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# Role of insurance in promoting sustainable development in OECD countries: Mediation analysis

Tran Thi Le Hien [1], Ho Thanh Tri [2], Pham Thi Tuong Van [3]

[a1] *Lecturer, Faculty of Finance and Accounting, Ho Chi Minh City University of Industry and Trade, 140 Le Trong Tan Street, Tay Thanh Ward, Tan Phu District, Ho Chi Minh City, Viet Nam*
[2] *Lecturer, Faculty of Finance and Accounting, Ho Chi Minh City University of Industry and Trade, 140 Le Trong Tan Street, Tay Thanh Ward, Tan Phu District, Ho Chi Minh City, Viet Nam*
[3] *Senior, State Securities Commission, 234 Luong The Vinh Street, Nam Tu Liem District, Hanoi, Viet Nam*



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**Abstract**

This study investigates the correlations between economic and financial indicators and sustainable development goals. Data spanning 1995 to 2022 were collected from 36 OECD countries, resulting in a dataset comprising 1,008 observations. The findings reveal the significant influences of the banking sector's loan assets, gross insurance premiums, gross domestic product, and tax environment on four dependent variables: carbon dioxide emissions, greenhouse gas emissions, material resources, and renewable energy. Furthermore, the study identifies that value added in financial corporations and patents related to environmental technologies impacts three dependent variables: carbon dioxide emissions, greenhouse gas emissions, and material resources. However, these factors do not influence renewable energy. Additionally, this study establishes that the banking sector's leverage, financial corporations' debt-to-equity ratio, financial intermediation ratio, and gross domestic spending on Research and Development R&D affect renewable energy. However, economic debt alone influences carbon dioxide emissions. Moreover, the results indicate that gross insurance premiums mediate between GDP and carbon dioxide emissions, greenhouse gas emissions, material resources, and renewable energy. These outcomes underscore the significance of insurance premium policies, environmental taxes, bank lending management, and corporate debt management as crucial tools for mitigating the environmental impacts of sustainable development.

Keywords: OECD, sustainable development, green finance, insurance, CO2 emissions.

## 1 Introduction

In recent years, fossil fuels have accounted for the largest share of total energy consumption worldwide, accounting for 81% of global energy consumption (IEA, 2022). Fossil fuels emit greenhouse gases, particularly carbon dioxide (CO2), which is the primary driver of climate change and affects human health and the environment. Additionally, the melting of ice in the Arctic and Antarctic has caused an increase in global average temperatures and sea levels. Clean water scarcity is a concern in some regions, and elsewhere, ineffective clean water management prevails. Deforestation and logging have led to the loss and degradation of forests and natural ecosystems. Europe is experiencing a range of implications of climate change, encompassing social,

environmental, and economic aspects. Climate change is predicted to cause a shift in Europe's energy demand, with a drop in heating requirements and an increase in cooling requirements (Filahi et al., 2023). Energy systems have been challenged by this shift in energy consumption, necessitating flexibility in energy generation. Evaluating European Union member states using the INFORM assessment tool provides valuable insights into the relationships between climate change, emissions volume, and poverty. This research emphasizes that climate change directly impacts the environment and society, particularly in terms of emissions and poverty levels (Spirkova et al., 2022). Consequently, countries must reduce their global greenhouse gas (GHG) emissions and need to transition to a low-carbon economy, which will significantly impact their industries and banking. Industries with high GHG emissions, such as energy, transportation, and manufacturing, may face major challenges in reducing carbon emissions (Apergis et al., 2018; Nguyen & Kakinaka, 2019; Saidi & Omri, 2020). Measures such as improving energy efficiency, developing renewable energy, and altering production and consumption patterns can result in higher costs, operational disruptions, and shifts in market share (Aye & Edoja, 2017; Ridzuan et al., 2020). Implementing measures, such as improving energy efficiency, developing renewable energy, and changing production and consumption patterns, can cause short-term difficulties and changes. However, developing financial instruments such as climate insurance is important in building resilience and readiness to face climate change. Therefore, it is necessary to develop and implement climate insurance tools to support the response capacity and reduce damage to businesses and communities. This can simultaneously provide new business opportunities and promote sustainable development.

The transition to a low-carbon economy has also profoundly affected banks. High carbon-emitting companies that can easily access bank loans and private credit can sustain their operations, contributing to increased carbon emissions. Conversely, banks can support carbon reduction by prioritizing lending and investing in environmentally friendly businesses and projects. They can also provide subsidized loans for renewable energy projects and green manufacturing. Simultaneously, governments are adopting carbon pricing to incentivize businesses to reduce their GHG emissions, potentially impacting corporate cash flows and the value of corporate loans, particularly for businesses in the high-emission sectors. However, transitioning to a low-carbon economy allows banks to develop new products and services supporting environmentally conscious businesses. Therefore, the banking and financial industries must bear significant responsibility due to the link between their lending and investment and carbon emissions (Farhani & Ozturk, 2015; Samour, 2019; Yao et al., 2020).

Studies have indicated that financial development can increase carbon emissions as countries advance economically, often at the expense of environmental sustainability (Farhani & Ozturk, 2015). However, other studies have suggested that financial development can reduce carbon emissions, with financial reforms benefiting environmental quality (Kim et al., 2020; Zhao & Yang, 2020). According to Ganda (2019), in OECD countries, domestic bank loans to the private sector negatively correlate with greenhouse gas emissions and carbon emissions, suggesting that financial development may positively impact environmental quality. Green bonds should be included in these markets for effective risk diversification and analysis of the relationship between green bonds and OECD financial markets (Yadav et al., 2022).

The four dependent variables in this study describe the development goals: CO2 emissions, GHG emissions, renewable energy use, and resource use. The 11 independent variables encompass financial indicators, including gross insurance premiums, value-added in financial corporations, banking sector leverage, debt-to-equity ratio, debt in the total economy, financial intermediation ratio, and loan assets in the banking sector. National economic development indicators include gross domestic product (GDP), gross domestic spending on research and development (R&D), patents on environmental technologies, and environmental taxes. Accordingly, data from 36 OECD countries from 1995 to 2022 were collected and analyzed. The methodology involved several steps. First, the stationarity of the data was checked. Next, autocorrelation and multicollinearity were examined, followed by an estimation of the four models' feasible generalized least squares panel model. Finally, the mediating variables were tested.

The primary objective of this study was to determine the extent to which financial index factors influence sustainable development. The second objective was to assess the impact of economic development on sustainable development. The third objective was to determine gross insurance premiums' mediating role in the relationship between GDP and sustainable development indicators. This study aimed to provide evidence for governments, financial institutions, and policymakers to make informed decisions to achieve overall environmental sustainability. The gap and importance of this study is to minimize emissions and transition to a low-carbon economy; prior researchers cannot specify this relationship; however, the current study aims to address and fill this research gap.

## 2 Literature Review

### *2.1. Theory of Sustainable Development*

Forestry experts from the seventeenth and eighteenth centuries introduced the concept of sustainable yield in response to dwindling forest resources across Europe (Grober & Cunningham, 2012; Warde, 2011). The United Nations SDGs provide a comprehensive framework for sustainable development, encompassing economic, social, and environmental dimensions. Within this framework, the role of gross insurance premiums and tax environment can be examined in specific SDGs, such as Goal 13 (Climate Action) and Goal 9 (Industry, Innovation, and Infrastructure). Theoretical development can explore how insurance premiums and tax policies contribute to achieving these goals by incentivizing sustainable practices and investments. The sustainable development model assumes that financial and business activities must be assessed based on criteria that consider environmental and social factors. Sustainable development focuses on key works that explore how firms can achieve competitive advantage and sustainability by leveraging their resources. The research by Hart (1995) titled "A natural-resource-based view of the firm" examines how a firm's competitive advantage is linked to its natural resource endowment. It suggests that a firm's unique combination of tangible and intangible resources can lead to sustainable competitive advantage. The study focuses on natural resources as a source of competitive advantage, including tangible assets such as land, minerals, and energy sources and intangible resources like knowledge, reputation, and relationships with stakeholders. The findings indicate that when well managed and leveraged, a firm's natural resource endowment can significantly contribute to its competitive advantage and long-term success. The study underscores the importance of a firm's ability to identify, acquire, and develop unique natural resources that are valuable, rare, difficult to imitate, and non-substitutable. Expanding on this perspective, Russo and Fouts (1997) conducted research in their article titled "A Resource-based Perspective on Corporate Environmental Performance and Profitability." Their empirical analysis demonstrates a positive correlation between strong environmental performance and financial success. This research underscores the potential of environmental resources to create competitive advantages. Achieving sustainable development requires balancing the three pillars of economy, society, and environment (Grober & Cunningham, 2012; Caradonna, 2022; Du Pisani, 2006). Haessler (2020) suggested that organizations addressing natural environmental issues should focus on long-term profit goals rather than short-term economic benefits.

### *2.2. Environmental Fiscal Reform Theory*

The term "Environmental Fiscal Reform" (EFR) describes applying fiscal tools such as taxes and subsidies to encourage sustainable growth and ecologically responsible conduct. The effects of export diversification, green technology innovation, and fiscal decentralization on environmental sustainability goals have been investigated in several countries, including the BRICS countries (Udeagha, & Ngepah, 2023). EFR is based on environmental economics theory, which suggests that tax and expenditure policies can incentivize environmentally friendly behavior and reduce pollution. EFR results from research and development undertaken by numerous international organizations, governments, and researchers worldwide. The Guidance on carbon pricing and environmental tax structures is an instrument by which the Organization for Economic Co-operation and Development (OECD) has successfully assisted nations in implementing EFR. To accomplish environmental and climate goals, this study offers guidelines for using carbon pricing and other environmental tax mechanisms (Jonassen et al., 2023; Koval et al., 2023). With mechanisms such as benefits, subsidies, transfer payments, and adjustments to environmental tax rates, the use of green financial instruments in fiscal policy has been suggested as a way to manage environmental concerns and guarantee economic sustainability (Koval et al., 2023)

### *2.3. Theory of Green Finance, Green Banking, and Green Insurance*

Green finance encompasses financing environmentally friendly projects, including renewable energy, alternative energy, energy efficiency, recycling of products, waste management, and green industrial development projects. Its goal is facilitating organizational sustainability (Zheng et al., 2021). Tripathy (2019) indicated that financial development positively influences India's economic growth. Furthermore, as Yu (2023) highlights, digital technology can significantly reduce the carbon intensity of the financial system through three pathways: enhancing financial market efficiency, promoting financial innovation, and reinforcing transparency and accountability in financial institutions. Research has demonstrated that financing is pivotal in directing green economic resources during the transition to a low-carbon economy (Geddes et al., 2018; Nie et al., 2016). However, the financial system must be mindful of potential risks, particularly in the scientific and prudent use of credit policies to guide

the transition to a low-carbon economy (Gunningham, 2020; Jiang et al., 2020). It is also emphasized that the financial market should serve as the primary driving force for the swift transition to a low-carbon economy (Li et al., 2018).

Green banking originated with the Dutch Triodos Bank in 1980 (Yadav & Pathak, 2013) and was first implemented in Florida in 2009 (Sharma & Choubey, 2022). Green banking actively supports initiatives to transform the traditional economy into a low-carbon, climate-friendly one. Green banks assume responsibility for environmental protection (Burhanudin et al., 2021), proactively functioning as socially conscious management agencies to foster internal and external environmental sustainability (Sharma & Choubey, 2022).

Green insurance refers to products and services that promote environmentally friendly practices and foster sustainable development. Green insurance is classified into three types. The first is insurance against environmental risks, aimed at protecting individuals and businesses from financial losses caused by environmental events, such as natural disasters and environmental pollution. The second type is insurance for green economic activities to support businesses engaged in green economic activities, such as renewable energy and organic farming. The third type is insurance, which promotes green lifestyles, encouraging individuals to save energy and use public transport (Chummun, 2023). The demand for green insurance is increasing, and the insurance industry needs to meet this demand by developing innovative products and services. The insurance sector should collaborate with governments, non-profit organizations, and other stakeholders to promote green insurance development and implementation. It is necessary to examine the activities of insurance and reinsurance companies within the European Union regarding their obligations to comply with standards and regulations on sustainable insurance, implement measures to mitigate environmental and climate-related risks, and ensure transparency and comprehensive reporting of sustainable insurance activities (Barabanova, 2023).

### *2.4. The Porter hypothesis*

The Porter Hypothesis (PH) suggests that environmental regulations can promote innovation and improve economic performance. Many studies have explored this hypothesis in different contexts, including the research by Van Leeuwen and Mohnen (2016). The literature extensively examines the influential works of Porter (1991) and Porter and van der Linde (1995). These studies originated from analyzing differences in environmental regulation stringency and economic performance across countries. As a result, the PH has sparked significant theoretical and empirical research. Despite criticisms of relying on anecdotal evidence and lacking a strong theoretical foundation, the PH proposes strict environmental regulations, such as higher insurance premiums for practices that harm the environment, which can motivate companies to innovate toward cleaner technologies and processes. This innovation can lead to reduced emissions and more efficient use of resources, aligning with sustainability goals. By combining technology innovation with proactive environmental strategies, firms can navigate regulatory challenges, enhance environmental performance, and achieve long-term success.

## 3 Materials and Methods

### *3.1. Materials*

CO2 emissions, GHG emissions, renewable energy, and material resources estimate sustainable development. The core financial indicators include banking sector leverage, financial corporations' debt-to-equity ratio, debt to the total economy, financial intermediation ratio, loan assets in the banking sector, gross insurance premiums, and value-added indicators in financial corporations. In addition, national economic development indicators include GDP, gross domestic spending on R&D, the tax environment, and patents on environmental technologies. All research variables are presented in Table 1.

**Table 1.** Description of the research variables

| Variable name | Symbol | Unit of measurement | Measurement | Research |
|---|---|---|---|---|
| *Banking sector leverage* | BSECTOR | % | Total financial assets of banking sector / Total equity of banking sector | Bauer and Hann (2010), Chava (2014) and Oikonomou et al. (2014) |
| *Financial corporations' debt to equity ratio* | FCDEPT | % | Total debt of financial corporations / Total equity of financial corporations | Aibar-Guzmán et al. (2023) |

| | | | | |
|---|---|---|---|---|
| *Debt of total economy* | DEBTE | % of GDP | Total debt of government + Total debt of households + Total debt of businesses | Sun et al. (2022), Larsson and Larsson (2023) |
| *Financial intermediation ratio* | FININTER | Number | Financial assets of financial intermediaries / GDP | Zhang and Chen (2017) |
| *Loans assets of the banking sector* | LOANSAS | Percentage | (Loans assets of the banking sector / Currency and deposits liabilities of the banking sector) * 100 | Chava (2014), Oikonomou et al. (2014), Zhang and Chen (2017) |
| *Gross insurance premiums* | GIP | Million US dollars | Total premiums received by insurance companies | Eling and Lehmann (2018), Scholtens (2011), Andersen and Bonat (2017) |
| *Value-added in financial corporations* | VAIF | 1,000 US dollars | Total revenue of financial corporations – Total intermediate consumption of financial corporations | Zhang and Chen (2017) |
| *Gross domestic product* | GDP | US dollars | Consumption + Investment+ Government spending + Net exports | Ekins (1997) |
| *Gross domestic spending on R&D* | GDSRAD | US dollars | Total spending on R&D by all resident companies, research institutes, university and government laboratories, etc. | Ekins (1997), Sarpong et al. (2023), Karkowska (2019) |
| *Tax environment* | TAXEN | Total, % of GDP | Total tax revenue / GDP | Sarpong et al. (2023) |
| *Patents on environment technologies* | PET | Percentage | Patents on environment technologies (%) = (Number of patents on environment technologies / Total number of patents) * 100 | Karkowska (2019), Oyebanji et al. (2022) |
| *$CO_2$ emissions* | $CO_2$ | Tons | Total mass of $CO_2$ emitted / Time period | Tariq et al. (2022), Hou and Fang (2023) |
| *GHG emissions* | GREENHOE | Tons | Total mass of GHG emitted / Time period | Mehmood et al. (2023), Giljum et al. (2015) |
| *Material resources* | MARE | Millions of tons | Total mass of material resources / 1,000,000 | Giljum et al. (2015) |
| *Renewable energy* | REEN | Total, % of primary energy supply | Total energy from renewable sources / Total energy | Chen et al. (2022), J and Majid (2020) |

*Source: own collaboration*

### *3.1.1. Sustainable development variables*

Greenhouse gas emissions (GREENHOE) are defined as the total quantity of greenhouse gases emitted from human activities and include carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and hydrofluorocarbons (HFCs). Thus, GHG emissions are an important indicator for evaluating environmental performance; the higher the GHG emissions, the lower the environmental performance. GHG emissions are an important issue that must be addressed to achieve sustainable development. Research on GHG emissions and sustainable development is becoming increasingly diverse (Mehmood et al., 2023).

CO2 emissions measure CO2 released from human activities, such as production, transportation, and energy use (Tariq et al., 2022). CO2 emissions are important indicators of the impact of business and financial activities on climate change. They are principally the gases generated from the burning of fossil fuels for producing goods or are created during the consumption of solid, liquid, and gaseous fuels. Lower CO2 emissions reflect higher environmental performance toward the goal of sustainable development (Hou & Fang, 2023).

Renewable energy (REEN) measures the amount of energy generated from natural sources such as sunlight, wind, water, and geothermal energy for electricity production, heating, cooling, and other applications. Renewable energy can contribute significantly to sustainable development, and renewable energy strategies can promote sustainable economic growth by creating jobs, reducing energy costs, and reducing environmental

pollution (Chen et al., 2022). J and Majid (2020) found that renewable energy was important in promoting sustainable development in India.

Material resources (MARE) measures the extraction of natural resources for producing goods and services. Material resources include minerals, metals, wood, oil, and gas. Lower material resource consumption implies a lower environmental impact, leading to higher environmental performance. Research has shown that material resource use in developed countries is much higher than in developing countries (Giljum et al., 2015). Materials can be used to address sustainable development challenges, such as climate change, environmental pollution, and poverty. The primary areas where materials can address sustainable development challenges include energy, construction, transport, and manufacturing (Green et al., 2012).

*3.1.2. Financial indicators system*

Banking sector leverage (BSECTOR) measures the capital banks provide to businesses and households to enable them to undertake economic activities. These activities include production, energy consumption, and investment in GHG emissions projects. When the banking sector's leverage is high, banks lend money to businesses and households. This can lead to economic growth but can also increase CO2 emissions. Research by Oikonomou et al. (2014) on the impact of sustainable activities on the pricing of corporate debt and the credit quality of bond issuances found that each environmental sustainability factor significantly reduced risk premium, thereby reducing the cost of corporate debt.

The financial corporation debt-to-equity ratio (FCDEPT) measures and provides insight into the level of financial corporate debt relative to equity. Businesses must focus on improving corporate governance to build and implement effective climate change management strategies, thereby enhancing their ability to adapt and develop sustainably in the context of climate change (Aibar-Guzmán, Raimo, Vitolla, & García-Sánchez, 2023).

Debt of total economy (DEBTE) measures an economy's total debt, including government, private sector, and foreign currency debt. Excessive debt can negatively affect development goals. Environmental performance and the sustainable development of enterprises are two important factors to consider in debt cost management. Therefore, enterprises must focus on sustainable development and improving environmental performance to reduce capital costs and enhance competitiveness (Sun et al., 2022). Environmental, social, and governance (ESG) performance positively affects corporate debt. Specifically, enterprises with higher ESG performance tend to have lower debt costs, whereas carbon emissions negatively affect corporate debt costs (Larsson & Larsson, 2023).

The financial intermediation ratio (FININTER) measures the level of financial system development within an economy. A high financial intermediation ratio indicates that the economy's financial system is well-developed and can provide effective financial services to businesses and households. Research shows that environmental performance and financial decisions are two important factors to consider in promoting the sustainable financial development of environmentally friendly enterprises in both the short and long term (Zhang & Chen, 2017). Environmentally friendly enterprises should improve their environmental performance and make financial decisions to enhance their competitiveness and sustainable development.

Loan assets in the banking sector (LOANSAS) measure the capital banks allocate for lending, influencing economic growth. This growth, however, comes with environmental consequences. Building on the resource-based view of the firm (Hart, 1995; Russo & Fouts, 1997). Bauer and Hann (2010) highlight the connection between environmental management practices and credit risk. Their study shows that companies with poor environmental performance tend to have lower credit scores and higher borrowing costs. Conversely, companies that effectively manage their environmental risks tend to have higher credit scores and lower borrowing costs. In addition to this, companies that face significant environmental risks outside their control tend to incur higher capital costs. Firms lacking robust environmental strategies face financial penalties (Chava, 2014), while those prioritizing sustainability gain financial advantages. Therefore, financial development, which includes metrics such as bank assets and return on assets, can promote renewable energy consumption, green growth, and reducing carbon emissions (Tran, 2023).

Gross insurance premiums (GIP) measure total insurance premiums collected by insurance companies in a country. In this context, Eling and Lehmann's (2018) research provides further insights into the insurance industry's role in promoting environmentally friendly activities. They suggest that insurance premiums can

incentivize companies to invest in cleaner technologies and processes and adopt environmentally responsible practices. The insurance industry can encourage companies to seek lower premiums and achieve long-term efficiency gains by pricing insurance premiums to reflect environmental risk. Such practices would support the Porter Hypothesis, which proposes that stricter regulations can reduce emissions and enhance innovation. Furthermore, Scholtens (2011) spotlights how insurance companies, through their procurement and investments, can drive the adoption of cleaner technologies, particularly in terms of renewable energy. The authors recommend that future studies explore corporate structures within the financial or industrial sectors that create barriers to technology adoption.

*3.1.3. National Economic Development Management variables*

Value added to financial corporations (VAIF) is a measure of financial corporations' contributions to the overall economy and provides a measure of the productivity and profitability of the financial sector. Investors increasingly value environmental performance when making investment decisions, as awareness of environmental risks to businesses is growing. Companies that improve their environmental performance can potentially increase corporate value and attract more investors (Yadav et al., 2016).

GDP is a measure of the size of an economy, reflecting the total value of the final goods and services produced in a country over a given period. Ekins (1997) studied the relationship between economic growth and environmental pollution, arguing that this relationship can be described by an inverted Kuznets curve, in which environmental pollution increases in the early stages of economic growth and decreases as the economy develops.

TAXEN is a tax on activities that pollute the environment. The purpose of this tax was to encourage businesses and individuals to reduce pollution. When businesses and individuals pay taxes on pollution, they are more likely to find ways to reduce pollution and save money. Environmental and green energy taxes support E7 economies in achieving their carbon neutrality goals (Sarpong et al., 2023).

Gross domestic spending on R&D (GDSRAD) measures a country's level of investment in research and development. R&D includes the development of renewable energy technologies such as solar energy, wind energy, and hydropower. It also includes the development of more efficient waste treatment technologies that can help reduce waste, protect the environment, and conserve natural resources. R&D innovation helps businesses improve productivity, efficiency, and competitiveness. Therefore, R&D promotes the development of new technologies that address sustainability challenges (Sarpong et al., 2023). Banks that focus on innovative products and services, build missions and visions, and increase the use of technology have a positive impact on sustainability (Karkowska, 2019).

Patents on environmental technologies (PET) measure a country's technological development. For example, increasing the number of patents for environmental technology and sustainability is a positive sign of Spain's efforts to achieve sustainable development (Oyebanji et al., 2022).

*3.2. Research Data and Research Model*

This study collected data from 36 countries in the Organization for Economic Co-operation and Development (OECD), as demonstrated in the Appendices. The data were collected between 1995 and 2022. The data were processed and cleaned to obtain 1,008 lines of the data used. Eviews software was used to perform descriptive statistical analysis and check the stationarity of the data according to the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) methods. After the data became stationary, the correlations and multicollinearity of the selected variables were tested. When the research variables had a low degree of multicollinearity, the next step was to perform panel least-squares and intermediate regression analyses. These results provide important information on the effect of financial indicators on sustainable development.

The research model is as follows:

**Model 1**. $CO_2 = \beta0+\beta1*BSECTOR+\beta2*FCDEPT+\beta3*DEBTE+\beta4*FININTER+\beta5*LOANSAS+\beta6*GIP+\beta7*VAIF+\beta8*GDP+\beta9*GDSRAD+\beta10*TAXEN+\varepsilon$

**Model 2**. GREENHOE = α0+α1*BSECTOR+α2*FCDEPT+α3*DEBTE+α4*FININTER+α5*LOANSAS+α6 *GIP+α7*VAIF+α8*GDP+α9*GDSRAD+α10*TAXEN+ε

**Model 3**. MARE = θ0+θ1*BSECTOR+θ2*FCDEPT+θ3*DEBTE+θ4*FININTER+θ5*LOANSAS+θ6 *GIP+θ7*VAIF+θ8*GDP+θ9*GDSRAD+θ10*TAXEN+ ε

**Model 4**. REEN = γ0+ γ1*BSECTOR+γ2*FCDEPT+γ3*DEBTE+γ4*FININTER+γ5*LOANSAS+γ6 *GIP+γ7*VAIF+γ8*GDP+γ9*GDSRAD+γ10*TAXEN+ε

This study adopts a mediation analysis framework to examine if gross insurance premiums (GIP) mediate between a country's Gross Domestic Product (GDP) and various environmental indicators. This approach is inspired by the work of MacKinnon and Dwyer (1993) and MacKinnon et al. (2007), focusing on analyzing mediated effects. Understanding mediation is crucial as it allows us to move beyond simple correlations and explore how GDP translates into environmental impact, including CO2 emissions, GHG emissions, material resources, and renewable energy. The analysis follows a two-step approach. Firstly, regression models establish significant relationships between the variables, mirroring the causal steps approach proposed by MacKinnon and Dwyer (1993). This includes examining the impact of GDP on gross insurance premiums (T3), the influence of gross insurance premiums on each environmental indicator (CO2 emissions, GHG emissions, material resources, and renewable energy), and the direct effect of GDP on each environmental indicator. This step helps understand how the relationships change when the mediator is introduced. Following these foundational steps, the next phase formally tests gross premiums' mediation effect.

($CO_2$, GREENHOE, MARE, REEN) = T0 + T1 * GDP + T2 * Gross insurance premiums + T3 * GDP * Gross insurance premiums + ε

## 4 Results

### *4.1. Descriptive Statistics of the Research Variables*

**Table 2.** Descriptive statistics for the variables

| Variable | Obs. | Mean | Std. dev. | Min | Max |
|---|---|---|---|---|---|
| Bsector | 1,008 | 19.830 | 24.343 | 1.040 | 285.100 |
| FCDept | 1,008 | 5.142 | 3.675 | 0.439 | 31.750 |
| DebtE | 1,008 | 725.565 | 1,077.891 | 50.580 | 10,438.000 |
| FinInter | 1,008 | 0.554 | 0.427 | 0.184 | 4.535 |
| LoansAs | 1,008 | 74.126 | 34.061 | 11.884 | 251.340 |
| GDP | 1,008 | 34,800,000,000 | 18,800,000,000 | 145,000,000 | 140,000,000,000 |
| GDSRaD | 1,008 | 1.789 | 0.994 | 0.111 | 5.705 |
| PET | 1,008 | 10.518 | 4.242 | 1.060 | 31.580 |
| TaxEn | 1,008 | 2.316 | 0.863 | -1.530 | 5.360 |
| GIP | 1,008 | 112,841.600 | 351,543.700 | 89.880 | 3,242,715.000 |
| VAIF | 1,008 | 54.452 | 12.060 | 13.980 | 93.830 |
| ReEn | 1,008 | 16.005 | 16.156 | 0.310 | 89.750 |
| MaRe | 1,008 | 704.420 | 1,667.115 | 3.292 | 15,229.180 |
| $CO_2$ | 1,008 | 362,546.800 | 928,916.100 | 33.750 | 6,132,183.000 |
| Greenhoe | 1,008 | 445,568.800 | 1,143,958.000 | 33.750 | 7,511,448.000 |

Source: *own collaboration*

According to Table 2, the average CO2 emissions in the OECD countries amount to 362,546.8 tons, with GHG emissions averaging 445,568.8 tons. The average material resource utilized was 704.42 million tons, and renewable energy constituted 16.005 percent of the primary energy supply. The results indicated elevated CO2 emissions from production, substantial GHG emissions, and a high level of resource consumption for both

production and further consumption, suggesting the use of unsustainable materials. However, clean energy use is low. Consequently, OECD countries must prioritize efforts to reduce CO2 emissions, mitigate environmental impacts, and foster the development of environmentally friendly economies. Simultaneously, they should explore methods for decreasing resource consumption and promoting the transition to recycled and reused materials for sustainable development.

### *4.2. Results of Unit Root Tests*

The Phillips-Perron (PP) (Perron, 1990) and augmented Dickey-Fuller (ADF) (Dickey & Fuller, 1979) tests are the most common and effective methods for testing panel data stationarity. The ADF test considers the autoregressive nature of a series and correlations between its lag values. Therefore, both the ADF and PP tests were employed in this study. If the P-value was less than the significance level (0.05), it was concluded that the series was stationary.

**Table 3.** Results of **Augmented Dickey-Fuller** and **Phillips-Pearson** tests

| Variables | Augmented Dickey-Fuller (ADF) | | | | Phillips-Pearson (PP) | | | |
|---|---|---|---|---|---|---|---|---|
| | At Level | | First Difference | | At Level | | First Difference | |
| | T value | P value | T value | P value | T value | P value | T value | P value |
| BSECTOR | -3.4858 | 0.0005 | -12.1400 | 0.0000 | -5.5799 | 0.0000 | -39.4742 | 0.0000 |
| FCDEPT | -2.6437 | 0.0080 | -13.1257 | 0.0000 | -4.2874 | 0.0000 | -40.5483 | 0.0000 |
| DEBTE | -4.3583 | 0.0000 | -7.4225 | 0.0000 | -4.2647 | 0.0000 | -28.7901 | 0.0000 |
| FININTER | -8.1941 | 0.0000 | -29.5846 | 0.0000 | -7.9206 | 0.0000 | -29.7207 | 0.0000 |
| LOANSAS | -2.4234 | 0.0150 | -23.0309 | 0.0000 | -2.4645 | 0.0134 | -30.6739 | 0.0000 |
| GDP | -2.4169 | 0.0152 | -10.3397 | 0.0000 | -3.1622 | 0.0016 | -47.7458 | 0.0001 |
| GDSRAD | -2.4527 | 0.0138 | -32.9277 | 0.0000 | -2.3406 | 0.0187 | -33.0485 | 0.0000 |
| PET | -0.9375 | 0.3105 | -12.2172 | 0.0000 | -3.5522 | 0.0004 | -72.2421 | 0.0001 |
| TAXEN | -1.6326 | 0.0968 | -9.3091 | 0.0000 | -2.2905 | 0.0213 | -48.9231 | 0.0001 |
| GIP | 4.1815 | 1.0000 | -2.4198 | 0.0151 | 1.1123 | 1.0000 | -32.6155 | 0.0000 |
| VAIF | -0.7453 | 0.3936 | -10.9416 | 0.0000 | -11.1152 | 0.2422 | -52.3322 | 0.0001 |
| REEN | -3.7323 | 0.0002 | -32.8352 | 0.0000 | -3.7114 | 0.0002 | -32.8495 | 0.0000 |
| MARE | -2.0392 | 0.0398 | -11.5080 | 0.0000 | -5.2410 | 0.0000 | -43.1969 | 0.0001 |
| $CO_2$ | -0.1758 | 0.6227 | -30.5667 | 0.0000 | -0.4386 | 0.5245 | -30.5781 | 0.0000 |
| GREENHOE | -0.6705 | 0.4267 | -31.0819 | 0.0000 | -0.8695 | 0.3392 | -31.0863 | 0.0000 |

*Source: own collaboration*

The results of the ADF and PP tests in Table 3 reveal that BSECTOR, FCDEPT, DEBTE, FININTER, LOANSAS, GDP, GDSRAD, REEN, and MARE are all stable at zero difference. In contrast, GIP, VAIF, CO2, and GREENHOE were not stationary at zero difference, but all were stationary at the first difference in the ADF and PP tests. In contrast, PET and TAXEN were stationary at the first difference in the ADF test but also stationary at zero difference in the PP test.

### *4.3. Multicollinearity Test*

According to the general convention, Pearson correlation coefficients ranging from 0.3 to 0.7 are considered moderate, those from 0.7 to 0.9 are considered high, and those at 0.9 or above are considered very high. To ensure that the overall correlation between the selected independent and dependent variables is relatively low (i.e., multicollinearity is low), the Pearson correlation coefficient between the independent variables must be less than 0.3.

**Table 4.** Results of correlation test

| | BSECTOR | FCDEPT | DEBTE | FININTER | LOANSAS | GDP | GDSRAD | PET | TAXEN | GIP | VAIF | REEN | MARE | CO2 | GREENHOE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **BSECTOR** | 1 | | | | | | | | | | | | | | |
| **FCDEPT** | 0.42 | 1 | | | | | | | | | | | | | |
| **DEBTE** | 0.03 | -0.25 | 1 | | | | | | | | | | | | |
| **FININTER** | -0.1 | 0.024 | 0.12 | 1 | | | | | | | | | | | |
| **LOANSAS** | -0.1 | -0.12 | -0.2 | 0.198 | 1 | | | | | | | | | | |
| **GDP** | -0.1 | -0.34 | 0.59 | 0.185 | -0.0 | 1 | | | | | | | | | |
| **GDSRAD** | -0.1 | -0.08 | 0.04 | 0.051 | 0.14 | 0.36 | 1 | | | | | | | | |
| **PET** | 0.03 | -0.05 | 0.07 | -0.0 | 0.06 | 0.11 | -0 | 1 | | | | | | | |
| **TAXEN** | -0.2 | -0.02 | -0.0 | -0.01 | 0.08 | -0.1 | 0.07 | -0.1 | 1 | | | | | | |
| **GIP** | -0.0 | -0.06 | 0.01 | -0.01 | -0.0 | 0.19 | 0.26 | -0.0 | -0.3 | 1 | | | | | |
| **VAIF** | -0.4 | -0.04 | -0.2 | 0.173 | -0.1 | -0.1 | 0.06 | 0.01 | 0.06 | 0.15 | 1 | | | | |
| **REEN** | -0.1 | -0.15 | 0.05 | -0.11 | 0.43 | 0.22 | 0.05 | 0.04 | 0.03 | -0.2 | -0.1 | 1 | | | |
| **MARE** | -0.0 | -0.04 | -0.0 | 0.015 | 0.07 | 0.05 | 0.16 | -0.0 | -0.3 | 0.71 | 0.19 | -0.2 | 1 | | |
| **CO2** | -0.0 | -0.03 | -0.0 | -0.0 | 0.03 | 0.09 | 0.21 | -0.1 | -0.3 | 0.9 | 0.17 | -0.2 | 0.813 | 1 | |
| **GREENHOE** | -0.0 | -0.04 | -0.0 | 0.007 | 0.04 | 0.09 | 0.2 | -0.1 | -0.4 | 0.9 | 0.16 | -0.2 | 0.813 | 0.813 | 1 |

*Source: own collaboration*

As shown in Table 4, the overall correlation coefficients were generally < 0.3. This indicates that the overall correlation between the selected independent and dependent variables was relatively low i.e., the multicollinearity between the variables was insignificant. In addition to performing a correlation analysis on the selected variables, a variance inflation factor (VIF) test was used to determine whether there is a multicollinearity problem between the variables (Table 5). The results in Table 4 show that the correlation coefficients between the independent variables did not exceed 0.7, and the results in Table 5 show that the VIF values were all less than 10. Therefore, multicollinearity was not a significant problem.

**Table 5.** Results of Variance Inflation Factor VIF

| Variable | VIF |
|---|---|
| BSECTOR | 1.5907 |
| FCDEPT | 1.4802 |
| DEBTE | 1.8445 |
| FININTER | 1.3565 |
| LOANSAS | 1.8523 |
| GDP | 2.4036 |
| GDSRAD | 1.3636 |
| PET | 1.0731 |
| TAXEN | 1.3442 |
| GIP | 6.0783 |
| VAIF | 1.3792 |
| REEN | 1.7061 |
| MARE | 3.0725 |
| GREENHOE | 8.4124 |

*Source: own collaboration*

### *4.4. Regression Results*

**Table 6.** Regression results of 36 countries during the period 1995–2022

| Variable | $CO_2$ | | GREENHOE | | MARE | | REEN | |
|---|---|---|---|---|---|---|---|---|
| | Coefficient | P value | Coefficient | P value | Coefficient | P value | Coefficient | P value |
| **BSECTOR** | -372.185 | 0.543 | -127.071 | 0.866 | 1.586 | 0.380 | -0.091 | 0.000 |
| **FCDEPT** | 3728.175 | 0.343 | 414.458 | 0.932 | -11.019 | 0.343 | 0.380 | 0.004 |
| **DEBTE** | 36.545 | 0.015 | 35.950 | 0.052 | 0.069 | 0.121 | 5.11 | 0.920 |
| **FININTER** | -19,980.394 | 0.514 | 997.413 | 0.979 | -31.630 | 0.726 | -11 | 0.000 |
| **LOANSAS** | 2261.233 | 0.000 | 2903.393 | 0.000 | 58.436 | 0.000 | 0.251 | 0.000 |
| **GDP** | -4440714447 | 0.000 | -5313709360 | 0.000 | -9443443 | 0.001 | 330828 | 0.000 |
| **GDSRAD** | 8033.675 | 0.565 | -7621.232 | 0.657 | 13.728 | 0.739 | -2 | 0.001 |
| **PET** | -11670.371 | 0.000 | -15195.041 | 0.000 | -18.958 | 0.026 | -0.1489 | 0.126 |
| **TAXEN** | -109691.225 | 0.000 | -135206.801 | 0.000 | -280.916 | 0.000 | -1 | 0.004 |
| **GIP** | 2.329 | 0.000 | 2.879 | 0.000 | 0.003 | 0.000 | 1.02 | 0.000 |
| **VAIF** | 3401.409 | 0.003 | 3662.606 | 0.010 | 15.638 | 0.000 | 0.0234 | 0.547 |

*Source: own collaboration*

The results in Table 6 demonstrate that the banking sector's loan assets and gross insurance premiums have a significant impact on all four indicators: CO2 emissions, GHG emissions, material resources, and renewable energy (P<0.05). Concurrently, the value added in financial corporations influences the three factors of CO2 emissions, GHG emissions, and material resources but not renewable energy use.

Table 6 shows that the GDP and tax environment also significantly affect all four indicators (P<0.05). Conversely, patents on environmental technologies impact just three factors – CO2 emissions, GHG emissions, and material resources – but not renewable energy. Furthermore, the findings indicate that banking sector leverage, financial corporations' debt-to-equity ratio, financial intermediation ratio, and gross domestic spending on R&D impact renewable energy. The debt of the entire economy affects only CO2 emissions. The coefficients of the impact of GDP on CO2 and GHG emissions, material resources, and renewable energy decrease when gross insurance premiums are introduced into the model. This finding implies that gross insurance premiums mediate the relationships between GDP and CO2 and GHG emissions, material resources, and renewable energy. Additional evidence supporting this conclusion is presented in Table 7.

**Table 7.** Results of mediation analysis

| Variable | CO2 | | GREENHOE | | MARE | | REEN | |
|---|---|---|---|---|---|---|---|---|
| | Coefficient | P value | Coefficient | P value | Coefficient | P value | Coefficient | P value |
| GDP | -0.000001705 | 0.000 | -0.00000227 | 0.000 | -0.0000000049 | 0.008 | 0.000000000205 | 0.000 |
| GIP | 5.88 | 0.000 | 7.1692 | 0.000 | 0.0087 | 0.000 | -0.0000375 | 0.000 |
| MEDIATION | -0.000000000063 | 0.000 | -0.000000000076 | 0.000 | -0.000000000000094 | 0.000 | 0.0000000000000005 | 0.000 |

*Source: own collaboration*

The mediation analysis (Table 7) reveals that the impact of gross insurance premiums on CO2 emissions, GHG emissions, and material resources is positive. In contrast, the coefficient of the impact on renewable energy is

negative and statistically significant. This implies that as gross insurance premiums increase, CO2 emissions, GHG emissions, and material resources increase, and renewable energy decreases. The coefficient of the impact of GDP on gross insurance premiums (T3) is negative and statistically significant, suggesting that gross insurance premiums decrease as GDP increases.

## 5 Discussion and Conclusions

Based on research results from 36 OECD countries from 1995 to 2022, the findings in this study offer substantial theoretical and empirical contributions to the field of sustainable finance and investment (Tables 6 and 7).

### *5.1. Discussion*

This study advances the understanding of the financial sector's role in environmental sustainability in several ways. Firstly, the distinct and significant influence of bank loan assets and gross insurance premiums highlights the need to move beyond a monolithic view of the "finance industry." Our findings strongly align with the resource-based theory (Hart, 1995; Russo & Fouts, 1997), demonstrating that diverse financial institutions' strategic capital allocation decisions have tangible consequences for emissions and resource use within OECD countries. While this study focuses on developed economies, the findings have implications for the EKC (Ekins, 1997). The mediation effect suggests that financial practices can shape the relationship between growth and environmental impact within the OECD, potentially decoupling them. This adds nuance to EKC discussions as it implies policy tools beyond solely targeting GDP can be crucial. Additionally, on the empirical side, this approach offers valuable insights with potential implications for policy design within the broader Environmental Fiscal Reform (EFR) frameworks. While EFR emphasizes government taxation, this study highlights the potential to shape environmental performance through the private financial sector.

Secondly, the finding that gross insurance premiums mediate the GDP-emissions relationship offers a novel contribution. This mediation emphasizes the insurance industry's outsized role in either exacerbating or mitigating the environmental effects of economic growth. This contrasts with some earlier studies that often considered insurance activities a neutral 'byproduct' of development. Further research is urgently needed to understand the mechanisms behind this mediation effect, as this can potentially inform policy and insurance product design.

The study's results resonate with Bauer and Hann (2010) in finding a connection between financial institutions and environmental performance metrics. However, the specific focus on insurance premiums provides additional insights into how the risk-focused nature of insurance underwriting can shape emission and resource consumption patterns. Additionally, the specific focus on insurance premiums highlights a potential mechanism for fulfilling the vision of the Porter Hypothesis. By pricing premiums to reflect environmental risk, the insurance industry could incentivize companies to invest in cleaner technologies and processes, seeking lower premiums and long-term efficiency gains. This would support the idea that more stringent regulations can reduce emissions and enhance innovation.

The discovery that gross insurance premiums serve as a mediator highlights the distinct ways the insurance industry can influence these outcomes. This has significant theoretical implications for the resource-based view, furthering our understanding of the financial sector's role in shaping emissions and resource consumption patterns. Additionally, on the empirical side, this approach offers valuable insights for designing policy interventions and sustainable insurance practices, with the potential to fulfill the vision of the Porter Hypothesis. The potential for insurance premiums to drive cleaner innovation aligns with the hypothesis. However, like Van Leeuwen and Mohnen (2016), the connection between innovation and outcomes (renewables) is complex. This highlights the need to examine factors beyond pure technological innovation, like industry governance (Scholtens, 2011) and insurance regulation, to understand why OECD nations struggle to translate patents into widespread renewable adoption. Furthermore, the weak link between environmental patents and renewable energy use raises questions about the effectiveness of purely technology-driven approaches. Future studies, potentially drawing on Scholtens' (2011) focus on governance, should explore whether corporate structures within the financial or industrial sectors create barriers to technology adoption – even within the relatively innovative context

of the OECD. This investigation should also consider whether existing insurance industry practices and regulatory frameworks sufficiently promote the widespread adoption of these patented technologies.

### *5.2. Limitations and Future Research*

The study's focus on OECD countries leaves open questions regarding the generalizability of these findings to developing economies or those with different financial system structures. Additionally, a longitudinal study could provide deeper insights into causality and how regulatory changes impact the dynamics observed. Future research could build upon this by delving into specific sustainable finance practices within the insurance and banking sectors to pinpoint the most impactful interventions for promoting a low-carbon transition. Future research should also investigate the conditions under which insurance premium models might best stimulate innovation in line with the Porter Hypothesis and the potential for unintended negative consequences on developing economies.

### *5.3. Conclusion*

This research highlights the complex interplay between financial sector activities and environmental outcomes within developed economies. The study underscores the need for policymakers, industry leaders, and researchers to embrace a nuanced view of the financial industry and recognize its potential to be either a powerful driver of or a significant brake on environmental progress. Importantly, it suggests that insurance premium models could be pivotal in determining whether the OECD achieves sustainable innovation alongside economic growth.

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**APPENDIX: LIST OF 36 OECD MEMBER COUNTRIES**

| Number | Country | Number | Country |
|---|---|---|---|
| 1 | Australia | 19 | South Korea |
| 2 | Austria | 20 | Latvia |
| 3 | Belgium | 21 | Lithuania |
| 4 | Canada | 22 | Luxembourg |
| 5 | Czech Republic | 23 | Mexico |
| 6 | Chile | 24 | Netherlands |
| 7 | Denmark | 25 | New Zealand |
| 8 | Estonia | 26 | Norway |
| 9 | Finland | 27 | Poland |
| 10 | France | 28 | Portugal |
| 11 | Germany | 29 | Slovak Republic |
| 12 | Greece | 30 | Slovenia |
| 13 | Hungary | 31 | Spain |
| 14 | Iceland | 32 | Sweden |
| 15 | Ireland | 33 | Switzerland |
| 16 | Israel | 34 | Türkiye |
| 17 | Italy | 35 | United Kingdom |
| 18 | Japan | 36 | United States |