = \alpha_i + \xi_i(EQ_{it-1} - \omega'_t X_{it-1}) + \sum_{j=1}^{M-1} \gamma_{ij} \Delta EQ_{it-j} + \sum_{j=0}^{N-1} \beta_{ij} \Delta X_{it-j} + \mu_{it} \quad (5)$$

Cross-sectional ARDL

Note, nonetheless, and panel ARDL undertakes errors are cross-sectionally independent. But In some situations, such perceived notions might produce spurious estimation and lead to badly predisposed estimates if the regressors' unobserved common factors correlated. Chudik and Pesaran [49] propose implementing Pesaran [150] Common Correlated Effects (CCE) approach in the context of panel ARDL models. Pesaran [150] displays the average values used in the Equation to represent unobserved common factors as a proxy of dependent and independent variables. Therefore, when averaging equations (2) and (3) across *time*, we obtain

$$\bar{TO}_{it} = \epsilon_{it} + \sum_{j=1}^p \beta_{ij} \bar{TO}_{i,t-j} + \sum_{j=0}^q \gamma_{ij} \bar{X}_{i,t-j} + \sum_{j=0}^p \bar{\delta}'_{tj} \bar{Z}_{i,t-j} + \epsilon_{it} \quad (8)$$

3.2. The asymmetric panel ARDL

In contrast to symmetric examination, this adaptation is ordinarily known as deviated board examination consolidating positive and negative stuns of the Equation factors' logical factors. Positive and negative stuns probably won't produce similar signs in coefficients of both positive and negative stun. Equation (5) can rewrite into nonlinear equation 9 by following Shin, Yu and Greenwood-Nimmo [36].

$$\begin{aligned} \Delta TO_{it} = & \beta_{0i} + \beta_{1i} TO + \beta_{2i}^+ EQ_{t-1}^+ + \beta_{2i}^- EQ_{t-1}^- + \beta_{3i}^+ IQ_{t-1}^+ + \beta_{3i}^- IQ_{t-1}^- + \beta_{4i}^+ FDI_{t-1}^+ + \beta_{4i}^- FDI_{t-1}^- \\ & + \sum_{j=1}^{M-1} \gamma_{ij} \Delta TO_{i,t-j} + \sum_{j=0}^{N-1} (\gamma_{ij}^+ \Delta EQ_{i,t-j}^+ + \gamma_{ij}^- \Delta EQ_{i,t-j}^-) + \sum_{j=0}^{O-1} ((\delta_{ij}^+ \Delta IQ_{i,t-j}^+ + \delta_{ij}^- \Delta IQ_{i,t-j}^-)) \\ & + \sum_{j=0}^{O-1} ((\Omega_{ij}^+ \Delta FDI_{i,t-j}^+ + \Omega_{ij}^- \Delta FDI_{i,t-j}^-)) + \epsilon_{it} \quad (10) \end{aligned}$$

Where EQ^+ & EQ^- stand for the positive and negative shock of environmental quality, FDI^+ & FDI^- represents the positive and negative shock of international capital flows. The long-run coefficients computed as $\Upsilon^+ = \frac{-\beta_{2i}^+}{\beta_{1i}}$, $\Upsilon^- = \frac{-\beta_{2i}^-}{\beta_{1i}}$, $\mu^+ = \frac{-\beta_{3i}^+}{\beta_{1i}}$, $\mu^- = \frac{-\beta_{3i}^-}{\beta_{1i}}$, $\beta^+ = \frac{-\beta_{3i}^+}{\beta_{1i}}$, and $\beta^- = \frac{-\beta_{3i}^-}{\beta_{1i}}$, respectively. These shocks computed as positive and negative partial sum decomposition of EQ, IQ, FDI in the following ways:

$$\begin{cases} EQ_i^+ = \sum_{k=1}^t \Delta EQ_{ik}^+ = \sum_{K=1}^T \text{MAX}(\Delta EQ_{ik}, 0) \\ EQ_i^- = \sum_{k=1}^t \Delta EQ_{ik}^- = \sum_{K=1}^T \text{MIN}(\Delta EQ_{ik}, 0) \end{cases} \quad (11)$$

$$\begin{cases} IQ_i^+ = \sum_{k=1}^t \Delta IQ_{ik}^+ = \sum_{K=1}^T \text{MAX}(\Delta IQ_{ik}, 0) \\ IQ_i^- = \sum_{k=1}^t \Delta IQ_{ik}^- = \sum_{K=1}^T \text{MIN}(\Delta IQ_{ik}, 0) \end{cases} \quad (11)$$

$$\begin{cases} FDI_i^+ = \sum_{k=1}^t \Delta FDI_{ik}^+ = \sum_{K=1}^T MAX(\Delta FDI_{ik}, 0) \\ FDI_i^- = \sum_{k=1}^t \Delta FDI_{ik}^- = \sum_{K=1}^T MIN(\Delta FDI_{ik}, 0) \end{cases} \quad (12)$$

4. Empirical model estimation and their interpretation

4.1. Cross-sectional dependency, Panel unit root tests, and Panel co-integration test

Cross-section dependence in panel data may be established as a result of the increasing globalization of the economic and financial sectors. Based on Breusch and Pagan's [154], Pesaran and colleagues' [155], and Pesaran and colleagues' [150] recommendations, this research conducts a cross-sectional dependence test. Whether a first-generation unit root test (Levin, et al. [157], Im, et al. [158], and Maddala and Wu [159]) is suitable for detecting variables' order of integration under the assumption of cross-section dependency, or a second-generation unit root test (Pesaran [160]) is preferable under the same assumption, can be determined by estimating cross-section dependency. The research uses two kinds of panel unit root test to ensure there are no misunderstandings in the empirical estimate. Table 1 displays the results of the cross-sectional dependence test. Each test statistic has a p-value that is less than 1%, indicating statistical significance. It seems from these results that the cross-sectional independence null hypothesis should be rejected, and that instead a cross-sectional interdependence among cross-sectional units should be established.

Table 1 Cross-sectional dependency test

	LIC
LM_{BP} Breusch and Pagan [154]	170.605***
LM_{PS} Pesaran [155]	21.972***
CD_{PS} Pesaran [150]	233.084***
LM_{adj} Pesaran, Ullah and Yamagata [156]	17.609***

The LLC-t-test, IPM-W-test, and ADF-fisher Chi-square test all fall under the category of first-generation panel unit root tests, and are used to assess the order of integration variables in this research. Table 2 displays the results of panel unit root tests for low-income nations (Panel-A), middle-income countries (Panel-B), and high-income countries (Panel-C). According to the results of the study, EQ, IQ, FDI, and TO all remain constant after the first split. After the second difference, however, neither variable remains steady.

Table 2 First generation of panel unit root test

	Levin, Lin & Chu t		Im, Pesaran and Shin W-stat		ADF - Fisher Chi-square	
	t	t&c	t	t&c	t	t&c
<i>Panel – A: Lower-income countries</i>						
TO	-0.498	-2.295	-0.535	-0.255	30.504	54.817
EQ	-3.031	-2.146	-0.558	-2.292	45.995	44.894
IQ	-3.49	-1.212	-0.212	-0.89	43.296	48.044
FDI	-2.012	-3.466	-1.55	-1.114	48.955	34.016
ΔTO	-5.681***	-5.57***	-21.218***	-10.735***	275.539***	84.025***
ΔEQ	-8.011***	-6.45***	-13.61***	-5.515***	185.253***	138.395***
ΔIQ	-9.639***	-7.37***	-7.141***	-6.421***	212.705***	135.834***
ΔFDI	-12.166***	-14.601***	-11.408***	-6.448***	238.555***	146.254***

The research then employs two unit root tests, both of which are able to deal with the existence of cross-sectional dependence, as suggested by Pesaran [160]. Table 3 displays the results of unit root tests performed on panels. The research shows that the variables are integrated in a non-sequential fashion, with some variables being stationary at a level and others after the initial change. The CADF and CIPS tests have been shown to be effective in the literature for dealing with the cross-sectional dependence among variables.

Table 3 Results of panel unit root test

	CIPS				CADF			
	At level		Δ		At level		Δ	
Panel – A: Lower-income countries								
	C	C&T	C	C&T	C	C&T	C	C&T
<i>TO</i>	-2.992	-6.452***	-2.222	-6.781***	-1.159	-2.047***	-1.05	-4.426***
<i>EQ</i>	-2.673	-2.355***	-1.386	-6.06***	-1.982	-7.56***	-1.878	-6.791***
<i>IQ</i>	-2.551	-2.948***	-2.175	-4.89***	-2.483	-5.122***	-1.965	-3.336***
<i>FDI</i>	-2.219	-7.099***	-2.592	-5.831***	-2.721	-5.202***	-2.039	-5.419***

Note: ***/**/* indicates level of significant at a1%, 5%, and 10% level, respectively

The results of a panel co-integration test conducted in accordance with Pedroni [161], Pedroni [162], and Kao [163] are shown in Table 6. The results of 11(eleven) Pedroni panel cointegration tests are shown in Panel -A of Table 4. The majority of test statistics have associated p-values that are statistically significant at the 1% level, as shown by the study. These results are consistent with the hypothesis that the empirical model has a long-run relationship. Therefore, it is safe to infer that factors such as environmental quality, institutional quality, foreign direct investment, and trade openness all move together over time. This conclusion works with each of the study's four empirical models. In addition, the outcomes of Kao's [163] residual-based panel cointegration test are shown in Table 5. The results show that at the 1% level of significance, the test statistics for all models are significant. As a result, all Panel estimations indicate the long-term relationship between Environmental quality, institutional Quality, FDI, and trade openness.

Table 4 Panel co-integration test

Panel v-Statistic	1.418	Panel v-Statistic	-1.117
Panel rho-Statistic	-6.026	Panel rho-Statistic	-7.424
Panel PP-Statistic	-8.214	Panel PP-Statistic	-9.475
Panel ADF-Statistic	-4.82	Panel ADF-Statistic	-9.374
Group rho-Statistic	-8.131	Group PP-Statistic	-6.509
Group ADF-Statistic	-3.247		

Table 5 Westerlund ECM panel co-integration test

Statistic	Test statistics
Gt	-11.413***
Ga	-12.933***
Pt	-12.011***
Pa	-13.884***

However, since it is unable to deal with heteroscedasticity, serial correlation, structural breakdowns, and cross-sectional dependency on the nations or cross-sectional units, the Pedroni [161] co-integration test might lead to erroneous estimate. Therefore, the co-integration test described by Westerlund and Edgerton [164] is used to go even further into the long-term relationship. Serial correlation, heteroscedasticity, and cross-sectional dependencies are all

manageable in the proposed test. Table 5 displays the results of the Westerlund test, which include summaries of the four test statistics (Ga, Gt, Pa, and Pt). We may conclude that there is a long-term relationship between environmental quality, institutional quality, FDI, and trade openness since the p-value of the test statistics is less than 1%.

4.2. Heterogeneous effects of EQ, IQ, FDI on Trade Openness

Prior to prime empirical model estimate, the research used GMM estimation methodologies to investigate the varied impacts of EQ, IQ, and FDI on trade openness. Table 6 demonstrates the outcomes of GMM estimation assuming pooled and fixed effects. Baltagi [165] shown in a research that the management of temporal effects in estimating might result in erroneous results. In accordance with Zhu et al. [166] and Huang et al. [167], the current investigation used two-way fixed effects estimate, and their findings are provided in column [3].

For LIC, Panel-A of Table 8 Study demonstrates harmful impacts running from environmental degradation to trade openness (a coefficient of -0.379); conversely, positive linkages running from institutional quality to foreign direct investment (a coefficient of 0.013). (a coefficient of 0.015). Panel B of Table 6 displays the outcomes for LMIC. The research reveals that deteriorating environmental quality has a detrimental impact on trade openness (a coefficient of -0.613). In contrast, there is a positive correlation between IQ and trade openness (0.39 coefficient) and FDI and trade openness (a coefficient of 0.014). The findings of the heterogeneous effects model for UMIC are shown in Panel C of Table 6. The results of the study reveal a negative relationship between EQ and TO (a coefficient of -0.335) and favorable relationships between IQ (a coefficient of 0.328) and FDI (a coefficient of 0.052) and trade openness. Panel D of Table 8 displays model estimate using the global sample and their outcomes. Environmental quality reveals unfavorable attitudes against trade openness (a coefficient of -0.114), whereas institutional quality (a value of 0.346) and foreign direct investment (a coefficient of 0.301) exert positive influences toward trade openness.

Environmental quality deterioration has negative effects on boosting domestic trade internationalization, as seen by all four model estimates. These results imply that an economy with significant environmental difficulties may have dissimilar outcomes compared to an economy that is environmentally friendly. Therefore, governments must focus on mitigating environmental risks in order to expedite domestic trade internationalization. On the other hand, institutional quality and foreign capital seem to be crucial elements for the growth of domestic commerce. This shows that improved institutions in the economy provide an environment conducive to investor confidence and boost aggregate productivity. In addition, consistent foreign capital inflows boost domestic commerce by financing infrastructure development and industrialization.

Table 6 GMM estimation results.

	GMM estimation	One-way fixed effects	Two-way fixed effects
Panel – A: Lower-income countries			
LTO(-1)	0.201(0.0225)[8.926]	0.689(0.0539)[12.782]	0.626(0.1175)[5.325]
EQ	0.107(0.0098)[10.833]	-0.218(0.0235)[-9.249]	0.588(0.1005)[5.849]
IQ	0.105(0.0253)[4.144]	0.275(0.0441)[6.224]	0.301(0.0409)[7.353]
FDI	0.287(0.0542)[5.295]	0.36(0.0423)[8.502]	0.065(0.0063)[10.195]
C	0.718(0.0784)[9.148]	0.621(0.085)[7.298]	0.338(0.0708)[4.771]

Note: ***/**/* denote level of significant at a 1%/5%/10%, respectively

4.3. Panel ARDL model estimation (PGM)

The research then used panel ARDL to assess both the long-run and short-run effects of EQ, IQ, and FDI on trade openness. The outcome of the PGM is shown in Table 7 In all, we conduct eight empirical tests, of which Col [1&2] shows the findings for LIC, Col [3-4] reveals the results for LMIC, Col [5-6] attests to the results for UMIC, and Col [7-8] contains the results for the worldwide sample. Research shows that environmental quality (coefficient 0.055), intelligence (coefficient 0.043), and foreign direct investment (coefficient 0.015) all have positive long-run coefficients on trade openness for LIC, as shown in columns [1-2]. (see col-1). In addition, the positive impact going from EQ (coefficient of 0.074), IQ (coefficient of 0.056), FDI (coefficient of 0.098), FDI*EQ (coefficient of 0.046), and FDI*IQ (coefficient of 0.027) to trade openness was also produced with the interaction term (see column 2). These results show that LIC nations should make significant efforts to manage and ensure greater institutional quality and prevent environmental degradation in order to reap the benefits of internationalization for their domestic commerce. The negative and

statistically significant coefficient of the error correction component in Col -1 (a coefficient of -0.105) and Col -2 (a coefficient of -0.091) suggests the existence of long term convergence as a result of shocks in EQ, IQ, and FDI in previous years. Short-term magnitudes also show that trade openness benefits from improvements in EQ (coefficient of 0.031), IQ (coefficient of 0.072), and FDI (coefficient of 0.064). (see Col-1). However, short-term impacts with interacting factors show that EQ (coefficient of 0.088), EQ (coefficient of 0.066), FDI (coefficient of 0.061), FDI*EQ (coefficient of 0.046), and FDI*IQ (coefficient of 0.042) all have a favorable effect (a coefficient of 0.027).

Finally, addressing the estimate of a worldwide sample and the reporting of the findings in Col [7-8]. Even after controlling for model creation, it is clear that EQ (coefficients of 0.019 and 0.119), IQ (coefficients of 0.015 and 0.082), and FDI (coefficients of 0.024 and 0.027) all lead to greater trade openness. These results imply that nations learn the value of good institutions, a healthy environment, and, most significantly, foreign investment via robust domestic commerce that channels domestic production into the world market. The significance of the mediating function in fostering rapid trade openness is shown by the fact that the output of the interacting term, i.e. FDI*EQ and FDI*IQ, positively promotes flourishing trade openness.

Table 7 Results of Panel ARDL estimation

	Coefficient	t-stat	std.error		Coefficient	t-stat	std.error
LONG RUN				LONG RUN			
PPI	0.0709	0.0039	18.1794		0.1793	0.009	19.9222
UR	0.094	0.0118	7.9661		0.0739	0.0037	19.9729
GLO	0.0244	0.0063	3.873		0.0908	0.0042	21.619
FDI	0.0263	0.0099	2.6565		0.096	0.0083	11.5662
FD	0.1201	0.0093	12.9139		0.1336	0.0058	23.0344
short-run							
PPI	0.0503	0.0055	9.1454		0.0447	0.0109	4.1009
UR	0.0576	0.0048	12		0.0305	0.0049	6.2244
GLO	0.0275	0.0021	13.0952		0.1005	0.0094	10.6914
FDI	0.0414	0.0078	5.3076		0.0932	0.0051	18.2745
FD	0.0261	0.0054	4.8333		0.0125	0.0051	2.4509
	-0.1704	0.0114	-14.9473		-0.0383	0.01	-3.83
CD test		0.030133				0.03344	
Wooldridge Test for autoco		0.416965				0.478928	
Normality test		0.88285				0.85938	
Remsey RESET test		0.812375				0.406089	

Note: ***, ** and * denote 1, 5 and 10% levels of significance respectively

Next, we examine the influence of environmental quality, institutional quality, and foreign direct investment on trade openness based on the premise of cross-sectional dependence, which is established by using the CD test (see Table 3). The research adheres to the paradigm proposed by Chudik and Pesaran [49], also known as cross-sectionally enhanced ARDL.

Table 8's column [1-2] displays the findings for LIC. See column [1] for evidence that (a coefficient of 0.118), IQ (a correlation of 0.032), and FDI (a coefficient of 0.091) are positively correlated with trade openness over the long term. EQ (a coefficient of 0.134), IQ (a coefficient of 0.077), and FDI (a coefficient of 0.074) have a favorable impact on trade openness, as do EQ (a coefficient of 0.134), IQ (a coefficient of 0.077), and FDI (a coefficient of 0.074). In addition, the coefficient of the interacting term reveals a favorable relationship between FDI*EQ (coefficient of 0.041) and FDI*IQ (coefficient of 0.024) and trade openness. The sign of the error correction term for models -1 (a coefficient of -0.317) and -2 (a coefficient of -0.445) is negative and statistically significant at the 1% level, indicating the existence of long-

term convergence owing to initial shocks in independent variables. In addition, the evaluation of short-run elasticity demonstrated a positive relationship between environmental quality and trade openness (a coefficient of 0.018 in model -1 and a coefficient of 0.016 in model -2, respectively). Nonetheless, the impacts of IQ and FDI reveal mixed shocks, that is, a positive connection in Model-1 and a negative link in Model -1, although none of the coefficients are statistically significant.

Table 8 Results of Panel CS-ARDL estimation

	Coefficient	t-stat	std.error	Coefficient	t-stat	std.error
LONG RUN						
PPI	0.1795	0.0062	28.9516	0.0773	0.0053	14.5849
UR	0.1563	0.0104	15.0288	0.0784	0.0063	12.4444
GLO	0.06	0.0116	5.1724	0.0307	0.0102	3.0098
FDI	0.16	0.008	20	0.146	0.0075	19.4666
FD	0.0947	0.0044	21.5227	0.0651	0.0109	5.9724
short-run						
PPI	0.0419	0.0109	3.844	0.0774	0.0049	15.7959
UR	0.0343	0.0087	3.9425	0.0395	0.0112	3.5267
GLO	0.0202	0.0062	3.258	0.0626	0.0052	12.0384
FDI	0.044	0.0054	8.1481	0.0915	0.0104	8.798
FD	0.0128	0.0072	1.7777	0.1173	0.011	10.6636
	-0.1717	0.0069	-24.884	-0.0785	0.0092	-8.5326
CD test		0.020853			0.02896	
Wooldridge Test for autoco		0.505231			0.043698	
Normality test		0.967942			0.97501	
Remsey RESET test		0.073911			0.050846	

Note: ***/**/* denotes level of significance at a 1%/5%/10%, respectively

Next, we use a previously constructed asymmetric empirical model (see Equation 13) to evaluate potential asymmetric impacts ranging from environmental quality, institutional quality, foreign capital flows, and trade openness.

The long-term coefficients and symmetry test reports for Panel-A and the short-run coefficients and symmetry test for Panel-B are shown in Table 9, respectively. Long-term (panel-A of Table 11), all eight (8) tested models show a positive correlation between EQ, IQ, and FDI asymmetry shocks and trade openness. More specifically, for Low-Income-Countries, see Column [1-2], there are asymmetric effects in EQ, IQ, and FDI; for example, EQ+ (a coefficient of 0.033 in model-1 and 0.076 in model-2), EQ- (a coefficient of 0.056 in model-1 and 0.080 in model-2), IQ+ (a coefficient of 0.043 in model-1 and 0.096 in model-2), IQ- (a coefficient of 0.032 in Based on these results, it seems that there will be waves of either kind for changes in research variables related to trade openness. When looking at the elasticity of asymmetry, it is clear that negative shocks are more noticeable than positive shocks across the board. As a result, LIC nations must prevent any further reductions in institutional strength, ecological sustainability, or foreign direct investment (FDI). A panel of LMIC results are reported in columns [3-4]. Positive correlations between EQ, IQ, and FDI can be seen across all four models, with EQ+ (a coefficient of 0.163 in model-3 and 0.091 in model-4), EQ- (a coefficient of 0.068 in model-3 and 0.054 in model-4), IQ+ (a coefficient of 0.061 in model-3 and 0.052 in model-4), IQ- (a coefficient of 0.029 in model-3 and 0.019 in model-4), and FDI+ (The research shows that lower-middle-income countries are more susceptible to positive shocks that increase trade openness, thus it's important to take the steps needed to improve trade openness in terms of institutional quality, environmental quality, and inflows of foreign direct investment (FDI). However, economic results might be negatively impacted by lack of knowledge. Meanwhile, the data for high-income nations are shown in columns [5-6]. There is no doubt that EQ+ (a coefficient of 0. 284in model-5 and 0. 059in model-6), EQ- (a coefficient of 0. 148in model-5 and 0.052in model-6), IQ+ (a coefficient of 0. 069in model-5 and 0. 093in

model-6), IQ- (a coefficient of 0.089 in model-5 and 0.078 in model-6), and FDI+ (a coefficient of 0.071 in model-5 and 0.081 in model-6), Here, positive shocks are more pronounced in size than negative ones; however, reaping advantages is essential for moving beyond the current levels of EQ, IQ, and FDI. Therefore, the overall status of trade openness might be harmed by a downward tendency.

The short-run coefficient is shown in panel B of Table 9. Long-run convergence is detectable through the ECT coefficient owing to shocks in the explanatory variable in earlier years. At the 1% level of significance, all of the model ECT are significantly negative. Additionally, the asymmetry coefficient of environmental quality, i.e. positive and negative shocks, disclosed mixed direction of linkage, suggesting that EQ+ indicates both a positive and negative connection with trade openness. Positive and negative IQ shocks have opposite impacts on trade openness, and the coefficients are often positive and statistically significant. On the other hand, both positive and negative shocks in FDI reveal marginally significant impacts leaning in favor of further trade liberalization.

In the end, a typical Wald test is used to analyze the outcomes of symmetry tests under the null hypothesis of long- and short-term symmetry. By looking at the p-value of the Wald test, we can see that there is evidence of asymmetry in the impacts along the dimensions of environmental quality, institutional quality, foreign direct investment, and trade openness. This ruling is relevant to both a long-term and a quick inquiry. .

Table 9 Results of Nonlinear ARDL estimation

	LIC	
	[1]	[2]
Panel -A: Long-run Coefficients		
Υ^+	0.1166(0.062)[1.877]	0.0801(0.025)[3.166]
Υ^-	0.1331(0.047)[2.825]	0.088(0.036)[2.404]
μ^+	0.1512(0.059)[2.549]	0.0956(0.068)[1.387]
μ^-	0.1134(0.063)[1.785]	0.1024(0.05)[2.023]
β^+	0.0899(0.043)[2.052]	0.0665(0.059)[1.113]
β^-	0.0985(0.057)[1.725]	0.0991(0.025)[3.856]
EQ*FDI	0.0803(0.084)[0.955]	0.0768(0.06)[1.275]
FDI*IQ	0.0919(0.082)[1.111]	0.0767(0.026)[2.95]
<i>Symmetry test</i>		
W_{LR}^{EQ}	10.85	4.215
W_{LR}^{IQ}	5.146	4.558
W_{LR}^{FDI}	2.778	5.151
ζ	0.0156(0.006)[2.247]	0(0.002)[0]
π^+	-0.0002(0.006)[-0.03]	0.043(0.006)[6.505]
π^-	0.0174(0.007)[2.364]	0.0381(0.004)[8.447]
λ^+	0.0394(0.002)[14.379]	-0.0075(0.004)[-1.569]
λ^-	0.0166(0.007)[2.122]	-0.0064(0.007)[-0.815]
ϵ^+	0.0097(0.006)[1.534]	0.0281(0.002)[9.894]
ϵ^-	0.0143(0.008)[1.748]	0.0486(0.005)[9.31]
EQ*FDI	0.0126(0.008)[1.542]	-0.0097(0.005)[-1.649]
IQ*FDI	0.0035(0.006)[0.575]	0.0081(0.005)[1.454]

Symmetry test		
W_{SR}^{EQ}	8.138	10.099
W_{SR}^{IQ}	12.163	11.223
W_{SR}^{FDI}	10.67	11.05

Note: ***/**/* denotes level of significance at a 1%/5%/10%, respectively

Causality test with symmetry and asymmetry of EQ, IQ, FDI, and Trade openness

The following section deals with assessing directional causality by following the Non-granger causality framework familiarized by Toda and Yamamoto [50]. The study performs causal models with symmetric and asymmetric effects of EQ, ID, and FDI, and their results report in Table 10 and **Error! Reference source not found.1**, respectively.

The results of causality tests with the symmetric assumption unveil several causality effects running in the empirical models. However, considering the pattern of directional linked causalities are sub-grouped into two, i.e., bidirectional causality and unidirectional casually. Bidirectional causality refers to causal effects running in either direction. Study reveals the presence of *feedback hypothesis between* Institutional quality and trade openness [IQ \leftrightarrow TO] available in all panel countries; environmental quality and trade openness [EQ \leftrightarrow TO] available in UMIC, and foreign direct investment to trade openness [FDI \leftrightarrow TO] available in LMIC and UMIC. Furthermore, the study establishes a unidirectional causal effect running from environmental quality to trade openness [EQ \rightarrow TO] available in LIC, LMIC

Table 10 Results of causality test with symmetric effects

	TO	EQ	IQ	FDI	Causality remarks
Panel A: for lower-income countries					
		(3.1679)**[3.3389]	(2.0042)*[2.1124]	(3.8193)**[4.0255]	EQ \rightarrow TO; IQ \leftrightarrow TO; IQ \leftrightarrow EQ; FDI \leftrightarrow EQ; FDI \leftrightarrow IQ; TO \rightarrow FDI
EQ	(5.4771)***[5.7729]		(2.7577)*[2.9066]	(5.3825)***[5.6732]	
IQ	(2.0722)*[2.1841]	(4.2221)**[4.45]		(2.2061)*[2.3252]	
FDI	(3.4612)**[3.6481]	(2.4473)*[2.5795]	(2.5409)*[2.6781]		

Note: ***/**/* denotes level of significance at a 1%/5%/10%, respectively

Moreover, several empirical studies see [168-170] investigated directional causality by applying non-causality tests initiated by Dumitrescu and Hurlin [51]. The results causality test reports in Table . It is observable that the feedback hypothesis holds in explaining the causality between trade openness and environmental quality [TO \leftrightarrow EQ], institutional quality and trade openness [IQ \leftrightarrow TO], and foreign direct investment and trade openness [FDI \leftrightarrow TO].

Table 11 Non-causality test by applying Dumitrescu and Hurlin [51]

	TO	EQ	IQ	FDI
TO		(3.0828)**[3.2493]	(3.2082)**[3.3815]	0.849[0.8949]
EQ	(4.9426)***[5.2095]		1.7725[1.8683]	(4.3358)**[4.5699]
IQ	(3.7502)**[3.9527]	(4.6748)**[4.9272]		(1.9373)*[2.0419]
FDI	(5.4325)***[5.7258]	(3.0839)**[3.2504]	(3.7534)**[3.9561]	

Note: ***/**/* denotes level of significance at a 1%/5%/10%, respectively

5. Discussion of the study findings

The research findings indicate a positive correlation between environmental quality and the inflow of foreign direct investment (FDI) into low-income countries. Foreign direct investment (FDI) tends to be higher in countries that have more efficient pollution control measures, sustainable resource management practices, and stricter environmental regulations. In light of the importance of long-term sustainability and ethical business practices, this research

demonstrates that investors are progressively factoring in environmental considerations when making investment decisions. According to the research, there exists a significant correlation between institutional quality and FDI inflows in low-income nations. Countries exhibiting lower levels of corruption, stronger governance, and more transparent regulatory frameworks and legal systems are more prone to attract foreign direct investment (FDI). This highlights the significance of robust institutions in cultivating a hospitable atmosphere for foreign investors and mitigating their perceived risk.

The research has revealed an interaction impact between environmental attributes and institutional quality. The data suggests that countries possessing robust institutional quality have the potential to leverage their favorable conditions to draw in greater amounts of foreign direct investment. To rephrase, robust institutions provide the necessary framework for capitalizing on favorable circumstances and attracting investors. The findings hold noteworthy policy implications for developing countries that aim to draw foreign direct investment. Policymakers should prioritize effective pollution control methods, sustainable resource management techniques, and strict environmental legislation to enhance environmental quality. Efforts should be directed towards enhancing institutional quality through measures such as enhancing governance, augmenting transparency, and reducing corruption. Addressing these concerns could enhance a nation's competitiveness and attractiveness to potential investors. The report highlights the importance of implementing sustainable development strategies as a means of attracting foreign direct investment (FDI). The consideration of sustainability in the environment is gaining increasing importance among investors. Therefore, it is advisable for developing nations to prioritize sustainable development and integrate environmental concerns into their laws and practices as a means of boosting their Foreign Direct Investment (FDI) inflows. The findings of this study contribute to the existing literature on the determinants of foreign direct investment (FDI) in low-income countries. Specifically, the research underscores the importance of environmental factors and institutional quality in attracting FDI. The research offers a comprehensive framework for examining investment decisions and provides valuable insights into the changing preferences of foreign investors by expanding our understanding of the factors that influence FDI. It is imperative to highlight that the conclusions of the study are substantiated by both empirical inquiry and econometric modeling. The interpretation and generalization of the results should be approached with caution due to potential caveats in the study, such as incomplete data, a limited sample size, or a narrow focus on a single nation. The results of the study underscore the importance of environmental attributes and institutional quality as crucial predictors of foreign direct investment inflows in low-income countries, as previously discussed. The information presented herein may assist politicians, investors, and academics in advancing their objectives of sustainable development, enhanced governance, and a flourishing economy by enhancing the investment climate.

6. Conclusion and Policy Implications

The objective of the study is to assess the potential impact of environmental quality and foreign capital flows on trade openness in LICM countries from 1971 to 2018. The study conducts various empirical tests, such as panel ARDL based on Pesaran and Smith's approach, CS-ARDL based on Chudik and Pesaran's framework nonlinear Panel ARDL, and Toda and Yamamoto causality test with symmetry and asymmetry of EQ and FDI in the Equation. These tests aim to explore the impact of EQ, IQ, and FDI on trade openness by examining their patterns and magnitudes. The following are the key findings:

Initially, conventional unit root tests and unit root tests were conducted, with consideration given to cross-sectional dependency when specifying variables of integration. The study's findings indicate a varied order of integration. Specifically, researcher variables exhibit either stationary behavior at a level I (0) or after the first difference I (1). However, no variable demonstrates integration after the second difference. Moreover, the outcomes of the cross-sectional dependency assessment reveal shared characteristics present in the research variables.

Secondly, the evaluation of long-run cointegration is carried out by conducting a panel analysis as per Pedroni. ADF test as per Kao and Westerlund and Edgerton [164]. Based on the test statistics, there appears to be a long-term correlation among EQ, IQ, FDI, and trade openness. This implies that these variables may exhibit similar trends over an extended period.

Thirdly, the estimation of ARDL and CS-ARDL reveals the extent of the impact of environmental quality, and indicates that FDI is positively correlated with trade openness, particularly in the long run. The aforementioned findings indicate that the expansion of domestic trade through internationalization can be expedited by emphasizing environmental factors, enhancing institutional quality, and maintaining a steady influx of FDI. The aforementioned findings are substantiated by empirical literature. It has been advocated that the sharing of technological knowledge enables countries to attain a competitive position in the global business arena, thereby compelling them to undertake requisite measures for the development of institutional quality. In the economy, institutions of high quality create a competitive

edge over other nations and entice foreign investors to redirect their investments towards economies with superior institutional quality. In the short term, this text effectively argues that countries can enhance their domestic trade by improving their environmental development processes, establishing better institutions, and creating a favorable environment for foreign investors.

The results of the Wald test support the null hypothesis and indicate the presence of asymmetry in both the long and short run. All test statistics' associated p-values are statistically significant. In terms of the long-run coefficient assessment, it is apparent that trade openness is positively associated with both positive and negative shocks in environmental quality, institutional quality, and foreign direct investment. Based on the findings, it can be inferred that over a prolonged period, fluctuations in EQ, IQ, and FDI may result in trade openness. However, when it comes to environmental quality, negative shocks appear to have a greater impact than positive ones.

The aforementioned factors comprise environmental quality, institutional quality, and foreign direct investment (FDI). The findings underscore the correlation between environmental characteristics and institutional caliber in relation to their impact on investment decisions in developing countries with lower economic status. Based on the research findings, countries possessing favorable environmental characteristics and strong institutional frameworks are more inclined to receive greater levels of foreign direct investment. Moreover, it underscores the importance of responsible business practices and sustainable development practices in attracting global investors.

The subsequent policy proposals could be presented to enhance the inflow of foreign direct investment in lower-income countries. The aforementioned policy recommendations are derived from the findings of the conducted research. To improve environmental conditions, it is recommended that countries with lower incomes prioritize the protection of the environment and participation in environmentally responsible practices. Enhancing the efficacy of pollution control measures, implementing sustainable resource management practices, and enacting environmental legislation could potentially enhance the investment environment's attractiveness. The establishment of a sustainable and clean ecosystem is likely to attract the attention of environmentally-conscious investors and foster long-term economic growth.

To enhance the quality of institutions, policymakers ought to focus on improving governance structures, fostering transparency, and reducing corruption levels. Enhancing the quality of established institutions establishes a robust foundation for a conducive investment climate. This entails the implementation of efficient regulatory frameworks, the development of a well-defined legal system, and the elimination of bureaucratic obstacles to facilitate the investment process. Lower-income countries may enhance investor confidence and mitigate perceived risks by taking this measure. It is recommended that nations with lower per capita incomes prioritize sustainable development practices as a fundamental component of their economic policy, in order to promote sustainable development. Countries could potentially enhance their alignment with global sustainability objectives by incorporating environmental concerns into their development plans and prioritizing ethical economic practices. This strategy is poised to resonate with socially conscious investors and draw in foreign direct investment from companies committed to sustainable practices. To promote sustainable development and attract foreign direct investment, it is recommended that governments actively engage in public-private partnership activities. Collaborating with private businesses to address environmental concerns and improve institutional quality offers a primary advantage: the capacity to leverage experience, financial resources, and technological expertise. These collaborations possess the potential to contribute towards the development of a conducive investment environment and foster mutually beneficial ties between the public and private sectors.

To enhance data accessibility and transparency, it is recommended that governments prioritize the collection and dissemination of data. This will enable investors to access reliable and precise information. If data on environmental indicators, institutional quality, and economic performance are readily available and transparent, investors can make informed judgments based on accurate information. To enhance trust levels and attract additional foreign direct investment (FDI), it is recommended that national governments invest in data infrastructure and establish information exchange platforms. It is recommended to invest in initiatives that facilitate the creation of capacity and promote the transfer of knowledge. Countries with lower incomes can enhance their attractiveness to investors by investing in capacity-building initiatives and promoting knowledge transfer. The development of a skilled workforce, promotion of innovation, and establishment of favorable circumstances for technology transfer will not only attract foreign direct investment (FDI), but also enhance the country's long-term ability to achieve sustainable growth.

In summary, the research findings emphasize the significance of environmental attributes and institutional quality in the attraction of foreign direct investment (FDI) inflows in countries with lower incomes. Lower-income nations have the potential to create an attractive investment climate that is consistent with worldwide sustainability goals and fosters

economic expansion. This can be achieved by implementing policies and strategies that prioritize sustainable development, establishing robust institutions, and promoting transparency. These three pillars constitute the Sustainable Development Goals (SDGs). If the proposed policy ideas are implemented, they will contribute to the overall growth and prosperity of these nations.

Compliance with ethical standards

Disclosure of conflict of interest

There is no conflict of interest

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