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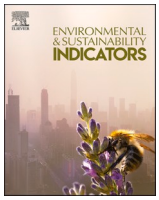

Analyzing financial development's moderating role on the investment-environmental quality nexus: Evidence from Australia using Autoregressive Distributed Lag approach

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ABSTRACT

Understanding the impact channels of financial development on environmental quality is vital for achieving desired environmental targets. While the direct impact of financial development on environmental quality has been extensively addressed, its indirect channel through investment has not been broadly explored. Thus, how financial development moderates the impact of domestic investments and foreign direct investments on environment can be an important research agenda. Therefore, this research purposes to study whether financial development moderates the impact of investments on environmental quality in Australia for the period from 1980 to 2021 using the Autoregressive Distributed Lag (ARDL) model. The key findings emphasize that financial development degrades environmental quality in Australia. Moreover, foreign direct investments have a positive effect on environmental quality, confirming the validity of the Pollution Halo Hypothesis in Australia. In contrast, domestic investments worsen environmental quality. Additionally, financial development does not mitigate the harmful impact of domestic investments on environmental quality. However, financial development plays a neutral role in moderating the impact of foreign direct investments on environmental quality while moderating the impact of domestic investment-environmetal quality relationship. These empirical findings provide diverse policy implications for ensuring environmental quality in Australia by strategically supporting both foreign and domestic investments.

1. Introduction

Currently, global economies are confronting environmental risks that present long-term threats to the ecological balance and human lives. Primarily, climate change stands out as the root cause of the environmental challenges currently being encountered worldwide. The contribution of toxic emissions from human activities and the depletion of resources largely exacerbates climate change (Xu and Liu, 2009). However, it extends beyond the borders of the emitters and has global impacts, affecting not only the present but also future generations. As such, it necessitates collective action to address the underlying causes in order to enhance a world that is suitable and livable for humans (Ruza and Caro-Carretero, 2022). Long-term collaborative strategies within global economies, such as Sustainable Development Goals, the Paris Agreement, etc. are particularly necessary to minimize environmental pollution. However, to achieve those targets, collaboration is required from all sectors, including households, the public sector, and the private sector.

Empirically, the literature extensively confirms that economic activities are key driving factors behind the environmental challenges faced by economies (Yiadom et al., 2023). Primarily, these economic activities are interconnected with the financial system of the economy, as it is the essence of the economy, sourcing and allocating financial resources to these activities (Yiadom et al., 2023). The financial system mitigates market failures and provides financial services to market participants, ultimately improving the economic status of the economy

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(Merton, 1995). Consequently, the financial system also has a direct responsibility regarding its financial allocations to address environmental issues and enhance environmental quality. To empirically address it, extant studies have dedicated substantial attention to examining the financial-environmental nexus. For example, studies by Tamazian et al. (2009); Charfeddine and Khediri (2016); Shahbaz et al. (2016); Yue et al. (2018); Adams and Klobodu (2018); Acheampong et al. (2020); Aluko and Obalade (2020); Ruza and Caro-Carretero (2022); and Xuezhou et al. (2022) have confirmed the direct impact of the financial system on the environment in the contexts studied.

The financial system of an economy provides a foundation for capital allocation among potential investment opportunities, monitoring, resolving information asymmetry, and risk diversification (Levine, 1997). Particularly, as the financial system in the economy develops, it enables more efficient financial services, which boosts economic growth. It enables financial providers to mobilize more savings towards profitable investment options available in the economy (Ndikumana, 2005). Additionally, financial development (hereafter FinD) allows institutions to enhance investments by reducing liquidity risk (Bencivenga and Smith, 1991). Furthermore, it lowers the cost of financing, which promotes capital investments in various sectors by eliminating constraints for investors (Ndikumana, 2005). Hence, well-developed in-house financial markets create a foundation for attracting domestic investments to the economy, which has a scale effect on the economy.

Meanwhile, existing wisdom strongly links the financial system to the channeling of foreign investments into the country. FinD enhances a country's attractiveness as a destination for foreign investments by improving capital allocation efficiency, reducing the cost of financing, mitigating risk, and ensuring a transparent and stable investment environment (Choong, 2012). Foreign investors primarily seek high-return investment opportunities with low transaction costs and access to diversified financial instruments and markets (Kaur et al., 2013). Additionally, foreign investments carry shared benefits for both the host and home economies. Primarily, they transfer technology, skills, and expertise to the host country, thereby improving economic output and overall economic wealth. Therefore, the presence of a well-developed financial system in the host economy is crucial for attracting foreign investors, as it is essential for bridging the savings-investment gap (Choong, 2012).

Importantly, capital investment sourced from both domestic and foreign sources increases the output level of the economy while impacting the environment either positively or negatively, relying on factors such as the nature of the investment and the regulatory environment of the economy. Primarily, the scale effect of these investments demands more resources in the production processes, ultimately leading to more toxic emissions and resource depletion (Yang et al., 2013). However, on a positive note, investments in energy-efficient technologies and the adoption of sustainable practices can positively impact the environment by reducing environmental degradation (Yang et al., 2013). More importantly, inefficient capital allocation can direct investments toward ventures that are unfavorable to the environmental sustainability.

From a sustainability perspective, both the financial system and investments should be responsible for addressing environmental aspects to create an environmentally healthy world. Therefore, FinD and investments inherently play a role in ensuring environmental quality (hereafter EnvQ). As discussed above, extant literature has empirically addressed the direct environmental impact of FinD. Similarly, a set of studies has examined the environmental impact of investments. However, most of these studies have focused on foreign direct investments (hereafter FDI), confirming their environmental impact through the Pollution Haven Hypothesis and the Pollution Halo Effect [see e.g., To et al., 2019; Doytch, 2020; Opoku and Boachie, 2020; Yiadom et al., 2023)]. But, there is an nonexistence of research works focusing on the environmental impact of domestic investments.

Prominently, existing empirical and theoretical understanding justifies that the financial system and its development are key factors in determining the investment level of an economy. It establishes an indirect link between FinD and the EnvQ through investment channels, indicating that FinD can either enhance or deteriorate EnvQ by facilitating investments. While existing scholarly works have extensively examined the direct environmnetal impact of FinD (See e.g., Acheampong et al., 2020; Shahbaz et al., 2013, 2017; Tamazian et al., 2009; Yue et al., 2018) and investments (see e.g., To et al., 2019; Doytch, 2020; Yiadom et al., 2023). The existing empirical evidence highlights the need to assess whether FinD can moderate the investment-EnvQ nexus to address the existing research gap. Only a few studies have addressed this issue, focusing primarily on the moderating role of FinD in the FDI-EnvQ nexus within specific contexts. This underscores the importance of examining how FinD moderates the broader investment-EnvQ nexus, considering both foreign and domestic investments, which are critical for economic progress. Hence, this study is dedicated to quantifying the moderating effect of FinD on the relationship between investment and EnvQ. Accordingly, the present research aims to examine the moderating impact of FinD on the investment-EnvQ nexus within a developed context—Australia—to provide evidence-based policy recommendations.

In 2023, Australia's investment accounted for a significant 24.3% of nominal GDP,[1] shaping the economic landscape. Additionally, domestic investment is key in Australia and tends to be larger than FDI (refer to Fig. 1). Australia's economy is characterized by a well-diversified economic structure and strong domestic investment capabilities. However, FDI focus on key areas that ensure national interest, such as national security, taxation, competition levels for domestic industries, and economic and community impact. Both domestic and foreign investments play vital roles in the Australian economy. Notably, the financial sector also comprised 7.4% of GDP,[2] making it the third-largest key sector of the economy. The Australian economy contributes approximately 1% of global emissions, underscoring the critical need for a prudent financial sector aligned with environmental sustainability. In this context, exploring the moderating role of financial system's growth helps understand whether Australia's financial system facilitates green investments effectively and contributes to meeting environmental targets. Additionally, understanding the FinD's moderating role on the investment-EnvQ nexus is essential for policymakers seeking to design strategies to achieve the carbon-neutral target by 2050, addressing the country-specific evidence gap in Australia.

Importantly, this study is novel because, to the best of our knowledge, it is the first empirical attempt to quantify the moderating impact of FinD on the investment-EnvQ nexus from a perspective not previously explored in the Australian context, thereby addressing a key contextual gap identified in the research. Insights from a developed country can serve as benchmarks for other developed nations striving to balance financial system-investments-environmental sustainability. Unlike prior work that often focuses solely on FDIs, this study provides new insights by examining how FinD moderates the environmental impact of both foreign investments and domestic investments, bridging the existing lack of evidence regarding the moderating role of FinD on domestic investments-EnvQ nexus. It significantly advances the study field by providing a comprehensive analysis of the investment-EnvQ relationship, with a specific focus on the type of investment. It enables a better understanding of how financial system can be leveraged for diverse investment types, crucial environmental policy-making. Moreover, as highlighted by Wijethunga et al. (2023), existing empirical works that modeled FinD and EnvQ typically quantified FinD through various dimensions, covering financial institutions and financial markets developments. However, existing studies have not fully captured FinD by using all its dimensions, including financial access, efficiency, depth,

[1] Australian Bureau of Statistics.
[2] Reserve Bank of Australia.

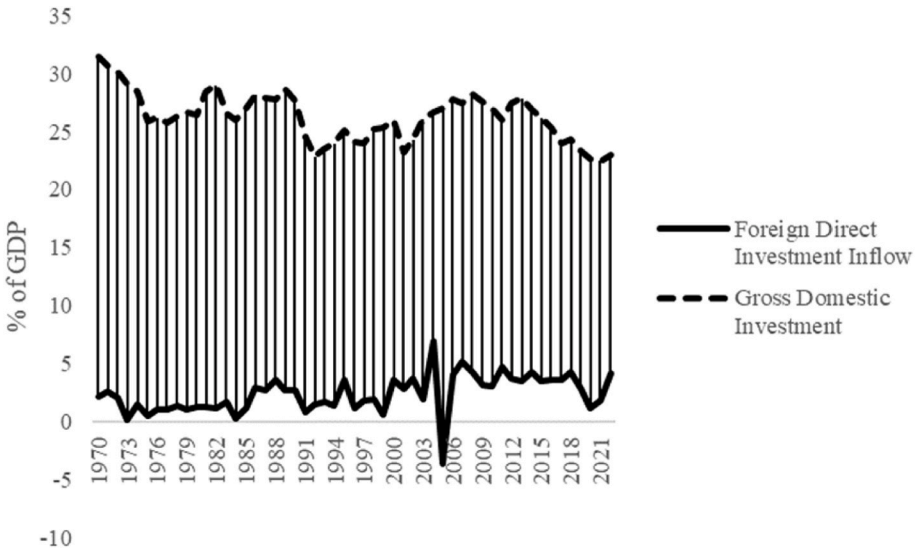

Fig. 1. Investments in Australia.
Data Source: World Bank.

and stability of financial institutions and financial markets. Thus, this study bridges that gap and stands unique among existing works by comprehensively capturing FinD.

Besides, the present empirical work makes substantial contributions to academics, researchers, and policymakers. These contributions include: (1) This study integrates the FinD-investments-EnvQ, offering an extensive framework for comprehending the moderating role of FinD in the investment-environment nexus; (2) It quantifies the moderating impact of FinD on the investment-environment link, thereby validating and challenging existing theories related to the investment-environment nexus; (3) By focusing on the Australian context, this study offers insights into how FinD interacts with investments to impact EnvQ in a developed economy. These insights can serve as valuable lessons for economies with similar economic and financial structures in making policy decisions to ensure EnvQ.

The remaining arrangement of the research paper is as follows. Section 2 outlines the theoretical foundation and reviews the empirical studies relevant to the field of study. Section 3 elaborates on the methodology adopted in the study, including model construction, data collection, and econometric estimation techniques. Section 4 elaborates the results of the econometric analysis and discusses the research findings. Section 5 wraps up the study by discussing its policy implications.

2. Literature review

2.1. Financial development and investments

The FinD-investment nexus is justified by various schools of thought in economics. Endogenous growth theory emphasizes that FinD facilitates efficient resource allocation and mobilization, which can lead to rapid economic growth. The financial system, including financial institutions and financial markets, helps overcome market frictions, leading to more productive investments and sustained economic progress. Similarly, neoclassical growth theory also underscores the FinD-investment relationship. It highlights that FinD affects the investment level of the economy by mobilizing savings into investments. This process enables capital accumulation, as the financial system expands the availability of funds necessary for investments, thereby enhancing the economy's capital accumulation. Another prominent theory, asymmetric information and agency theory emphasizes that information asymmetry between borrowers and lenders leads to market failures. However, FinD mitigates the problem of information asymmetry faced by both domestic and foreign investors. FinD ensures information symmetry in the financial market, promoting efficient investment opportunities for investors.

The theoretical framework outlined above emphasizes the significance of well-functioning financial markets and institutions within the financial system in facilitating investments. Importantly, FinD creates an environment that promotes investment by facilitating resource allocation and mobilization, reducing transaction costs, and ensuring information symmetry. A limited volume of studies have been conducted to examine the FinD-investment nexus empirically. Masih (1979) revealed that financial institutions, including both bank and non-bank financial institutions, facilitate the availability of funds in the economy, which in turn drives an increase in the level of private investments in the developing country of Pakistan. Furthermore, this study confirmed that FinD ensures the availability of funds for investments in the economy, which determines the level of investments more significantly than the interest rate. A prominent study by King and Levine (1993) confirmed that FinD is positively correlated with the accumulation of physical capital in the economy. It emphasized that FinD enhances the investment level within the studied context.

In line with Masih's (1979) empirical findings, Xu (2000) reaffirmed that FinD promotes domestic investments. Furthermore, Xu's (2000) study emphasized that investment serves as the fundamental channel through which FinD impacts economic growth. A prominent study by Ndikumana (2005) discovered that FinD positively impacts investments. However, the structure of the financial system does not significantly explain the level of domestic investments. Additionally, Sinha & Shastri (2021) revealed that both market-based and bank-based FinD significantly impact the investment level in the Indian economy. A recent study by He and Yoo (2024) evidenced that FinD increases the investment level in the studied context. However, differing from other studies, He and Yoo (2024) confirmed that this positive effect is valid only up to a specific threshold level; further development of the financial sector diminishes its positive impact on investments. Moreover, they confirmed that the FinD-investment nexus is influenced by the country's income level.

The extant literature has given less attention to modelling the FinD-domestic investment nexus. However, overemphasis on foreign investments, a substantial volume of studies has focused on linking FinD and FDI. Among those studies, Nasser and Gomez (2009) examined the relationship between FinD and FDI in Latin American economies, confirming that both stock market and banking sector development attract

FDIs to these economies. They further verified that FDIs do not flow to economies with underdeveloped financial systems. In line with Nasser and Gomez (2009), Hajilee and Nasser (2015) also affirmed that economies with developed financial systems host more FDIs than those with underdeveloped financial systems. However, opposing the above findings, Hausmann and Fernandez-Arias (2000) proved that more FDIs are attracted to countries with less FinD. Interestingly, Desbordes and Wei (2017) discovered that the FinD of both the host and home countries improves access to financial sources, which is significant in directly and indirectly attracting FDIs.

2.2. Investments and environmnetal quality

Besides, investments in diverse projects and business activities can influence the environment both positively and negatively. Investments in sustainable avenues, such as green technology and renewable energy, assist in achieving higher EnvQ. Conversely, investments that heavily utilize fossil energy resources and natural resources can adversely impact EnvQ (Liu et al., 2017). Importantly, theoretical understanding postulates the environmental impact of FDIs through three key theories: (1) the Pollution Halo Hypothesis, (2) the Pollution Haven Hypothesis, and (3) the Scale-Effect Hypothesis. The Pollution Halo Hypothesis suggests that FDIs have the potential to improve EnvQ because they often bring greener technologies and universal environmental standards to the host economy. The well-developed in-house financial system signals stability and transparency, thereby attracting foreign investments that prioritize environmental sustainability (Yiadom et al., 2023). In contrast, the Pollution Haven Hypothesis emphasizes that nations with lax environmental policies often tend to attract FDIs, which then degrade the EnvQ in the host countries. However, in practice, the financial system has the capability to mitigate the environmental damage caused by Pollution Heaven through green financing, regulatory enforcement, and the promotion of sustainable practices (Yiadom et al., 2023). The Scale-Effect Hypothesis, however, posits that while FDIs increase the host economy's output, they also contribute to higher environmental pollution (Pao and Tsai, 2011).

Empirically, Liu et al. (2017) revealed that domestic investments degrade EnvQ, whereas FDIs tend to enhance EnvQ in China. Importantly, scholars have given less attention to analyzing the environmental impact of domestic investments. However, the environmental consequences of FDIs have been extensively addressed by scholars. For example, Pao and Tsai (2011); Tang and Tan (2013); Ren et al. (2014); Zhang and Zhou (2016); and Liu et al. (2017) examined the environmental impact of FDIs and revealed diverse empirical results in the contexts they studied. From an Australian perspective, Wijethunga et al. (2024) validated the Pollution Halo Hypothesis, suggesting that the Australian economy is already attracting foreign investments that are favorable to the country's environmental conditions. However, evidence of the environmental impact of domestic investments remains absent in the Australian context.

2.3. Moderating impact of financial development in investment-environmnetal quality nexus

Interestingly, the financial sector directs capital flows towards investments in diverse projects and business activities, which ultimately affect the environment. As discussed above, FinD drives both domestic and foreign investments in the economy. In this context, the financial sector serves as a mediator in the economy, channeling funds toward investment activities. In view of existing empirical evidence, only a few studies have addressed the moderating role of FinD on investment-EnvQ nexus. Among those few studies, a study by Khan and Ozturk (2021) examined the direct and indirect effects of FinD on carbon emissions in developing economies. It discovered that the moderating impact of FinD on emissions is negative and statistically significant, implying that FinD mitigates the negative environmental impact of FDIs. Furthermore, the study confirmed the existence of the Pollution Haven Hypothesis in economies with weaker financial structures. However, it also confirmed that when FinD reaches a specific stage, the Pollution Haven Hypothesis ceases to exist. Similarly, Xu et al. (2021) explored the indirect effect of FinD on EnvQ through different channels in China. The results of Xu et al. (2021) contradict the empirical findings of Khan and Ozturk (2021), emphasizing that the moderating role of FinD through the investment channel degrades EnvQ.

Another empirical study by Udeagha and Breitenbach (2023) also attempted to examine the indirect impact of FinD through various pathways, including FDIs, in South Africa. In line with the findings of Khan and Ozturk (2021), Udeagha and Breitenbach (2023) confirmed the positive moderating role of FinD in enhancing EnvQ in South Africa by attracting foreign investments. Additionally, they confirmed that the underdevelopment of the financial system is a key factor for the existence of the Pollution Haven Hypothesis. Moreover, they found that if FinD reaches a certain level, the Pollution Haven Hypothesis ceases to exist in the economy. However, all these studies limited the measure of FinD to various financial institutional development measures and excluded financial market development indicators.

Importantly, Yiadom et al. (2023) study explored whether FinD in 43 Sub-Saharan African economies can overcome the adverse environmental impacts of FDIs. Unlike other studies, such as Khan and Ozturk (2021); Udeagha and Breitenbach (2023); and Xu et al. (2021), Yiadom et al. (2023) study considered three dimensions of FinD; financial access, financial depth, and financial efficiency. It empirically verified that financial depth and financial efficiency can mitigate the harmful effect of FDIs on the natural environment in the studied context. Additionally, in countries with an advanced financial system, financial depth and financial efficiency also mitigate the adverse environmental impacts of FDIs. However, FniD in less financially developed countries is ineffective in moderating the FDI-environmental relationship. However, these studies have entirely overlooked whether FinD moderates the environmental impacts of domestic investments, which play a catalytic role in economic progress and have notable environmental implications. Despite the extensive existing studies, several gaps remain unaddressed in this research domain. First, the extant literature primarily discovers the direct impact of FinD and FDIs on EnvQ. However, there is a lack of studies that focus on how FinD moderates the environmental impact of investments. Secondly, the existing literature has primarily focused on how FinD moderates the environmental impact of FDIs and neglected the nuanced differences in domestic investments' environmental impacts. As previously mentioned, a country's FinD is vital for promoting domestic investments, which ultimately affect the environment. However, whether FinD is able to moderate the environmental impact of domestic investments remains unexplored in the existing body of knowledge. Thirdly, to the best of our knowledge, no studies have explored the moderating role of FinD on EnvQ through the investment pathway, capturing all dimensions of FinD, including financial access, financial depth, financial efficiency, and financial stability. Finally, none of the existing studies have provided country-specific empirical facts for the Australian economy regarding the moderating impact of FinD on EnvQ via the investment channel. Therefore, this study addresses the aforementioned gaps to provide a broader empirical understanding of how FinD moderates the environmental consequences of FDIs and domestic investments, thereby contributing to evidence-based policy implications.

3. Methodology

To achieve the key objectives of the study, the construction of the conceptual framework and model, the data used, the econometric strategy employed, and the formulation of hypotheses are outlined in detail as follows.

3.1. Conceptual model

Fig. 2 depicts the conceptual model of this study, which includes variables grounded in empirical and theoretical foundations. Theoretically, the environmental impact of FinD is posited from two standpoints. The first standpoint is the adverse impact of FinD on EnvQ. FinD relaxes barriers to financial resources by lowering the cost of funding, thereby changing the consumption patterns of households and the production patterns of the business sector. This increased demand for resources and energy contributes to toxic emissions in the environment (Acheampong, 2019). The second standpoint is the positive effect of FinD on EnvQ. FinD can improve EnvQ by facilitating technological innovations, such as energy-efficient technologies (Tamazian et al., 2009; Acheampong et al., 2020). Extant empirical studies have revealed either positive or negative impacts of FinD on EnvQ across diverse contexts. This study also anticipates either a positive or negative impact of FinD on EnvQ in Australia.

As discussed in the literature review, FDIs can have either a positive or negative influence on the EnvQ of the host economy. Theoretically, the Pollution Haven Hypothesis emphasizes the adverse effect of FDIs on the host country's environment, while the Pollution Halo Hypothesis supports the positive impact of FDIs on EnvQ in the host country. Therefore, this study anticipates either a positive or negative impact of FDIs on Australia's EnvQ to validate either the Pollution Haven Hypothesis or the Pollution Halo Hypothesis. Similarly, domestic investments also significantly impact EnvQ in both positive and negative ways. Investments in manufacturing, mining, and non-renewable energy generation often result in toxic emissions that harm the environment (Shahbaz et al., 2013). Conversely, domestic investments in green technology and sustainable practices have a positive impact on the environment by reducing pollution (Shahbaz et al., 2013). This study expects either a positive or negative impact of domestic investments on EnvQ in Australia.

In the literature review section, we discussed the relationship between FinD and investments, emphasizing that FinD is crucial for attracting both FDIs and domestic investments. Based on this theoretical and empirical foundation, we propose the following hypothesis to test the moderating effect of FinD on EnvQ through the investment channel: FinD significantly moderates the either a positive or negative impact of FDIs/domestic investments on EnvQ in Australia. This study anticipates that FinD will influence how investments affect EnvQ, either enhancing or mitigating the environmental impacts of FDIs and domestic investments.

Understanding the relationship between economic growth and EnvQ is grounded in the Environmental Kuznets Curve (EKC) hypothesis. The EKC suggests that economic growth affects environmental degradation differently at various stages of economic development. Specifically, it suggests an inverted U-shaped relationship between economic growth and environmental degradation, indicating that in the short run, economic growth degrades the environment. However, when economic growth reaches a certain point, it begins to positively impact the environment. Following the EKC, a substantial volume of studies has discovered the economic growth-EnvQ relationship. Among these studies, Shahbaz et al. (2017) confirmed that economic growth does not contribute to an increase in carbon emissions in Australia. However, Marques et al. (2018) and Rahman and Vu (2020) presented contradictory evidence, indicating that Australia's economic growth degrades its EnvQ. Based on the existing mixed empirical evidence, this study predicts either a positive or negative impact of economic growth on EnvQ in Australia.

Generally, energy consumption is closely linked with economic growth, which increases the contribution of carbon emissions to the environment (Crompton and Wu, 2005; Nasreen et al., 2020). However, high dependency on non-renewable energy sources is the primary cause of environmental degradation and climate change, whereas renewable energy aids in improving environmental quality (Shahzad, 2020). Munir and Riaz (2020) revealed that increased consumption of non-renewable energy sources, such as oil, gas, and electricity, in Australia raises carbon dioxide levels in the environment. Similarly, Rahman & Alam (2022) empirically confirmed that non-renewable energy consumption in Australia deteriorates EnvQ. Based on existing empirical evidence and the fact that Australia heavily depends on non-renewable energy, this study anticipates that energy consumption degrades EnvQ in Australia.

Trade openness expands the scale of the economy, thereby increasing economic activities. This improvement in scale increases production and consumption habits, which negatively impacts the environment by degrading its quality (Le et al., 2016). Conversely, a country's level of trade openness can positively impact EnvQ through the technique effect. Trade openness can lead to higher income levels, which in turn drive greater economic development and the imposition of stricter environmental regulations (Antweiler et al., 2001). Additionally, trade openness encourages the adoption of cleaner production methods, thereby improving EnvQ (Antweiler et al., 2001; Copeland and Taylor, 2005). As a developed country, Australia is expected to experience a positive impact of trade openness on EnvQ. Similarly, Rahman & Vu (2020) confirmed that trade openness reduces carbon emissions in the Australian economy.

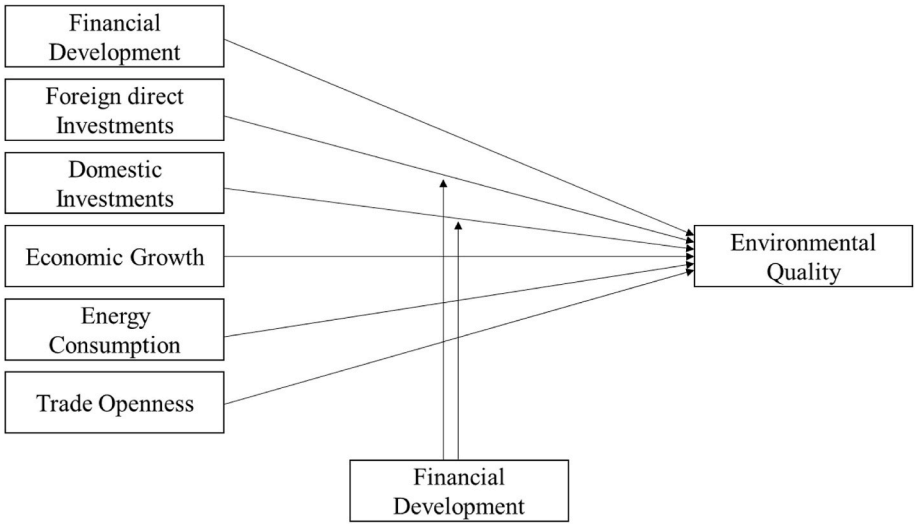

Fig. 2. Conceptual model: the moderating impact of FinD on EnvQ.

3.2. Model specifications, variable selection and data

To enhance the study's objectives, two different models are defined based on the model specifications used by Acheampong et al. (2020) and Rjoub et al. (2021). The primary model is designed to analyze the direct impact of FinD on EnvQ, alongside other explanatory variables examined in this study. These variables include FDI, domestic investments, energy consumption, trade openness, and economic growth,. The second model, the moderating model, introduces an interaction term to quantify the moderating role of FinD through the investment channel. It includes two interaction terms (FinD*FDI and FinD*DINV) to measure the indirect impact of FinD on EnvQ through FDI and domestic investment pathways. The general functions are given as follows: Equation (1) represents the general EnvQ function for the main model, while Equation (2) represents the general EnvQ function for the moderating model.

$$EnvQ = f(FinD, FDI, DINV, EG, ENG, TO) \quad (1)$$

$$EnvQ = f(FinD, FDI, DINV, EG, ENG, TO, (FinD^{*}FDI), (FinD^{*}DINV)) \quad (2)$$

Where EnvQ denotes environmental quality. Financial development, foreign direct investments, domestic investments, economic growth, energy consumption, and trade openness are represented by FinD, FDI, DINV, EG, ENG, and TO respectively. (FinD*FDI) and (FinD*DINV) represent the interactions between FinD and FDI, and between FinD and domestic investments, respectively.

The inclusion of variables in the model is grounded in the theoretical and empirical rationale outlined above section 2.1. Accordingly, the estimated economic models, represented by Equation (1) and Equation (2), are rewritten below as Equation (3) and Equation (4) in logarithmic terms to address the exponential variations in the proxy data used in the econometric estimations.

$$lnEnvQ_t = \alpha + \beta_1 lnFinD_t + \beta_2 lnFDI_t + \beta_3 lnDINV_t + \beta_4 lnEG_t + \beta_5 lnENG_t + \beta_6 lnTO_t + \varepsilon_t \quad (3)$$

$$lnEnvQ_t = \alpha + \beta_1 lnFinD_t + \beta_2 lnFDI_t + \beta_3 lnDINV_t + \beta_4 lnEG_t + \beta_5 lnENG_t + \beta_6 lnTO_t + \beta_7 (lnFinD^{*}lnFDI)_t + \beta_8 (lnFinD^{*}lnDINV)_t + \varepsilon_t \quad (4)$$

Where, $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7$, and β_8 represent the coefficients of the explanatory variables: FinD, FDI, domestic investments, economic growth, energy consumption, trade openness, and the interactions between FinD and FDI, as well as between FinD and domestic investments, respectively. ε indicates the error term of the estimation model, and t symbolizes time.

The econometric analysis uses annual frequency data due to its availability. The study period covers the years from 1980 to 2021. As noted in existing empirical works, FinD can be measured through various indicators. However, to address the gap highlighted by Wijethunga et al. (2023), the proxies utilized for FinD cover all its dimensions, including financial access, financial depth, financial efficiency, and financial stability. Therefore, the overall financial development index data from the IMF, along with bank credit to bank deposit (%) and stock market volatility (%), are used as proxies to measure FinD. The IMF financial development index measures three dimensions of FinD. To capture the excluded dimension of financial stability, stock market volatility (%) and bank credit to bank deposit (%) are included. This data is sourced from the Global Financial Development Database and Bloomberg, respectively. Following the study by Shujah-ur-Rahman et al. (2019), Principal Component Analysis (PCA) is used to construct the composite index for FinD. Table 1 summarizes the results of the PCA, which indicate that the extraction of the first component, with an eigenvalue greater than 1 (2.895735), explains 96.19% of the standardized variance.

Table 1
Principal component analysis for the composite financial development index.

Principal Components	Eigen Values	Proportion	Cumulative Proportion
1	2.895735	0.9619	0.9619
2	0.100926	0.0336	0.9955
3	0.003339	0.0045	1.0000
Financial Indicator	Eigenvectors (loading)		
Indicator 1	0.907643		
Indicator 2	0.704273		
Indicator 3	0.656931		

Source: Authors' calculations.

Indicator 1 is the overall financial development index of the IMF, Indicator 2 is bank credit to bank deposits (%), and Indicator 3 is stock market volatility (%). EnvQ is proxied by total greenhouse gas emissions. Most existing empirical works use carbon emissions to quantify EnvQ. However, greenhouse gas emissions provide a more comprehensive measure that captures diverse environmental impacts. This is because they include six different emissions, each affecting the environment to varying degrees. The greenhouse gas emission data are sourced from the World Bank Database and Australia's National Greenhouse Gas Emission Inventories. Additionally, economic growth, energy consumption, and trade openness are measured by GDP per capita, primary energy consumption per capita, and total exports and imports of goods and services, respectively. FDI as a percentage of GDP and fixed capital formation as a percentage of GDP are used as proxies to measure FDIs and domestic investments, respectively. Furthermore, a summary of the variables, their proxy measures, and the data sources is presented in Table 2.

3.3. Empirical estimation strategy

This study employs the Autoregressive Distributed Lag (ARDL) model as the primary econometric strategy, aligning with the methodology utilized by Shujah et al. (2019) to analyze the moderating impact of FinD on EnvQ. The ARDL model is particularly advantageous due to its flexibility in handling variables that are stationary at level series and first differencing stages (Pesaran et al., 2001). The ARDL approach is efficient for testing cointegration in small samples, making it preferable over other cointegration estimation techniques (Rjoub et al., 2021). The ARDL estimation method also allows for overcoming serial correlation and managing endogeneity issues by selecting appropriate lags (Pesaran and Shin, 1997). Additionally, the ARDL model allows for simultaneous estimation of short-run and long-run relationships, making it suitable for analyzing both immediate and sustained moderating impacts of FinD on investments-EnvQ nexus. The following Equations (5) and (6) present the ARDL models for the main model and the moderation model,

Table 2
Summary of proxy variables and source of data.

Variable	Proxy	Source of Data
EnvQ	Total greenhouse gas emissions (Metric tons)	National greenhouse gas emission inventories World Bank Database
FinD	Overall financial development index Bank credit to bank deposits (%)	International Monetary Fund Global financial development database
	Stock price volatility (%)	Bloomberg database
FDI	Foreign direct investment as a percentage of GDP	World Bank Database
DINV	Fixed capital formation as a percentage of GDP	World Bank Database
EG	GDP per capita (Current US$)	World Bank Database
ENG	Primary energy consumption per capita (kWh/person)	World Bank Database
TO	Total exports and imports of goods and services (% of GDP)	World Bank Database

respectively, as defined in Equations (3) and (4). Moreover, the Akaike Information Criterion (AIC) is applied as the basis for selecting the optimal lag length in the ARDL estimations.

$$\Delta lnEnvQ_t = \beta_0 + \sum_{i=1}^{p} \delta_1 \Delta lnEnvQ_{t-i} + \sum_{i=0}^{p} \delta_2 \Delta lnFinD_{t-i} + \sum_{i=o}^{p} \delta_3 \Delta lnFDI_{t-i} + \sum_{i=0}^{p} \delta_4 \Delta lnDINV_{t-i} + \sum_{i=0}^{p} \delta_5 \Delta lnEG_{t-i} + \sum_{i=0}^{p} \delta_6 \Delta lnENG_{t-i} + \sum_{i=0}^{p} \delta_7 \Delta lnTO_{t-i} + \beta_1 lnEnvQ_{t-1} + \beta_2 lnFinD_{t-1} + \beta_3 lnFDI_{t-1} + \beta_4 lnDINV_{t-1} + \beta_5 lnEG_{t-1} + \beta_6 lnENG_{t-1} + \beta_7 lnTO_{t-1} + \varepsilon_t \quad (5)$$

$$\Delta lnEnvQ_t = \beta_0 + \sum_{i=1}^{p} \delta_1 \Delta lnEnvQ_{t-i} + \sum_{i=0}^{p} \delta_2 \Delta lnFinD_{t-i} + \sum_{i=o}^{p} \delta_3 \Delta lnFDI_{t-i} \sum_{i=0}^{p} \delta_4 \Delta lnDINV_{t-i} + \sum_{i=0}^{p} \delta_5 \Delta lnEG_{t-i} + \sum_{i=0}^{p} \delta_6 \Delta lnENG_{t-i} + \sum_{i=0}^{p} \delta_7 \Delta lnTO_{t-i} + \sum_{i=0}^{p} \delta_8 (\Delta lnFinD_{t-i} * \Delta ln\ FDI_{t-i}) + \sum_{i=0}^{p} \delta_9 (\Delta lnFinD_{t-i} * \Delta ln\ DINV_{t-i}) + \beta_1 lnEnvQ_{t-1} + \beta_2 lnFinD_{t-1} + \beta_3 lnFDI_{t-1} + \beta_4 lnDINV_{t-1} + \beta_5 lnEG_{t-1} + \beta_6 lnENG_{t-1} + \beta_7 lnTO_{t-1} + \beta_8 (lnFinD_{t-1} * lnFDI_{t-1}) + \beta_9 (lnFinD_{t-1} * lnDINV_{t-1}) + \varepsilon_t \quad (6)$$

This study applied the bounds testing approach to confirm the long-run association between the variables, a requirement for estimating the long-run coefficients. Following this, an error correction model (ECM) was used to quantify the short-run dynamics. The ECMs for the main model and the moderating model are presented in Equations (7) and (8), respectively.

$$\Delta lnEnvQ_t = \delta_0 + \sum_{i=1}^{p} \delta_1 lnEnvQ_{t-i} + \sum_{i=0}^{p} \delta_2 \Delta lnFinD_{t-i} + \sum_{i=0}^{p} \delta_3 \Delta lnFDI_{t-i} + \sum_{i=0}^{p} \delta_4 \Delta lnDINV_{t-i} + \sum_{i=0}^{p} \delta_5 \Delta lnEG_{t-i} + \sum_{i=0}^{p} \delta_6 \Delta lnENG_{t-i} + \sum_{i=0}^{p} \delta_7 \Delta lnTO_{t-i} + \psi ECT_{t-1} + \varepsilon_t \quad (7)$$

$$\Delta lnEnvQ_t = \delta_0 + \sum_{i=1}^{p} \delta_1 lnEnvQ_{t-i} + \sum_{i=0}^{p} \delta_2 \Delta lnFinD_{t-i} + \sum_{i=0}^{p} \delta_3 \Delta lnFDI_{t-i} + \sum_{i=0}^{p} \delta_4 \Delta lnDINV_{t-i} + \sum_{i=0}^{p} \delta_5 \Delta lnEG_{t-i} + \sum_{i=0}^{p} \delta_6 \Delta lnENG_{t-i} + \sum_{i=0}^{p} \delta_7 \Delta lnTO_{t-i} + \sum_{i=0}^{p} \delta_8 (\Delta lnFinD_{t-i} * \Delta lnFDI_{t-i}) + \sum_{i=1}^{p} \delta_9 (\Delta lnFinD_{t-i} * \Delta lnDINV_{t-i}) + \psi ECT_{t-1} + \varepsilon_t \quad (8)$$

Ensuring the robustness of the fitted model is a crucial element in data analysis. Therefore, to test the robustness of the fitted ARDL models, we employed various residual diagnostic tests and stability diagnostic tests, including the serial correlation LM test, heteroskedasticity test, normality test, CUSUM test, and CUSUM of squares test. Additionally, to further assess the robustness, we re-estimated models 3 and 4 using the Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) methods.

4. Results and discussion

Table 3 presents the descriptive statistics of the logarithmic form of the dataset, which provides a foundation for understanding the characteristics of the data used in the study. The table indicates that LnFinD, LnFDI, LnENG, and LnTO are negatively skewed, meaning these data series are skewed to the left. LnEnvQ, LnDINV, and LnEG are approximately symmetric. All the variables follow a normal distribution, as none of them exhibit statistically significant Jarque-Bera values. Additionally, LnEQ, LnDINV, LnENG, and LnTO exhibit relatively low variability, while LnFD and LnFDI show relatively high variability. However, LnEG has moderate variability.

Confirming the order of integration in the data series is crucial for implementing the proposed econometric estimation, thereby advancing the study's objectives. The results of the Augmented Dickey-Fuller test, utilized to test the unit root, are provided in Table 4. Accordingly, LnFinD, LnDINV, and LnFDI are stationary at their level series, while the other variables are non-stationary at their level series. Even though, these non-stationary variables become stationary at the first-difference level. This indicates that the order of integration for variables is either I(0) or I(1), satisfying the prerequisites for applying the ARDL estimation technique.

Following the confirmation of the order of integration, two separate ARDL models were estimated: the main model and the moderating model. The optimal lag for each variable was determined using the Akaike Information Criterion (AIC). Accordingly, the ARDL model specified in Equation (5) is set as ARDL (1, 2, 1, 2, 1, 1, 1), and the ARDL model in Equation (6) is set as ARDL (1, 2, 1, 2, 1, 1, 1, 1, 1).

Next, the results of the cointegration test, conducted using the bounds test approach, are summarized in Table 5. The presence of a cointegration relationship among the variables is necessary to estimate the long-run effect of the explanatory variables on EnvQ in Australia. The results affirm the dismissal of the null hypothesis—that there is no cointegration among the variables—in support of the alternative hypothesis, which suggests that cointegration exists among the variables under study. This conclusion is supported by the fact that the F-statistic for both models is greater than the upper bounds. The results show a long-run equilibrium relationship among the variables estimated in Model 1 (LnEnvQ, LnFinD, LnFDI, LnDINV, LnEG, LnENG, LnTO) and Model 2 (LnEnvQ, LnFinD, LnFDI, LnDINV, LnEG, LnENG, LnTO, LnFinD*LnFDI, LnFinD*LnDINV), allowing for the estimation of long-run coefficients. The presence of a cointegration relationship indicates that the variables in each model move together in the long run. This suggests that targeting one variable through policy interventions may have predictable long-term impacts on other variables. The estimated results for the long-run coefficients are then shown in Table 6.

The results of Model 1, the main model, indicate that all the studied variables have a statistically significant impact on EnvQ in Australia. Overall, in long-run, FinD, domestic investments, economic growth, and energy consumption degrade EnvQ by contributing more greenhouse gas emissions to the Australian economy. However, FDIs and trade openness improve EnvQ in Australia. Specifically, a 1% increase in FinD leads to a 0.1352% increase in greenhouse gas emissions, indicating that improvements in the financial system degrade environmental conditions in Australia. This suggests that Australia's financial system is still directing financial flows towards profitable avenues rather than environmentally sustainable ones. This finding is consistent with the empirical arguments presented by Acheampong (2019); Charfeddine and Ben Khediri (2016).

Mainly, the results indicate that both FDIs and domestic investments impact EnvQ in Australia. However, these impacts show two distinct effects on EnvQ. A 1% change in FDIs affects EnvQ by 0.0801%. The negative sign of the coefficient further reveals that an increase in FDI flow to Australia reduces greenhouse gas emissions. This finding

Table 3
Descriptive statistics.

Description	LnEnvQ	LnFinD	LnFDI	LnDINV	LnEG	LnENG	LnTO
Mean	20.256	−0.652	0.581	3.280	10.192	11.065	3.631
Median	20.278	−0.357	0.642	3.546	9.995	11.092	3.676
Maximum	20.532	0.358	1.943	3.449	11.129	11.188	3.824
Minimum	20.012	−3.245	−1.553	3.128	9.230	10.884	3.351
Std. Dev.	0.1359	1.031	0.769	0.074	0.616	0.086	0.133
Skewness	0.0010	−0.613	−0.895	−0.012	0.100	−0.458	−0.487
Kurtosis	2.1084	3.884	3.928	2.661	1.604	1.962	1.959
Jarque-Bera	1.390	2.353	2.949	0.201	3.479	3.351	3.557
Probability	0.498	0.436	0.309	0.904	0.175	0.187	0.168
Sum	850.778	−27.398	23.836	137.79	428.092	464.738	152.506
Sum Sq. Dev.	0.758	43.602	23.689	0.225	15.564	0.306	0.726

Source: Authors' calculations

Table 4
The results of unit root test.

Variable	Level series	1st difference	Order of integration
LnEnvQ	−1.4870	−6.5864***	I(1)
LnFinD	−2.7314*	−7.4207***	I(0) & I(1)
LnFDI	−4.2030***	−10.6610***	I(0) & I(1)
LnDINV	−2.7856*	−5.4174***	I(0) & I(1)
LnEG	−0.8705	−4.9901***	I(1)
LnENG	−1.2291	−5.1973***	I(1)
LnTO	−1.4550	−5.9829***	I(1)

Note: *** & * denote significance at 1% and 10% level, respectively.
Source: Authors' calculations.

Table 5
The results of the cointegration test.

Model 1			Model 2		
F-statistic	5.3716[a]		F-statistic	6.3975[a]	
k	6		K	8	
Critical Values	*I (0)*	*I (1)*	*Critical Values*	*I (0)*	*I (1)*
10%	*1.98*	*2.94*	*10%*	*1.85*	*2.85*
5%	*2.26*	*3.29*	*5%*	*2.11*	*3.15*
1%	*2.87*	*3.98*	*1%*	*2.62*	*3.77*

[a] denotes significance at 1% level.
Source: Authors' calculations.

supports the presence of the Pollution Halo Hypothesis. In the Australian economy, several factors contribute to the presence of the Pollution Halo Hypothesis, including stringent environmental regulations that all foreign investors must adhere to and technological transfers and innovations that promote the adoption of efficient technologies and cleaner production methods, thereby improving EnvQ. The environmental impact of domestic investment has shown an adverse effect on EnvQ in Australia. Statistically, it is confirmed that a 1% increase in domestic investments contributes to a 1.1389% increase in greenhouse gas emissions, which degrades the EnvQ in Australia. This finding aligns with the argument of Shahbaz et al. (2013). A significant portion of Australia's domestic investments flow into resource-intensive industries such as mining and agriculture, which lead to increased greenhouse gas emissions, thereby harming EnvQ.

Moreover, Australia's economic progress contributes to increased greenhouse gas emissions. This study confirmed that a 1% increase in economic growth results in a 1.5835% increase in toxic emissions. This finding reaffirms the existing evidence for Australia presented by Marques et al. (2018) and Rahman and Vu (2020) and it contrasts with the findings of Shahbaz et al. (2017). The possible reason behind the adverse impact of economic growth on environmental quality is that Australia's economy has traditionally relied on industries like mining, agriculture, and fossil fuel extraction, which are resource-intensive and environmentally degrading. As we anticipated, energy consumption also

Table 6
The results of the long-run effects.

Model 1-Direct impact				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LnFinD	0.1352	0.0432	3.1296	0.0000***
LnFDI	−0.0801	0.0218	−3.6743	0.0000***
LnDINV	1.1389	0.3265	3.4882	0.0000***
LnEG	1.0897	0.4625	2.3559	0.0270**
LnENG	2.8430	1.0052	2.8281	0.0093***
LnTO	−3.7774	0.7754	−4.8714	0.0001***
C	−43.4833	8.6836	−5.0074	0.0000***
R-squared	*0.8324*		*F-statistic*	*9.1632*
Adjusted R-squared	*0.7414*		Prob*(F-statistic)*	*0.0000*
Model 2- Indirect impact				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LnFinD	18.4198	10.6289	1.7329	0.0978*
LnFDI	−0.0658	0.0288	−2.2847	0.0342**
LnDINV	1.6360	0.9233	1.7719	0.0909*
LnEG	1.5835	0.5390	2.9377	0.0079***
LnENG	3.9693	1.2571	3.1572	0.0048***
LnTO	−3.2034	0.7170	−4.4673	0.0002***
LnFinD*LnFDI	0.1181	0.1392	0.8484	0.4058
LnFinD*LnDINV	5.2831	1.0853	4.8678	0.0001***
C	−70.0127	16.5826	−4.2220	0.0004***
R-squared	*0.8844*		*F-statistic*	*10.0451*
Adjusted R-squared	*0.7963*		Prob*(F-statistic)*	*0.0000*

Note: ***, ** & * denote significance at 1%, 5%, and 10% level, respectively.
Source: Authors' calculations.

adversely affects the EnvQ of Australia. Statistically, the ARDL long-run coefficients revealed that a 1% increase in energy consumption degrades the environment by adding 2.8430% to greenhouse gas emissions. Notably, Australia's energy consumption is predominantly sourced from fossil fuels—coal, oil, and gas—accounting for 90%, which significantly contributes to emissions in the atmosphere. The energy consumption-environment relationship revealed in this study is consistent with the findings of prior research by Rahman and Alam (2022). Importantly, trade openness shows a positive impact on EnvQ in Australia. The ARDL estimations imply that a 1% increase in trade openness contributes to a 3.7774% reduction in greenhouse gas emissions. This finding suggests that the Australian economy benefits environmentally from increased trade, likely due to the technology effect. Furthermore, it reaffirms the trade-environment relationship identified in prior studies by Antweiler et al. (2001); Copeland and Taylor (2005); and Rahman and Vu (2020).

The results of Model 2, the moderating model, are presented in the second section of Table 6. In line with the long-run coefficient results of the main model, the moderating model likewise demonstrates that FinD, domestic investments, economic growth, and energy consumption worsen the quality of the environment. In contrast, FDIs and trade openness improve EnvQ in Australia. In the long run, a 1% improvement

in Australia's financial system increases emissions by 18.4198%, exacerbating environmental pollution in the country. Notably, the long-run coefficient for FinD in Model 2 is greater than the corresponding coefficient in the main model. This divergence can be attributed to the inclusion of interaction terms in the moderating model estimations, which are not captured in the main model.

Additionally, the relationship between FDI and EnvQ is statistically significant in the long run, indicating that FDI supports to improving EnvQ in Australia, thereby establishing the presence of the Pollution Halo Effect. However, the relationship between domestic investment and EnvQ suggests an opposing impact, as domestic investment appears to have an adverse effect on the environment, contributing to a decline in EnvQ. Moreover, economic growth and energy consumption contribute to environmental pollution by increasing greenhouse gas emissions in the long run. Conversely, trade openness brings environmental benefits to the Australian economy, improving the EnvQ.

As shown in Table 6, the coefficients of (LnFinD*LnFDI) and (LnFinD*LnDINV) evaluate whether FinD moderates the impact of investments on Australia's EnvQ in the long run. The results indicate that the coefficient for (LnFinD*LnFDI) is statistically insignificant in the estimated ARDL long-run coefficients. This suggests that the combined impact of changes in both FinD and FDI on EnvQ is statistically insignificant, indicating that FinD does not have a moderating effect on EnvQ through the FDI channel. Additionally, in both models, statistically significant coefficients of FDI support the Pollution Halo Hypothesis in Australia. However, the combined impact of FinD and FDI indicates that the Pollution Halo Hypothesis is no longer present in the Australian context. In summary, FDI may independently drive improvements in EnvQ by introducing cleaner technologies, better environmental management practices, or advanced expertise, which are not reliant on the level of FinD. Australia's policies encouraging sustainable practices in foreign investments could make FDI environmentally beneficial in long run, even in the absence of FinD's moderating role. Notably, these findings are contradictory to the existing findings of Xu et al. (2021); Khan and Ozturk (2021); Udeagha and Breitenbach (2023); and Yiadom et al. (2023).

Conversely, the coefficient for (LnFinD*LnDINV) is estimated to be 5.2831 and is statistically significant at the 1% level. This suggests that a 1% increase in FinD and domestic investments, as captured by the combined effect (LnFinD*LnDINV), leads to a 5.2831% increase in greenhouse gas emissions. This indicates that the combined effect of FinD and domestic investments worsens EnvQ in the long run. Notably, both Model 1 and Model 2 show that domestic investment has an adverse impact on EnvQ, with coefficients of 1.1389 and 1.6360, respectively. The coefficient for (LnFinD*LnDINV) further confirms that FinD and domestic investments together have a more significant negative impact on the environment than either would individually. This suggests that Australia's FinD encourages domestic investments in sectors that are environmentally unsustainable, such as those with high natural resource utilization. Additionally, it suggests that FinD has a greater negative impact on the environment through the domestic investment channel, rather than through its direct effects.

The econometric estimations of the short-run model are stated in Table 7. The short-run estimates of the main model reveal that all variables impact EnvQ, except for FDI and trade openness. A 1% increase in FinD effects in a 0.9913% upsurge in emissions, thereby harming EnvQ. The immediate impact of FinD on EnvQ is consistent with its long-run impact, though the short-run impact is greater. The finding shows that FDI does not significantly contribute to improving EnvQ in the short run but does contribute in the long run can be attributed to the fact that the positive environmental impacts of FDI, such as technology transfer, the adoption of greener production processes, or improvements in environmental practices, may take time to materialize. In the short term, FDI may focus on setting up operations, while long-term environmental improvements require time to integrate. However, domestic investment is detrimental to EnvQ in the Australian context. Specifically, a 1% increase in domestic investment leads to a 1.6538% rise in emissions, worsening EnvQ. Notably, the short-run environmental impact of domestic investments is slightly higher than the long-run impact. Among the other observed coefficients, energy consumption and economic

Table 7
The results of the short-run effects.

Model 1- Direct impact				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LnFinD)	0.4768	0.3824	1.2467	0.2245
D(LnFinD (−1))	0.9913	0.4144	2.3920	0.0249**
D(LnFDI)	0.0022	0.0271	0.0827	0.9348
D(LnDINV)	0.2556	0.5499	0.4648	0.6463
D(LnDINV (−1))	1.6538	0.6051	2.7330	0.0116**
D(LnEG)	2.8825	1.0624	2.7131	0.0105**
D(LnENG)	2.6975	1.1306	2.3859	0.0238**
D(LNTO)	−0.7926	0.4651	−1.7038	0.1013
CointEq(-1)*	−0.9261	0.1243	−7.4503	0.0000***
R-squared	*0.7107*		*Durbin-Watson stat*	*1.6196*
Adjusted R-squared	*0.6547*			
Model 2-Indirect impact				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(LnFinD)	2.9076	4.4302	0.6563	0.5187
D(LnFinD(-1))	1.7874	0.3827	4.6698	0.0001***
D(LnFDI)	0.0667	0.0217	3.0635	0.0059***
D(LnDINV)	1.2405	0.5008	2.4770	0.0218**
D(LnDINV(-1))	1.7538	0.5059	3.4666	0.0023***
D(LnEG)	3.1103	1.2758	2.4379	0.0028***
D(LnENG)	3.9205	1.1485	3.4134	0.0019***
D(LnTO)	−0.6589	0.3862	−1.7057	0.1028
D(LnFinD*LnFDI)	0.0236	0.0471	0.5009	0.6206
D(LnFinD*LnDINV)	0.1359	0.0512	2.6534	0.0134**
CointEq(-1)*	−0.874959	0.091523	−9.560002	0.0000***
R-squared	*0.8006*		*Durbin-Watson stat*	*1.7265*
Adjusted R-squared	*0.7541*			

Note: *** & ** denote significance at 1% and 5% level, respectively.
Source: Authors' calculations.

growth significantly worsen EnvQ in the short run. In addition, the ECT reveals that EnvQ adjust back to equilibrium after changes in all the studied variables at a rate of 92.61%.

The observed coefficient of FinD in the moderation model provides evidence that FinD reduces EnvQ. However, the short-run impact of FinD is substantially smaller than its long-run impact. Contrary to its long-run impact, the short-run impact of FDI indicates that it does not contribute to a healthier environment. For instance, a 1% increase in FDI results in a 0.0667% deterioration in EnvQ. This finding contrasts with the estimated short-run results of the main model as well. Consistent with the long-run estimations, the immediate impact of domestic investments also worsens EnvQ. Specifically, a 1% increase in domestic investments results in a 1.2405% rise in greenhouse gas emissions. Additionally, the short-run elasticity of domestic investment is slightly lower than its long-run elasticity. The estimated short-run results further reveal that economic growth and energy consumption worsen EnvQ in Australia.

In the short-run estimations, the results show that FinD does not moderate the impact of FDIs on EnvQ. This is consistent with the results observed in the long-run estimations. It indicates that FinD does not alter the relationship between FDIs and EnvQ in either the long run or the short run. In other words, regardless of the level of FinD, the effect of FDIs on EnvQ remains constant. However, the effect of domestic investments on EnvQ changes with the level of FinD in Australia. According to the short-run estimations, a 1% combined increase in FinD and domestic investments worsens EnvQ by 0.1359%. In the short run, Australia's FinD moderates the impact of domestic investments on EnvQ by worsening it. However, the short-run impact is significantly less than its long-run impact. Finally, Fig. 3 graphically portrays the long-run and short-run impacts as revealed by the ARDL estimations.

To generalize the findings, the reliability of the results can be ensured using various robustness tests. The results of the serial correlation test, heteroskedasticity test, and Jarque-Bera test, as presented in Table 8, confirm the absence of serial correlation and heteroskedasticity, and indicate that the residuals follow a normal distribution in both estimated ARDL models. Additionally, the results of the CUSUM and CUSUM of Squares tests, shown in Figs. 4 and 5, demonstrate the stability of the parameters in the ARDL models over time.

Table 8
The results of diagnostic tests.

Diagonostic test	Model 1	Model 2
Jarque-Bera	0.3499 [0.8394]	0.6639 [0.7175]
Breusch-Godfrey Serial Correlation LM Test	0.5566 [0.6066]	0.2144 [0.8089]
Heteroskedasticity Test: Breusch-Pagan-Godfrey	0.7277 [0.7203]	0.5824 [0.8633]

Parenthesis "[.]" indicates the probability values.

To improve the reliability of the estimated results, the study applied Fully Modified Ordinary Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) to re-evaluate both the main model and the moderating model, as detailed in Equations (3) and (4). The estimated results are summarized in Table 9. As shown, all the modeled variables are statistically significant in the Model 1 estimations. This clearly suggests that FinD, domestic investments, economic growth, and energy consumption worsen EnvQ, while FDI and trade openness improve EnvQ. Like the ARDL long-run estimations, the FMOLS and DOLS estimations confirm the same impacts on the environment and further support the presence of the Pollution Halo Hypothesis in Australia. The results of the moderation model FMOLS and DOLS estimations are also consistent with the moderation model estimations of the ARDL model. Additionally, the findings verify that FinD moderates the impact of domestic investments on EnvQ, whereas FinD does not moderate the impact of FDI on EnvQ.

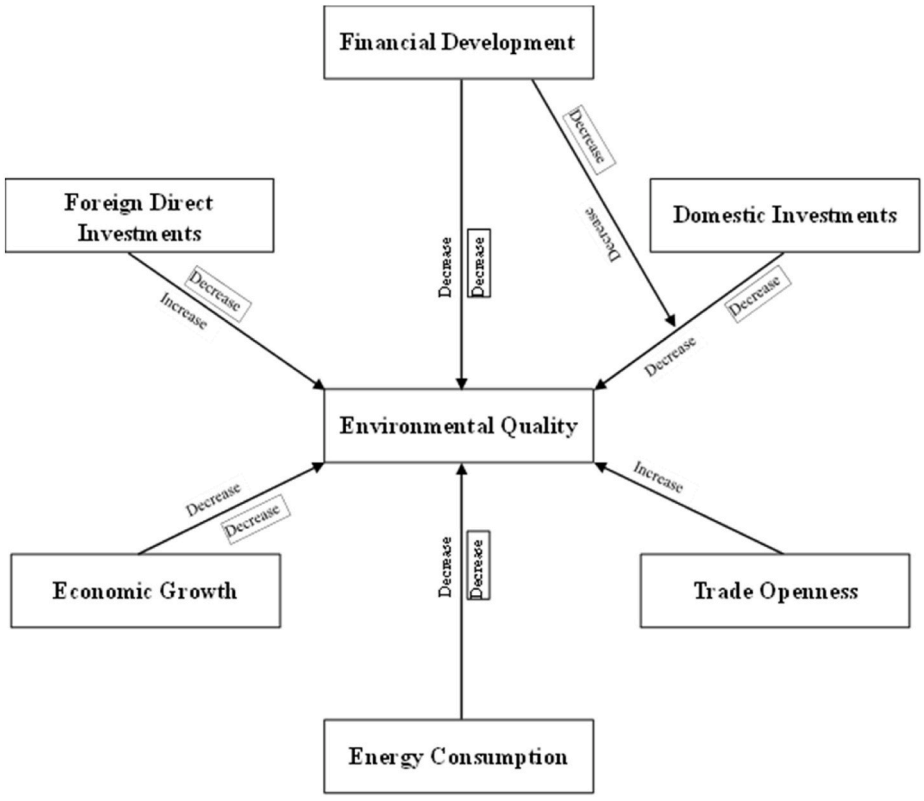

Fig. 3. Long-run and short-run impacts on EnvQ.
Note: Long-run impacts are depicted without rectangles, while rectangles represent short-run impacts.

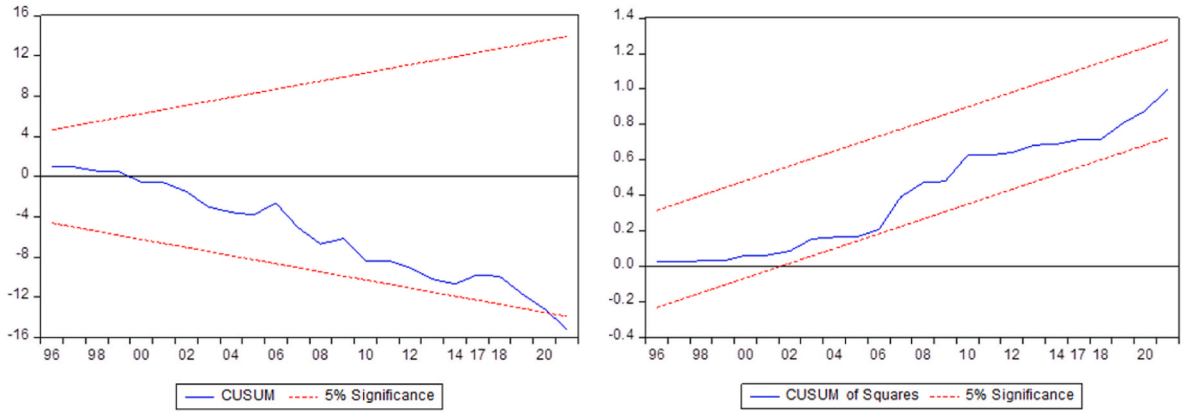

Fig. 4. Stability diagnostics of ARDL model 1.

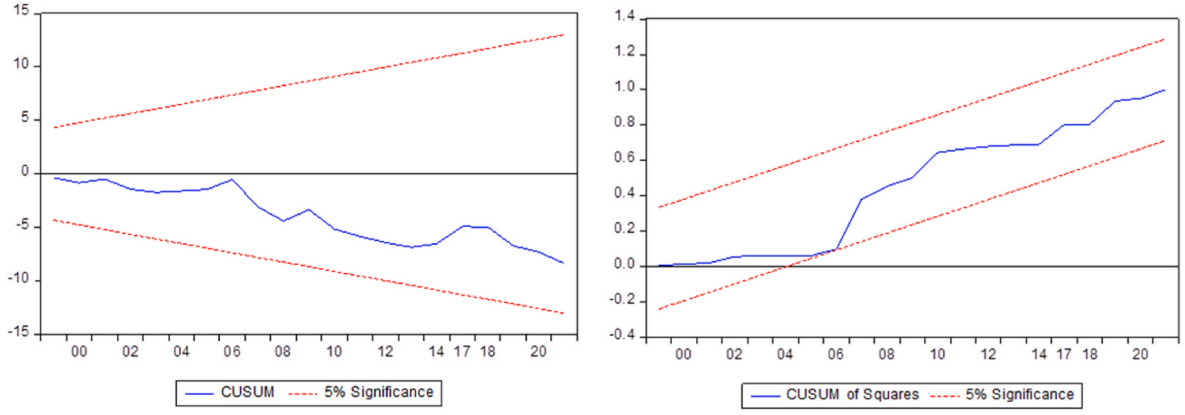

Fig. 5. Stability diagnostics of ARDL model 2.

Table 9
The results of FMOLS & DOLS tests.

Variable	Model 1- Direct impact		Model 2-Indirect impact	
	FMOLS	DOLS	FMOLS	DOLS
LnFinD	0.4483** (0.0546)	0.2733** (0.0283)	−11.3802** (0.0368)	6.3136** (0.0183)
LnFDI	−0.0535** (0.0398)	−0.0622** (0.0356)	−0.0590* (0.0729)	−0.2871** (0.0211)
LnDINV	0.2044** (0.0372)	1.9552* (0.0539)	0.7548** (0.0209)	9.0369** (0.0281)
LnEG	0.7585* (0.0540)	0.6975** (0.0473)	1.0471** (0.0296)	0.9329* (0.0577)
LnENG	2.9446*** (0.0007)	4.4951*** (0.0059)	3.6623*** (0.0013)	4.4261*** (0.0061)
LnTO	−2.1130*** (0.0002)	−4.4956*** (0.0002)	−1.7179*** (0.0031)	−1.8867* (0.0821)
LnFinD*LnFDI	–	–	−0.0787 (0.4735)	−0.3284 (0.4808)
LnFinD*LnDINV	–	–	3.1455** (0.0447)	23.3131** (0.0272)
C	−41.1147*** (0.0000)	−53.8687*** (0.0003)	−58.3093*** ((0.0000)	52.1502 (0.0000)
R-squared	*0.8299*	*0.9325*	*0.8796*	*0.9960*

Note: ***, ** & * denote significance at 1%, 5%, and 1% level, respectively.
Source: Authors' calculations.

5. Conclusion and policy implications

FinD plays a nuanced role in the economy, ultimately impacting the environment in ways that are significant for maintaining a livable atmosphere for humans. Therefore, analyzing the direct and indirect impacts of FinD on EnvQ is vital for policy implications. To bridge the existing empirical gap, this study explores whether FinD moderates the impact of investments on EnvQ in Australia. For this purpose, we employed the ARDL estimation technique over the period from 1980 to 2021 with two models: a main model and a moderating model. The key findings reveal that: (1) FDIs improve environmental quality in the long run, while domestic investments worsen EnvQ. This validates the presence of the Pollution Halo Hypothesis in Australia. However, in the short run, the Pollution Halo Hypothesis does not exist, and domestic investments have a similar impact as in the long run; (2) FinD worsens EnvQ in both the long run and the short run; (3) FinD moderates the impact of investments on EnvQ, but this moderation effect is significant only for domestic investments. The role of FinD in moderating the impact of FDI on EnvQ is neutral; (4) economic growth and energy consumption degrade EnvQ, while trade openness helps improve EnvQ.

The study's empirical findings have diverse policy implications applicable to Australia and other developed economies. The results indicate that FinD significantly impacts EnvQ by channeling funds to profitable investment avenues rather than environmentally sustainable

ones. Therefore, governing bodies should collaborate with financial markets and institutions to initiate green financing projects and policies that enforce strict environmental standards, ensuring that financial resources flow into environmentally healthy investments while maintaining profitability. Additionally, governing bodies should also regularly monitor the lending and investment activities of financial institutions through environmental risk assessments to ensure sustainable investments. FDI improves environmental quality in Australia in the long run, this presents a promising opportunity to leverage FDI as a tool for sustainable development. However, the Australian government should take action to maximize the long-term environmental benefits of foreign investments while mitigating their short-term environmental drawbacks. To this end, the government can offer targeted financial incentives, such as tax breaks, subsidies, or low-interest loans, to attract FDI in environmentally sustainable sectors such as renewable energy, energy efficiency technologies, waste management, and sustainable agriculture. By prioritizing green projects, the positive environmental impact of FDI can be maximized. The environmental regulations and standards related to foreign investments should be further strengthened, mandating adherence to sustainable practices. Particular attention should be paid to foreign investments in mining and other resource-extraction industries.

Despite the policy recommendations mentioned above, this study offers unique suggestions that deviate from existing works in this research domain. The finding that domestic investments degrade environmental quality in Australia has significant policy implications, particularly in guiding future investment strategies, regulatory frameworks, and financial incentives. For that, the government should strengthen environmental regulations for domestic investments, particularly in industries that have a significant environmental impact. Implement or reinforce pollution control measures, such as carbon taxes or emissions cap-and-trade schemes, for industries with high environmental degradation. Policies should target reducing air and water pollution, waste, and greenhouse gas emissions from domestic industries. Since FinD moderates the impact of domestic investments on EnvQ, policies could aim to strengthen financial markets to facilitate greater access to green financing for domestic firms. This could include developing specialized green bonds, sustainable investment funds, and providing subsidies or tax incentives for domestic firms engaging in environmentally beneficial activities. Policies could focus on promoting domestic investments in clean technologies, renewable energy, and sustainable industries through financial instruments that directly link environmental sustainability with financial returns. This could include providing favorable loan conditions or investment guarantees for projects that meet certain environmental standards. Moreover, transitioning conventional production processes to sustainable ones by adopting energy-efficient practices and shifting towards renewable energy with the support of the financial sector is essential for ensuring a healthy environment.

This study contributes to the literature by providing empirical evidence on the long-term and short-term effects of FinD, domestic investment, and FDI on EnvQ in Australia. It highlights the moderating role of FinD in shaping the impact of investments on EnvQ, offering new insights into the potential trade-offs between economic growth and sustainability. This research underscores the importance of integrating sustainability into FinD and investment strategies. The findings suggest that promoting FDI in environmentally friendly industries and fostering green domestic investments through regulatory frameworks could be essential in meeting global climate goals. Policymakers and financial institutions should consider these dynamics when designing policies that encourage the transition to a low-carbon economy, aligning policies with environmental objectives.

Even though this study presents valuable insights, there are several limitations that need to be recognized to identify areas for future research. Primarily, this study is limited to the period from 1980 to 2021 due to the availability of FinD data. Furthermore, the study considered FinD proxies that cover financial markets and financial institutions. However, due to data limitations, it excluded proxies that would cover aspects of financial stability in markets such as the debt market and insurance market. Therefore, this study opens opportunities for future researchers to extend the analysis using data up to more recent years and to consider diverse proxies to capture FinD comprehensively. Moreover, this study suggests avenues for future research to conduct micro-level analyses, such as examining the moderating role of FinD on the impact of investments on EnvQ in various industries like mining and agriculture. Importantly, the external validity of this study is limited, as the results might not be easily generalizable to other advanced economies. Australia is an exceptional economy with a diversified economic structure, highly dependent on resource extraction industries. It attracts more domestic and foreign investments in these industries compared to other manufacturing and service industries. These limitations in the generalizability of the results highlight the need for further comparative studies in other developed countries within this research domain.

CRediT authorship contribution statement

Ambepitiya Wijethunga Gamage Champa Nilanthi Wijethunga: Writing – original draft, Validation, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Mohammad Mafizur Rahman:** Writing – review & editing, Supervision. **Tapan Sarker:** Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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