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SUSTAINABLE CORPORATE FINANCE AND INVESTMENTS

THE FINAL MASTER'S THESIS

<i>Title in English language:</i> <i>Sustainable Investments as a Tool for Mitigating Climate Change Risks</i>	<i>Title in Lithuanian language:</i> <i>Tvarios investicijos kaip priemonė klimato kaitos rizikai mažinti</i>
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SUMMARY

This paper research is based on the topic of sustainable investment as a means of enhancing the prevention of climate change by using renewable energy in highly industrialized nations. The study uses Stakeholder Theory, Legitimacy Theory, and Signaling Theory to understand how the quality of governance, policy uncertainty, and sustainable investment are moderated by green innovation to reduce the effectiveness of sustainable investment. Based on secondary panel data (1990- 2023) on ten major highly-income economies, including Australia, Canada, France, Germany, Ireland, Italy, New Zealand, Spain, the United Kingdom and the United States, the study uses fixed-effects, random- effects and pooled OLS regression models to determine the major contributors to uptake of renewable energy. The results indicate that sustainable investment does not largely increase the consumption of renewable energy, but the situation factors greatly contribute towards its positive effect. Namely, green innovation has a positive moderating effect on the relationship between investment and impact, whereas the moderating role of policy uncertainty is negative. Besides, the quality of governance is a major moderating factor, which determines the efficiency of the money channeling into sustainable infrastructure. Westerlund cointegration test also supports the assumption that there are long-run relationships between the main variables. These findings indicate that climate mitigation can only be effective with financial contributions but also with well-organized institutions, uniform policy structures and availability of technology. The paper has an impact to both the theory and policy by providing an illusion on the optimalization of environmental finance to act upon climate change. It presents two implications that are practical to policy makers, investors, and sustainability planners who are trying to align green finance to the aim of climate in developed economies.

Keywords: *Sustainable investment, climate change mitigation, renewable energy, green innovation, governance, policy uncertainty, high-income countries, panel data analysis, ESG finance, sustainability strategy.*

SANTRAUKA

Šis straipsnis grindžiamas tvaraus investavimo, kaip atsinaujinančios energijos naudojimo stiprinančios klimato kaitos prevencijos priemonės labai išsivysčiusiose šalyse, tema. Tyrimo naudojama suinteresuotųjų šalių teorija, teisėtumo teorija ir signalizacijos teorija, siekiant suprasti, kaip žaliosios inovacijos mažina valdymo kokybę, politikos neapibrėžtumą ir tvarias investicijas, taip sumažindamos tvarių investicijų efektyvumą. Remiantis antriniais paneliniais duomenimis (1990–2023 m.) dešimtyje pagrindinių dideles pajamas gaunančių ekonomikų, įskaitant Australiją, Kanadą, Prancūziją, Vokietiją, Airiją, Italiją, Naująją Zelandiją, Ispaniją, Jungtinę Karalystę ir Jungtines Amerikos Valstijas, tyrime naudojami fiksuotų efektų, atsitiktinių efektų ir jungtiniai OLS regresijos modeliai, siekiant nustatyti pagrindinius veiksnius, prisidedančius prie atsinaujinančios energijos naudojimo. Rezultatai rodo, kad tvarios investicijos iš esmės nepadidina atsinaujinančios energijos vartojimo, tačiau situacijos veiksniai labai prisideda prie teigiamo jų poveikio. Būtent, žaliosios inovacijos turi teigiamą moderuojantį poveikį investicijų ir poveikio santykiui, o politikos neapibrėžtumo moderuojantis vaidmuo yra neigiamas. Be to, valdymo kokybė yra pagrindinis moderuojantis veiksnys, lemiantis pinigų nukreipimo į tvarią infrastruktūrą efektyvumą. Westerlundo kointegracijos testas taip pat patvirtina prielaidą, kad tarp pagrindinių kintamųjų egzistuoja ilgalaikiai ryšiai. Šie rezultatai rodo, kad klimato kaitos švelninimas gali būti veiksmingas tik esant finansiniam įnašui, taip pat gerai organizuotoms institucijoms, vienodoms politikos struktūroms ir technologijų prieinamumui. Straipsnis turi įtakos tiek teorijai, tiek politikai, nes sukuria iliuziją apie aplinkosaugos finansavimo optimizavimą siekiant reaguoti į klimato kaitą. Jame pateikiamos dvi praktinės išvados politikos formuotojams, investuotojams ir tvarumo planuotojams, bandantiems suderinti žaliąjį finansavimą su klimato kaitos tikslais išsivysčiusiose ekonomikose.

Raktiniai žodžiai: *tvarios investicijos, klimato kaitos švelninimas, atsinaujinanti energija, žaliosios inovacijos, valdymas, politikos neapibrėžtumas, dideles pajamas gaunančios šalys, panelinių duomenų analizė, ESG finansai, tvarumo strategija.*

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LIST OF ABBREVIATIONS

Abbreviation	Full Form
GHGs	Greenhouse Gases
ESG	Environmental, Social and Governance
OECD	Organisation for Economic Co-operation and Development
IEA	International Energy Agency
GSIA	Global Sustainable Investment Alliance
AUM	Assets Under Management
R&D	Research and Development
SDG	Sustainable Development Goals
ASEAN	Association of Southeast Asian Nations
OJK	Otoritas Jasa Keuangan
G7	Group of Seven
GMM	Generalized Method of Moments
RALS	Residual Augmented Least Squares
QUARDL	The Quantile Autoregressive Distributed Lags
RBV	Resource-Based View
OLS	Ordinary Least Squares
FMOLS	Fully Modified Ordinary Least Squares
DOLS	Dynamic Ordinary Least Squares
GDP	Gross Domestic Product
EU	European Union

INTRODUCTION

Relevance of the Study: Climate change has become the issue of global concern and is a threat to the ecological systems, human wellbeing, and economic prosperity. Climate change due to the unparalleled buildup of greenhouse gases (GHGs), especially carbon dioxide (CO₂) is increasing global temperatures, rising sea-level, loss of biodiversity, and extreme weather events (IPCC, 2023). Although over the decades many countries have engaged in climate diplomacy, most recent being Paris Agreement, 2015, global emissions remained on an upward trend to highest-record level of 36.8 billion metric tons of CO₂, 2023 (IEA, 2024).

Traditional mitigation strategies including carbon taxation, emission trading, subsidies of renewable energy, and regulatory measures have had partial success, but have not been effective in steering economic and financial systems on low-carbon pathways. There is growing consideration of the financial industry where investing choices can have a substantial impact on environmental results. This change has placed sustainable investment the process of considering environmental, social and governance (ESG) issues during financial decision-making on the agenda of climate policy and money debate.

Increased sustainable investment in the world has been impressive. The Global Sustainable Investment Alliance (GSIA, 2022) says that in 2022, investment assets under management had reached \$30.3 trillion of sustainable investment in 2022 (compared to 22.8 trillion in 2018). Parallel to this fact, the volume of green bonds began to issue almost six hundred and one billion dollars in 2024, which is about half a sustainable debt market (Climate Bonds Initiative, 2024)

This is a trend that is in line with the growing philosophy that the private capital, when properly placed, can represent a viable source and instrument of climatic mitigation—a philosophy, which has been articulated on the academic level as well as through institutional policy frameworks.

Emergence and Role of Sustainable Investment: Sustainable Investment is a financial reorientation: the long run co-creation of value (the long term) (both environmental and social) is integrated in place of an increase motivation oriented on short-term gains (profit maximization). Its major tools are:

i) The ESG Investing, which includes the non-financial variables (including carbon intensity, supply chain ethics, board diversity) as a part of the traditional investment analysis. ii) The fixed income securities are the Green Bonds which are actually used solely to fund any type of project

that has a favourable environmental impact such as the renewable energy schemes, energy conservation and clean transportation. iii) Impact Investing in this kind of investment, not only are the resulting social/environmental impacts measurable but they are also intended to deliver financial returns with those.

In Sustainable investments in volatile times: nexus of climate change risk, ESG practices, and market volatility (Naseer et al., 2024a) used panel data 2012-2021 and ESG performance is shown as a significant moderate of the impact of climatic risk on market volatility so that companies with high rating of ESG will be better off and less susceptible to climatic events, which are market volatility related. These findings are actual evidence to risk elimination component of investing.

Additionally, (Li, 2024a) identifies that the accrual of 1 percentage-point in the green finance has a positive effect on sustainability, 0.16 and 0.40 per cent respectively, in the short and long term respectively, but these effects of improvement in fossil fuel efficiency are even stronger, as high as 0.45 per cent in the long run such two effects show the shift to sustainability is central to investment in the green project upgrade effectiveness of the legacy energy systems.

Problem Statement: Despite the fact that there has been innovations of the sustainable mechanisms of finances, there are questions concerning whether these mechanisms are really effective as regards to the environment. First of all, since green bonds and ESG funds are actively marketed as climate-positive, because of the absence of the standardisation of measures, the possibility to check their impacts, and harmonisation of regulations, the phenomenon of greenwashing, albeit disguised rather than, is of concern.

Indiscriminate environmental disclosures and the factual impact of the financed projects on the environment is very likely to be challenging to determine, as (ElBannan & Löffler, 2024a) state that most green bond issuers (as well) make vague environmental disclosures. Besides this, the auditors note that though green bonds may have a marginal positive impact to the environmental rating they are not necessarily translated into a real reduction in emissions, in the event of creating weak monitoring and reporting standards.

Secondly, the size of sustainable investments and their orientation are ambiguously negatively affected due to climatic policy. Empirically, (Olasehinde-Williams et al., 2023a), the greater the uncertainty in the regulations, the less there is an investment in the clean areas and the less a steady market, at least where there is a problem of long-term infrastructures sensitive to climate.

Finally, even the efficacy of green finance is regionally eclectic. Even though some of the economies in OECD have quite mature sustainable finance market, the implementation of green finance is not feasible in the emergent economies where the institutional capacity, regulation, and frameworks of clarity or investor protection is lacking.

Research Objectives and Questions: The aim of the proposed research is to test the value and also the practicability of the idea of sustainable investment as a tool of controlling climate change.

Specially, the objectives are:

- To examine how different forms of sustainable investment contribute to global climate change mitigation.
- To identify the key drivers and barriers to sustainable investment practices that enhance climate action.
- To measure the impact of sustainable investment on carbon emissions reduction and renewable energy expansion.
- To analyze the moderating effects of governance, policy uncertainty and green innovation.
- To propose policy and regulatory recommendations that strengthen sustainable finance's role in climate change mitigation.

In line with the objectives, the study addresses the following core research questions:

1. How do different forms of sustainable investment contribute to climate change mitigation globally?
2. What is the measurable impact of sustainable investment strategies on carbon emissions reduction or renewable energy deployment?
3. How do governance, policy certainty, and innovation moderate the effect of sustainable investment on climate outcomes?

1. LITERATURE REVIEW

1.1 Conceptual Framework of Sustainable Investment and Climate Change Mitigation

Human caused greenhouse gas emissions remain large, at least through 2010 to 2023 have not yet moved out onto the rapid downward trajectory required to meet the Paris targets. Recent carbon budget estimates show continued high levels of fossil fuel CO₂ (with fossil CO₂ at roughly 37.4 billion tonnes in 2023 and total CO₂ roughly in the low 40 billion tonnes range), underscoring that global emissions are still rising for plateauing at dangerous levels rather than falling sharply. ([Global carbon Budget](#) & [Global carbon Project](#)). At the same time, renewable energy deployment has accelerated: net capacity additions for solar and wind increase strongly in 2010 to 2023 (solar additions in 2023 are much higher than 2022, and IEA data shows large year-on-year gains through 2023), demonstrating that technical replacement of fossil capacity is processing but not yet at the speed or scale to offset emissions growth. ([IEA Blob Storage](#)) (Energy Agency, 2023)

Financial flows into labeled sustainable instruments and into the clean-energy transition have grown markedly in the 2010-2023 period. The global sustainable investment alliance (GSIA) reported sustainable-investing AUM at tens of trillions of dollars (the 2022 GSIA put the figure around USD 30.3 trillion), and market trackers show record volumes of sustainable debt and label bonds in 2021-2022-2023 (Climate bonds/market reports indicate aligned sustainable debt volumes moving into the high hundreds of billions/trillions of USD annually). These flows matter, because scale determines the capacity to finance large-scale energy, transport and industrial transitions– but as other authors emphasize, the existence of flows alone does not guarantee measurable emissions reductions. (GSIA, 2022) (Climate Bonds Initiative, 2024)

Why Finance matters for mitigation? (Conceptual Framework)

Mitigation of climate change requires:

- a) Replacement of high carbon capital stock (power, plants, transport fleets, industrial plants)
- b) Investment in new low- carbon technologies and enable infrastructure (grids, storage, hydrogen hubs and
- c) Policy and governance that change incentives and remove barriers.

Financial markets and instruments influence all three channels: they allocate capital to projects and firms, they set the cost of capital (via risk pricing), and they signal preferences/expectation that feedback into corporate strategy and policy choices. Nonetheless, finance is not

neutral automatic switch— how capital is allocated (which instrument, what standards and what conditionality) is decisive for whether investment reduces emissions. This point is repeatedly emphasised both in empirical finance literature and in policy reviews.

1.1.1 Typology of sustainable investment strategies and their mitigation logic

Academic and practitioner literatures classify sustainable investments into designate strategies with different assumed mitigation logics:

- **Exclusion/negative screening:** Investors exclude high carbon or controversial sectors (fossil fuels, tobacco etc.). The intuition: withhold capital to penalize polluters. However, theory and experiments suggest exclusion often has limited real-world mitigation impact unless it changes a firm's cost of capital or operations directly. Market buyers can simply step into position sold by exclusionary investors, leaving corporate finance unchanged. (Karlsson-Larsson et al., 2025a) Summarize this trade off and report that exclusion remains the most used retail/ asset- manager-strategy despite limited expected mitigation potential (exclusion≈status quo in macro trumps unless combined with other mechanisms).(Karlsson-Larsson et al., 2025a)
- **Inclusion/positive screening and impact investing:** Actively allocating two firms or projects with explicit environmental outcomes (renewable projects, cleantech startups, energy-efficiency retrofits). Inclusion is more likely to have direct mitigation effects when it finances marginal, high-impact projects that would not otherwise attract capital (early-stage green tech, distributed renewables in under-served markets).(Karlsson-Larsson et al., 2025a) underline that inclusion strategies are used far less (often a small percentage of sustainable AUM) but in principle have greater mitigation potential because they can change the set of technologies deployed and support riskier, high impact innovation.
- **ESG Integration and stewardship:** Incorporate environmental (and social/governance) factors into credit and equity analysis and engage companies to enhance behaviour. This route aims to change from behaviour from within (through active ownership) or by re-pricing long-term risks and is frequently argued to be complementary to inclusion strategies. Several empirical studies and reviews suggest stewardship and ESG integration can spur corporate green investment when backed by credible engagement and regulatory framework.
- **Leveled green bonds/Sustainable bonds:** Instruments in which proceeds are earmarked for a specific green project (renewables, grids, water, low-carbon transport)

Labeled debt can lower the cost of capital for green projects and channel large institutional demand into climate projects. But labeling integrity (standards, verification) is critical to ensure proceeds finance real emissions reductions. Market trackers (Climate Bonds Initiative and related reports) document rapid growth in labeled issuance in 2010-2023; however, the mere growth of volumes is not proof of emissions abatements unless projects meet credible green definitions and deliberated outcomes are measured and reported.

1.1.2 Empirical findings and mechanisms from recent studies

(Karlsson-Larsson et al., 2025a) present an experimental investment paradigm that separates money-maximization, exclusion and inclusion strategies and finds a) Exclusion is a popular moral choice among investors despite limited expected (Climate Bonds Initiative, 2024) emissions impact, b) Inclusion is used less often but corresponds to consequentialist/utilitarian moral reasoning and crucially, c) Small “choice architecture” interventions (defaults, framing) can shift investor allocations toward inclusion—suggesting there are experimentally traceable behavioural levers to re-orient capital toward higher mitigation potential. It means that investor psychology and financial literacy are key drivers of whether sustainable finance is providing actual climate results.

(Y. He et al., 2025) analyze how local government debt and the development of digital finance interact with green innovation and carbon emissions in China. They find that rising local government debt can (in some contexts) increase emissions—partly by supporting growth of energy-intensive activities—but that when debt is deployed to promote green innovation it can reduce emissions. They highlight digital finance as a channel that can both help (by lowering financing friction for a green projects) and harm (through rising data-center energy use and other scale effects) depending on the policy and investment mix. The study illustrates the point that the fiscal side of finance matters: who borrows, how funds are allocated, and what conditions are attached fundamentally change climate outcomes.

1.1.3 Measurement, attribution and the real-world impact problem

A recurring theme across the empirical literature (and echoed in the experimental work) is measurement uncertainty and attribution difficulty. Key problems are:

- **Additionality:** Did the labelled investment finance something that would not have happened otherwise? (Critical for early stage take and for carbon projects)

- **Leakage and markets substitution:** Excluding a high limiting firm from a portfolio does not necessarily reduce that firm's ability to raise capital in aggregate; buyers main substitute. (Karlsson-Larsson et al., 2025 discuss this theoretical risk for exclusion strategies).
- **Standards and integrity of labels:** rapid growth in grain/sustainable bond issuance is promising, but heterogeneous standards and weak verification open the door to greenwashing; recent market reports show an increase in aligned/verified issuance but also emphasize the need for robust taxonomies and post-issuance reporting.

1.1.4 Synthesis and implications for mitigation strategy

Big sustainable finance-numbers (trillions in AUM, hundreds of billions in labeled debt) are necessary but not sufficient– the allocation toward inclusion (directly financing low-carbon capital, cleantech R&D and enabling infrastructure) appears more likely to generate measurable emissions reductions and pure exclusion, ceteris (GSIA, 2022)

Public borrowing, fiscal incentives, and regulation can either magnify or negate the climate impact of private finance (He et al., 2025 show how local government debt interacts with green innovation and data finance to shape emissions trajectories). Hence, understanding the policy-finance nexus is essential.

Credible taxonomies, rigorous verification and patrol investor defaults/engagement can nudge capital toward high-impact uses; experimental evidence suggests small interventions can change investor choices away from low-impact intuition toward higher-impact inclusion (but scaling those interventions remain an open question). (Climate Bonds Initiative, 2024)

1.2 Defining and categorizing Sustainable Investment

Sustainable Investment, often interchangeably called responsible investment or green finance, has evolved significantly over the past three decades. Early practices were dominated by ethical exclusion strategies—where investors avoided controversial industries such as tobacco, weapons, or fossil fuels. Over time, this evolved into environmental, social and governance (ESG) integration, which incorporated ESG factors into mainstream financial decision making. According to the Global Sustainable Investment Alliance (GSIA, 2022) by 2021-2022 global sustainable investment assets exceeds USD 30 trillion, representing nearly 40% of total managed assets in advanced economies, and these assets continued to expand through 2023. This index to us, brings to mind that sustainable investment is not the practice as a remote logical method of finance but is an element of the new paradigm of financial boldness.

It is important to show how sustainable finance found its niche in the Japan national strategies since the end of the Paris Agreement when the problem of green bonds is issued along with the support of policies is vital. The emerging trends are widespread in every part of the globe; the degree and policy of sustainable finance have been established through policy mechanisms and climate accords (Ullah et al., 2025a)

As the literature review shows, the categories of sustainable investment strategies are five:

1. Negative Screening (Exclusionary Investing): It is applied to exclude industries with a high carbon content or controversial ones in the portfolio. Despite its widespread application, it has been revealed that the sphere of mitigating climate is still narrow without considering them at a huge scale. In the case of (Karlsson-Larsson et al., 2025b) the preference to adopt exclusionary strategies can be attributed to the fact that it is ethically justified, indicating that, however, it does not have a major impact on the access to capital of firms.
2. Positive screening (Best-in-Class Investing): It is a selected group of companies with quite good ESG performance. It has been shown that firms that have a greater ESG rating are better placed when they have to deal with climate shock both financially and within the environment (Naseer et al., 2024a) Positive screening would form esteem and economic advantages of companies to observe more environmentally friendly practices.
3. ESG integration: ESG factors are echoed in the investment analysis in a structured way. (Ullah et al., 2025a) note that digital financial platforms can help to increase the transparency of ESG reporting to improve ESG integration. Another aspect is that ESG adds value to the economies of OECD, which is best introduced when combined with structural reforms like those associated with the efficiency of fossil fuels (Further) (Ali et al., 2024a)
4. Impact Investing, thematic investments: Impact investing is designed to accomplish quantifiable social and environmental outcome whereas thematic investments customarily invest in places such as renewable energy, sustainable agriculture and clean water. To illustrate, it is acknowledged that the investments related to forests will initially be required to reduce carbon footprints and enhance an ecological resilience (Z. Zhang et al., 2022a) Similarly, the sectors of energy, land and water system allocations are categorical to the achievement of climate related SDGs (Vinca et al., 2025a)

5. **Green Bonds and Climate-Aligned Debt Instruments:** Green Bonds can without a doubt be considered as one of the quickest growing types of sustainable finance. In 2023 this has reached above USD 600 billion in its issue and has an estimated total amount of over USD 1 trillion in issuance every year through 2025 (Climate Bond Initiative, 2025). Support has to demonstrate that when there is a strong governance, there is positive influence of climate. Precisely, in ASEAN, the carbon intensity within corporations decreased as a consequence of the problem of the issuance of green bonds a major margin (Robert Chowiendo et al., 2025a) Comparatively,(EIBannan & Löffler, 2024a) indicates that creditworthiness is jeopardized in cases where the disclosure standards are of low quality, which leads to the greenwashing risks being undermined. In Japan, Keep, (Schumacher et al., 2020)notes that successful green bond markets were coordinated by regulations.

1.3 Sustainable Investment and Climate Change Linkages

The relationship between Sustainable Investment and the climate mitigation can be linked in numerous ways though there is a redirection of the financial flows towards the high-carbon direction to the low-carbon direction which is one of the most visible. This is supported by facts which have established that the emission will be reduced once capital exceeds towards renewable energy and energy efficiency. One such study is the article Green Finance Investment and Climate Change Mitigation in OECD-15 European countries: RALS and QARDL Evidence (Ali et al., 2024a) which demonstrated that the reduction of CO₂ emissions is steep with the investment in green financing in both the short run and the long one and that the statistically significant tests and results of the econometric robustness showed. This makes the contribution aspect of the green finance to decarbonization of developed economies as one of the direct drivers in the historical context. Similarly, in Green Finance, Fossil Fuel Efficiency and Sustainable Development in OECD (Li, 2024a)find that sustainable finance flows increases the nature of efficiently using fossil fuel, and also, accelerating renewable investments to achieve two ends of economic growth and emission reduction.

Funding Renewable Energy and Clean Infrastructure: Sustainable funding has been a particular success specifically in the area of financing renewable energy and green infrastructure projects. The quantitative indicators of the role of green finance in the reduction of climate change risks provided in The Role of Green Finance in Mitigating Climate Change Risks: A Quantitative Analysis of Sustainable Investments (Zhao & Li, 2024a)are the quantitative demonstration that direct effect of investments in green financial projects is the development of renewable capacity

and the reduction of emissions, mainly in the economies of Asian-pacific countries. In the meantime, the industry-specific study shows that thematic investments are converted into actual mitigation. In *Sectoral Investments to Achieve Water, Energy and Land SDGs under Climate Change Uncertainty*, (Vinca et al., 2025a) pay attention to the fact that the targeting of finance to sustainable energy and water infrastructure is an action that does not solely offer resistance to climate shock but also generates resilience.

Green Bonds and Climate Outcomes: Green bonds remain one of the most studied fields of sustainable finance which relates to the concerns of climate change output. According to the *Green Bonds Issuance Role in Reducing Carbon Emissions: Evidence from ASEAN Economies* (Robert Chowiendo et al., 2025a) report, the green bond issuance lead to statistically significant impact in the corporate intensity of carbon emission, particularly in the energy-intensive industries. The country specific case studies involve this. *Green Bonds in Indonesia: Synergy between Bank Indonesia and Otoritas Jasa Keuangan* (Putri, Tristiyanto, et al., 2023) (Bank Indonesia and OJK, 2023) in the presented article confirms the notion that the collaboration between the regulation helped to make the green bond markets credible to attract funds to renewable projects with the measurable emission-reduction outcomes. On one hand, in *How Effectively do Green Bonds help the environment? The poor standards and disclosure systems sometimes harm impact, which is a concern of greenwashing*, (ElBannan & Löffler, 2024a)

Policy, Regulation and Investment Flows: This determines whether sustainable investment in policy environment is successful or not. The *Policy Uncertainty on Sustainable Investment: A Dynamic Analysis of the U.S.*, (Olasehinde-Williams et al., 2023a) shows that the uncertainty in policy fails to stimulate long-capital inflow to assets of sustainable investments and this undermines their effect on climate. On the contrary, in *National Climate Policy, Environment Regulation, and Media Attention: Implications of Sustainable Investment*, (Hussain & Zhou, 2025) believe that an appropriate extent of environmental management, along with the media, can be very beneficial in not only making investors more confident but also accelerate climate-oriented finance. Japan can be a good example in the region. In *Sustainable Finance in Japan*, (Schumacher et al., 2020) is an illustration of how with the facilitation of central bank and policies of the government, there was favourable environment to invest in green particularly, the concept of green bond and institutional direction.

Innovation, Digital Finance, and Climate Linkages: The literature on the subject is that financial innovation and digital finance boosts the climate-finance nexus. The study *In Mitigating Risk for Climate Change: The Role of Digital Finance Policy*, (Ullah et al., 2025a) states that the

digital financial platforms enhance the clarity and responsibility of ESG reporting that results in the enhanced manner of capital channelling to carbon-reducing projects. Going by this, in *The Role of Greener Innovation in Promoting Financial Inclusion to Achieve Carbon Neutrality*, (Brahmi et al., 2023a) assert that, green innovations augment the financial inclusion of people particularly the developing economies to ensure the broader participation in the low-carbon transition. In *Local Government Digital Finance and Climate Change: from the perspective of green innovation* (He et al., 2025b) postulates that in the area where increasing government debt will increase emissions, a fiscal debt allocated towards green innovation (with the aid of digital finance) does reduce carbon emissions.

Cross-sectoral and Regional Linkages: According to Multiple Studies, sustainable investment is not only tied to energy, however it is also tied to land use, forestry and the ecosystems in general. W. The paper *Sustainable carbon Footprint Growth Mechanism in Forest Systems*, (Z. Zhang et al., 2022a) notes that the forestry investment in Forest Systems is identified as the most important carbon sinks hence the direct linkage between finance and the emission reduction. Similarly, in the article *Role of Energy Mix in Determining Climate Change Vulnerability in G7 Countries*, (Dai et al., 2022) illustrate how a change of financial resources towards the renewable energy source in the G7 would be an efficient method of reducing exposure to risks linked to climate changes compared to fossil-based energy sources that would increase systematic exposure.

1.4 Drivers and Barriers to Sustainable Investment for Climate Change Action

Policy and Regulatory Frameworks: In *National Climate Change Policy, Environmental Regulation and Media Attention: Implications for Investment* (Hussain & Zhou, 2025) the two authors illustrate that, when these two factors are strong, that is, when it has a robust environmental regulation and control over the media, the investors will be convinced to invest a higher wealth in the green sector. In *Sustainable Finance in Japan* (Schumacher et al., 2020) says that due to the green Bond principles applied in Japan and the projects supported by the central bank the country was a leader in its field of developing sustainable finance in Asia.

The inception of market Incentives and risk management: *Market Incentives and risk management in Sustainable Investments in volatile times: Nexus of climate change risk, ESG practices and market volatility*, (Naseer et al., 2024a) has shown that ESG Portfolios are downside protection in volatile markets and are attractive to institutions (Pyka & Nocoń, 2021) the argument (Pyka & Nocoń, 2021) based on the premise of the argument in the Banks Capital Requirements in

Terms of Implementation of the Concept of Sustainable Finance is the fact that the capital adequacy regulations incentivize the banks to lend money to the sustainable projects, which makes the stability systematic.

Technical and Financial Innovation: (Ullah et al., 2025a) in Mitigating risks to climate change: the role in digital financial policy postulates that ESG accountability may be supplemented via digital financial policy including carbon tracking technology which is developed on blockchain. The presence of a sense of finances in unreserved areas can be arguably supported by mobile banking and inclusive finance because (Brahmi et al., 2023a) in The Role of Greener Innovations in Promoting Financial Inclusion in Achieving Carbon Neutrality has identified a connection between mobile banking and inclusive finance.

The International Collaboration and Global Standards: It is also highlighted in the article Exploring the Sustainable Development Path of a Green Financial Systems in the Context of Carbon Neutrality and Carbon Peaking, (Bai, 2022) that the international collaboration and global standards of the ESG disclosure helps in the process of reducing the cost of a transaction and making the cross-border sustainable investments attainable. In this relation, the investigation article by (Z. Zhang et al., 2022a) Green Finance and Carbon Emission Reduction: A Bibliometric Analysis and Systematic Review has discovered, the literature of the globe and policy coordination are informational tools of popularizing finance.

Sector-Specific Opportunities: Role of energy mix in determining climate change vulnerability in G7 Countries, (Dai et al., 2022) argues that green-oriented energy mixes create more green investments since the investors would choose to align to the decarbonization vectors. According to Sustainable Carbon Footprint Growth Mechanism in Forest Systems, (Z. Zhang et al., 2022a) forestry and land -based investments are coming out to be well-known cost-effective mitigation measures.

The biggest obstacles towards sustainable investment:

Policy and Climate Uncertainty: (Olasehinde-Williams et al., 2023a) in Effects of Climate Policy Uncertainty on Sustainable Investment: A Dynamic Analysis of the U.S. indicates that uncertainty warrants a negative impact on capital investment on environmentally friendly projects in the long term. Likewise, in Climate Investment and Financing, (Wang et al., 2025) Economic Growth Target Constraints and Urban Green Development Efficiency, it is explained that the short-term growth targets in China meet the requirements of the long-term green investment. In How Well do Green Bonds Work in Promoting the Environment? As (ElBannan & Löffler,

2024a) this is a danger to the possibility of the presence of the greenwashing because the standards of the disclosure mechanisms employed by the business are not high at all. (Z. Zhang et al., 2022a) have also stated that the incoherent techniques of measuring the effects of climate have hampered the measurement of actual efficiency of sustainable finance.

Structural and Institutional Constraint: This is because, in Local Government Debt, Digital Finance and Climate Change: Study from the Perspective of Green Innovation, (He et al., 2025b) local debt is noted to have an impact of not making the level of emissions lower, but instead, make the emissions higher, unless the funds are channeled through the agency of governance into conducting a real green innovation. In Banks Capital Requirements in Terms of Implementation of the Concept of Sustainable Finance, (Pyka & Nocoń, 2021) also states that gap of green lending will be a bottleneck in translation to banking risk frameworks of ESG.

Regional and Sectoral Inequality: In Sectoral Investments to Achieve Water, Energy and Land SDG under Climate Change Uncertainty, (Vinca et al., 2025a) signifies that, developing economies are challenged by the issues of attracting capital within the segments of into land-energy-water projects integrations as it is the case of the OECD countries. In Role of Energy Mix in Determining Climate Change Vulnerability in G7 Countries, (Dai et al., 2022) observe that the economies that predominantly work on fossil fuel are still overloading too much capital in the brown areas hence failing to develop the globe.

Information Asymmetry and Data Gaps: In Integrating Sustainability into Climate Finance by Quantifying the Co-Benefits and Market Impact of Carbon Projects, (Lou et al., 2022) argue that insufficient data on project-level co-benefits creates information asymmetries, discourages institutional investors from allocating large-scale capital. (Z. Zhang et al., 2022b) also emphasize that fragmented ESG data standards reduce comparability, slowing global capital flows.

1.5 Measurable Impact of Sustainable Investment

“Measurable impact” in climate finance is usually operationalized as one or more of the following outcomes that are assigned an emissions-equivalent value:

- Reduction in CO₂ (CO₂ equivalent) emissions at firm, sector or country level.
- Increases in installed renewable energy-efficiency improvements.
- Broader co-benefits (air quality, employment, resilience)

Authors stress that measurement requires clear baseline, attribution rules, and post-issuance monitoring– otherwise labeled finance risks being only reputational rather than real. (ElBannan & Löffler, 2024b); (Z. Zhang et al., 2022b).

Cross-country econometric evidence (macro and meso level): Several large-sample econometric studies find statistically significant negative relationships between green finance and emissions, though effect sizes and emissions, though effect sizes and robustness depend on model choice, institutional context, and control variables:

(Baştürk, 2024a) in “Does Green Finance Reduce Carbon Emissions? Global Evidence Based on System Generalized Method of Moments, applies system- GMM on an international panel and reports that higher green-finance indicators are associated with lower national CO2 emissions after controlling income, trade and energy structure. Baştürk highlights the importance of institutional quality as a moderator of the effect.

(Ali et al., 2024b) in green finance investment and climate change mitigation in OECD-15 European countries: RALS and QARDL Evidence, use RALS and QARDL methods on OECD-15 countries and find both short-run and long-run reductions attributable to green finance flows, with heterogenous impact across countries depending on energy mix and policy framework.

(Li, 2024b) Green finance, fossil fuel efficiency, and sustainable development in OECD, finds that green finance and improvements in fossil fuel efficiency jointly improve sustainability indicators, and quantify marginal effects that are meaningful at policy scale.

These macro/meso results are valuable because they show consistent directional evidence: green finance correlates with lower emissions across many settings. But authors also warn that macro correlations can mask heterogeneity (e.g. which instruments, which sectors, which governance settings), so micro and project-level analysis is needed for casual attribution.

Green bonds– project-level and firm-level evidence: Green bonds are frequently studied because they are labeled instruments intended to finance clearly define projects. The literature gives a mixed but cautiously optimistic verdict:

Positive evidence: (Robert Chowiendo et al., 2025b), in “The Green Bonds Issuance Role in Reducing Carbon Emission: Evidence from ASEAN Economies” examine firm-level data and find that firms issuing green bonds show reductions in carbon intensity following issuance, particularly when proceeds finance energy or process upgrade. Similarly, case evidence from Indonesia (“Green Bonds in Indonesia: Synergy between Bank Indonesia and Otoritas Jasa Keuangan”) shows that regulatory coordination channel proceeds into measurable renewable projects.

Caveats and limits: (ElBannan & Löffler, 2024b) How effectively do green bonds help the environment? analyse numerous green bond issues and warn about weak-post issuance reporting and inconsistent use-of-proceeds classifications. They document cases where labeled proceeds were used for projects with marginal emission benefits or where verifications were inadequate– a condition that reduces observed impacts.

ESG integration, stewardship and firm level outcomes: ESG integration and stewardship influence climate outcomes mainly by changing corporate incentives and lowering firm cost of capital. (Naseer et al., 2024b) in “Sustainable investments in volatile times: Nexus of climate change risk, ESG practices, and market volatility”, show that firms with stronger ESG practices experience lower climate-related market volatility and are more likely to invest in adaptation and mitigation measures. Their findings indicate a mechanism: ESG performance reduces perceived risk, which lowers the cost of capital for green investments. (Karlsson-Larsson et al., 2025a) in “Mitigating climate change with financial investments: exploring sustainable investment strategies in a novel experimental investment paradigm”, provide experimental evidence that active/inclusion for real-world mitigation because they directly fund marginal low-carbon projects and innovation rather than simply reallocating existing capital. Behavioural nudges and stewardship can thus shift actual allocations toward projects with measurable emissions impacts.

Sectoral evidence – energy, land/forestry and infrastructure: Sectoral studies show where measurable impacts concentrate:

Energy/renewables: (Zhao & Li, 2024b) in “The role of green finance in mitigating climate change risks: a quantitative analysis of sustainable investments” and (Vinca et al., 2025b) in “Sectoral investments to achieve water, energy and land SDG under climate change uncertainty”, both report that targeted investments in renewable generation and grids leads directly to increases in renewable capacity and displacements of fossil generation–outcomes that are relatively straightforward to measure at project and regional scale.

Land and Forestry: (W. Zhang & Liu, 2024) “Sustainable carbon footprint growth mechanism in forest systems under patterns of global climate change”, emphasize that finance for forest conservation and sustainable land use reliably produces measurable carbon sinks when monitoring is robust. These investments can be highly cost effective per tonne of CO₂ removed but require long time horizons and careful baseline settings.

Infrastructure and urban green development: Studies on urban green finance (climate investment and financing, economic growth target constraints and urban green development

efficiency) show that smart urban investments (public transit, district heating, efficiency buildings) yield measurable emissions reductions— although their attribution to private sustainable finance vs public capital is often entangled (authors in those studies stress mixed public-private financing architectures).

The role of governance, policy certainty and verification: Multiple papers underscores that policy credibility and verification frameworks multiply the realized impact of sustainable finance: (Olasehinde-Williams, Özkan, et al., 2023) “Effects of climate policy uncertainty on sustainable investment: a dynamic analysis for the U.S”, show that policy uncertainty reduces the pace and scale of private green investment—therefore even well designed instruments need stable policy signals to translate into measurable outcomes. (Z. Zhang et al., 2022b) “Green Finance and Carbon Emission Reduction: A Bibliometric Analysis and Systematic Review”, document that standardization of taxonomies, mandatory disclosure and third-party assurance are recurring recommendations across studies to improve impact measurability. (Y. He et al., 2025) “Local government debt, digital finance and climate change: Study from the perspective of green innovation”, provide evidence that when local public finance is aligned with green innovation (and supported by digital finance for transparency), measurable emission declines follow— in other words, governance quality conditions the translation of financial flows into climate outcomes.

Quantitative magnitudes reported in studies (examples): Authors often report elasticities or marginal effects; these should be read as context-dependent, but they are informative for order-of-magnitude thinking:

(Li, 2024b) in “Green finance, fossil fuel efficiency, and sustainable development in OECD”, reports that modest increases in green finance and fossil fuel efficiency indicators produce positive percentage changes in sustainability indices—illustrating that combined policy-finance packages have cumulative effects. (Ali et al., 2024b) “Green finance investment and climate change mitigation in OECD-15 European countries: RALS and QARDL evidence”, identify both short-run and long-run coefficients linking green investment to lower emissions— again, the key point is that effects are larger and more persistent in countries with stronger institutions.

Because studies use different dependent variables (CO₂ levels, carbon intensity, sustainability indices) and different identification strategies (GMM, QARDL, panel regression) direct numerical comparison across papers is difficult, but the consistent result is qualitative: sustainable finance investments are associated with emissions reductions, renewable deployment, or improved carbon intensity measures— especially conditional on governance and project quality.

Limits, attribution problems and common methodological pitfalls: Despite encouraging findings, the literature repeatedly warns about methodological issues:

Additionality: Did the investment enable an activity that would not have occurred otherwise? This is a central question for green bonds and impact investments (ElBannan & Löffler, 2024b)

Baseline and leakage: If a project reduces emissions locally but production shifts elsewhere (leakage), net climate gains may be smaller.

Measurement heterogeneity: Different studies use CO₂, CO₂ per unit output, sustainability indices, or project-level avoided emissions—comparability is low. (Z. Zhang et al., 2022b)

Post issuance reporting: the absence of robust ex-post verification undermines confidence in reported outcomes. (ElBannan & Löffler, 2024b) (Robert Chowiendo et al., 2025c)

Policy endogeneity: Countries that adopt green finance policies may differ systematically (like, richer, more regulatory capacity), so simple correlations can overstate casual impact unless instruments or dynamic panel methods are used (Baştürk, 2024a) (Ali et al., 2024b)

Synthesis: When does sustainable finance deliver measurable climate impact?

Bringing the evidence together, the literature identifies a set of enabling conditions for measurable impact:

High integrity of labels and taxonomies: Clear use of proceeds rules, mandatory reporting, and independent verification (ElBannan & Löffler, 2024b) (Z. Zhang et al., 2022b)

Stable and credible policy frameworks: long term carbon pricing or regulatory targets reduce investment uncertainty (Olasehinde-Williams, Özkan, et al., 2023)

Targeted allocation to high-impact sectors: Renewables, energy efficiency, forestry and urban infrastructure produce cleaner, measurable emission outcomes. (Zhao & Li, 2024b) (W. Zhang & Liu, 2024) (Vinca et al., 2025b)

Institutional capacity and governance: Effect sizes are larger where institutions are stronger (Baştürk, 2024a) (Ali et al., 2024b)

Complementary public finance and innovation support: Public debt deployed for green innovation and digital finance can amplify private green investment. (Y. He et al., 2025) (A. Ullah et al., 2025)

1.6 Theoretical Frameworks Underpinning Sustainable Investment for Climate Change Mitigation

Stakeholder Theory and Climate-Aligned Investment Behaviour: According to the stakeholder theory, firms are not only responsible to the stockholders, but to the other societal stakeholders, and communities, as well as future generations are included in the case. This theoretical perspective is more closely associated with the sustainable investment practices where investors do reward the climate-responsible corporations with favourable access to capital. As an example, in Sustainable Investments in Volatile Times: Nexus of Climate Risk, ESG Practices and Market Volatility, (Naseer et al., 2024a) the researchers prove that capital stability of companies, which are more ESG responsive, usually towards the demands of its stakeholders, is higher during the occurrence of a climate-related shock. This implies that investors are becoming stakeholder enforcers whereby they are conditioning access to finance based on environmental accountability. Further, the results of National Climate Change Policy, Environmental Regulation and Media Attention: Implication (Hussain & Zhou, 2025) (Hussain & Zhou, 2025) reveal that the investment flows are influenced by the public scrutiny and media discourses, which support the stance of stakeholders regarding social legitimacy as a financial resource. According to this framework, climate mitigation would be a prerequisite set by the society stakeholders, who are conveyed by investors activities.

Agency Theory and Adapting Investment Decisions to Climate Goals: Agency Theory is often used to point out the conflict between the principals (investors/citizens) and the agents (fund managers, corporate executives, local governments). Agency problems in the framework of sustainable investment can appear when the decision-makers are concerned not with the long-term climate consequences, but with the short-term financial profits. In Local government debt, Digital finance and climate changes: the study in terms of green innovation perspective, (He et al., 2025b) indicate that local governments can repurpose funds in politically-favourable-yet-carbon-intensive projects, unless digital money clarifications mechanisms make them accountable - a direct agency issue in green money allocation.

Equally, (Karlsson-Larsson et al., 2025b) in Mitigating Climate Change with Financial Investments indicate through experimental results that, default options and behavioural nudges minimize agency-induced deviations attempting to steer capital towards climate-positive results

despite financial agents being biased toward maximizing their profits. Therefore, the Agency Theory defines the reason why sustainable investments instruments need to be governed through disclosure regulation, digital surveillances and fiduciary climate-alignment regulations to make sure that the funds under the title of green investment can return a tangible reduction.

Resource-Based View (RBV) and Green Competitive Advantage: The Resources-Based View believes that companies can achieve competitive advantage due to their distinctive intangible and strategic resources. green innovation capability, carbon management systems, and sustainability reporting competencies are considered as strategic resources in climate finance, which enhances access to capital and environmental performance. As an example, in *The Role of Greener Innovation in Promoting Financial Inclusion to Achieve Carbon Neutrality* (Brahmi et al., 2023a) find that companies that have internal innovation capacity of green character are the more enticing targets of impact investors and can get access to less expensive finance. Similarly, *Green Finance, Fossil Fuel Efficiency and Sustainable Development in OECD* by (Li, 2024a) is another version that illustrates how firms that have improved fossil fuel consumption turn into investment targets, implying that an environmental performance in itself turns into a resource-based competitiveness. In this regard, RBV constructs sustainable finance not as an ethical requirement but as a strategic asset that is hard to find, with those firms which internalize climate innovation being in better financial positions in capital markets.

Diffusion of Innovation Theory and Adoption of Sustainable Investment Instruments: Diffusion of Innovation Theory explains how new financial instruments– such as green bonds, sustainability-linked loans or ESG integrated portfolios– spread across markets. In *Green Bonds in Indonesia: Synergy Between Bank Indonesia and Otoritas Jasa Keuangan*, (Putri et al., 2023) regulatory synergy is shown to accelerate market adoption, making Indonesia a regional early adopter. Similarly, in *Green Finance and Carbon Emission Reduction: A Bibliometric Analysis and Systematic Review*, (Z. Zhang et al., 2022b) document a rapid post-2020 diffusion of climate-labeled finance research and instruments, especially in OECD and ASEAN regions.

(Karlsson-Larsson et al., 2025a) further argue that behavioural incentives and default investment mechanisms accelerate the diffusion of sustainable investment choices among institutional and retail investors. Diffusion here is not only technological but cognitive and regulatory– requiring awareness, legitimacy, and institutional endorsement to cross the adoption threshold.

1.7 Identification of Research Gaps

Despite the growing body of literature on sustainable finance and climate change mitigation, several critical gaps remain that justify the need for this research:

Gap in Global Empirical Integration of Diverse Sustainable Investment Instruments: Existing studies tend to examine single financial instruments in isolation— for example, green bonds (Robert Chowiendo et al., 2025a), ESG integration (Naseer et al., 2024b) or digital green finance mechanisms (A. Ullah et al., 2025). However, comparative assessment across multiple types of sustainable investment flows (bonds, ESG portfolios, innovation finance, inclusion-based models) and their differentiated climate impacts remain limited. This is discussed in my research which would combine various long-lasting investing systems in a comparative climate mitigation focus.

Gap in Communicating Financial Flows to Quantifiable Emission Results with Ascertained Causality: A consistent shortcoming in the literature is the absence of standard measures and poor causal assignment. The research like (Baştürk, 2024b) (Does Green Finance Reduce Carbon Emissions? Global Evidence Based on System Generalized Method of Moments) and (Ali et al., 2024a) (green finance investment and climate change mitigation in OECD-15 European countries: RALS and QARDL evidence) determine correlations but fail to differentiate between financial green signalling and actual reduction of emission. My work focuses on quantitative effect- not only called finance- on the metric of additionality and (ElBannan & Löffler, 2024a) by (ElBannan & Löffler, 2024a) How effectively do green bonds help the environment?

Policy Finance Integration and Mitigation Convergence under Governance Variability: Although a policy certainty is cited as a phenomenon influencing or hindering it, not much research has assessed the extent to which the quality of governance, the coherence of regulations, or the design of climate policy alters whether sustainable investment can occur (Olasehinde-Williams et al., 2023a) (Effects of climate policy uncertainty on sustainable investment: a dynamic analysis of the U.S); (Hussain & Zhou, 2025) (National My thesis clearly has policy and governance as moderating variables- not to be realized in most of the macro studies.

Gap in Regional Equity and Climate Finance Distribution: A large part of the evidence is OECD-or G7-based, and little attention has been paid to ASEAN, South Asian, African and Latin American climate finance dynamics. Studies such as still reveal this, even when emerging economies are taken into consideration. (He et al., 2025b)(Local government debt, digital finance and climate change: Study from the perspective of green innovation) points out inconsistencies-

sustainable finance can either increase or decrease or decrease emissions based on the governance and the structures of debt allocation. My study is a multi-region comparative less, which touches on equity of the world and differentiation of financial effectiveness.

Gap in Integrating Innovation, Inclusion and Behavioural Dimensions: Behavioural and innovation-linked capital allocation– seen in (Karlsson-Larsson et al., 2025a) (Mitigating climate change with financial investments: exploring sustainable investment strategies in a novel experimental investment paradigm) and (Brahmi et al., 2023b) (The Role of Greener Innovations in Promoting Financial Inclusion to Achieve Carbon Neutrality: An Integrative Review)m is still emerging and remains fragmented in literature. There is no unified theoretical or empirical model linking financial inclusion, innovation capacity, digital finance transparency and real carbon outcomes. My work incorporates innovation and behaviour as core components, responding to this theoretical integration gap. While sustainable finance literature has expanded rapidly, there remains no integrative framework that evaluates multiple sustainable investment pathways, their measurable climate mitigation outcomes and the role of governance, regional disparity, innovation and verification integrity. This thesis, therefore, aims to address these gaps through a systematically comparative and impact-oriented approach aligned with climate policy objectives.

2. RESEARCH METHODOLOGY

2.1 Purpose, Hypothesis, and Research Model of the Study

Green investments that take into account environmental, social, and governance (ESG) aspects have become even more prominent in the international climate policy ((Naseer et al., 2024a)This paper will consider how various forms of sustainable investment, including ESG investing, green bonds, and impact investing, can be used to lower carbon emissions, expand renewable energy, and support the climate response in general (Li, 2024a)In addition, the paper will investigate the impact that the quality of governance, policy uncertainty, and green innovation have on the efficiency of such investments towards the achievement of the climate change reduction objectives (Olasehinde-Williams et al., 2023a) .It is assumed that the research will give important data, as it will involve the secondary analysis of how the financial markets can be optimized so as to assist in shifting to the low-carbon economy (Naseer et al., 2024a).

H1: Sustainable investment positively affects the tools to mitigate climate change.

Sustainable investment has a positive impact on the tools to combat climate change. Green investments have become a more and more popular area of investment in which companies can integrate the environmental, social, and governance (ESG) factors to achieve climate change reduction (Naseer et al., 2024a)Sustainable finance has been demonstrated through various methods to contribute directly to the reduction of carbon emissions and the growth of renewable energy capacity, thereby being an important instrument in the fight against climate change (Li, 2024a)Such investments guide capital to the projects to minimize environmental degradation and advance sustainable activities, proving that when the financial assets are aligned with the climate ambitions, the beneficial consequences may be considerable (Karlsson-Larsson et al., 2025b)Hence, the role of sustainable investment strategies is to enable the processes of switching to a low-carbon economy and to overcome the acute global issue of climate change (Olasehinde-Williams et al., 2023a)

H2: Governance moderates the relationship between sustainable investment and the tool to mitigate climate change.

There is a moderating effect of governance in the relationship between sustainable investment and the tool to mitigate climate change. Sustainability of investments is strongly dependent on the quality of governance (Ullah et al., 2025a). Good governance structures, such

as quality of regulations and political stability, are the pillars that enable sustainable investment strategies to thrive, and this means that investments are made in projects that have quantifiable climate impact (Schumacher et al., 2020). On the other hand, poor governance and regulatory frameworks could potentially result in a poor performance of these investments since they bring in more uncertainty and reduce investor confidence (Olasehinde-Williams et al., 2023a) In such a way, governance is a moderator because it either enhances or decreases the effects of sustainable investments on the mitigation of climate change and, therefore, is a crucial aspect of transitioning the financial system to sustainability (Li, 2024a).

H3: Policy uncertainty negatively moderates the relationship between sustainable investment and the tool to mitigate climate change.

Policy uncertainty moderates the relationship between sustainable investment and the tool to mitigate climate change negatively. The uncertainty of the policies, in particular, regarding climate-related policies, can be one of the factors that could severely deter the efficiency of sustainable investments (Karlsson-Larsson et al., 2025b). Investors also need to know the consistent and predictable policy measures to be committed to the long-term investment in green projects, and any doubt about forthcoming regulation would deter investment in climate solutions (Olasehinde-Williams et al., 2023a) The research has demonstrated that when there is a high degree of regulatory uncertainty, a decrease in clean energy industries' investments and an increase in volatility in the market are observed, especially in long-term projects like climate-relevant infrastructure (Naseer et al., 2024a) .The adverse moderating impact of policy uncertainty, therefore, renders the potential of sustainable investment to reduce climate change hard to achieve (ElBannan & Löffler, 2024a)

H4: Green innovation positively moderates the relationship between sustainable investment and the tool to mitigate climate change.

Green innovation plays an intermediary positive role between sustainable investment and the tool to mitigate climate change. Green products and processes (clean technologies and energy-saving solutions) must be developed and implemented to ensure significant climate mitigation results are achieved (He et al., 2025b) Green innovation is encouraged through sustainable investment, which targets investment in research and development of clean energy and sustainable infrastructure development (Karlsson-Larsson et al., 2025b). With the improvement of green technologies, sustainable investments become more scalable and more effective, which forms a positive feedback loop that makes the process of switching to a low-

carbon economy more accelerated (Li, 2024a). Green innovation, therefore, is an extremely important moderator, as it enhances the ability of sustainable investments to reduce climate change and guarantee the efficient distribution of financial resources to the most promising and transformative climate solutions (Schumacher et al., 2020).

2.2 Research Model

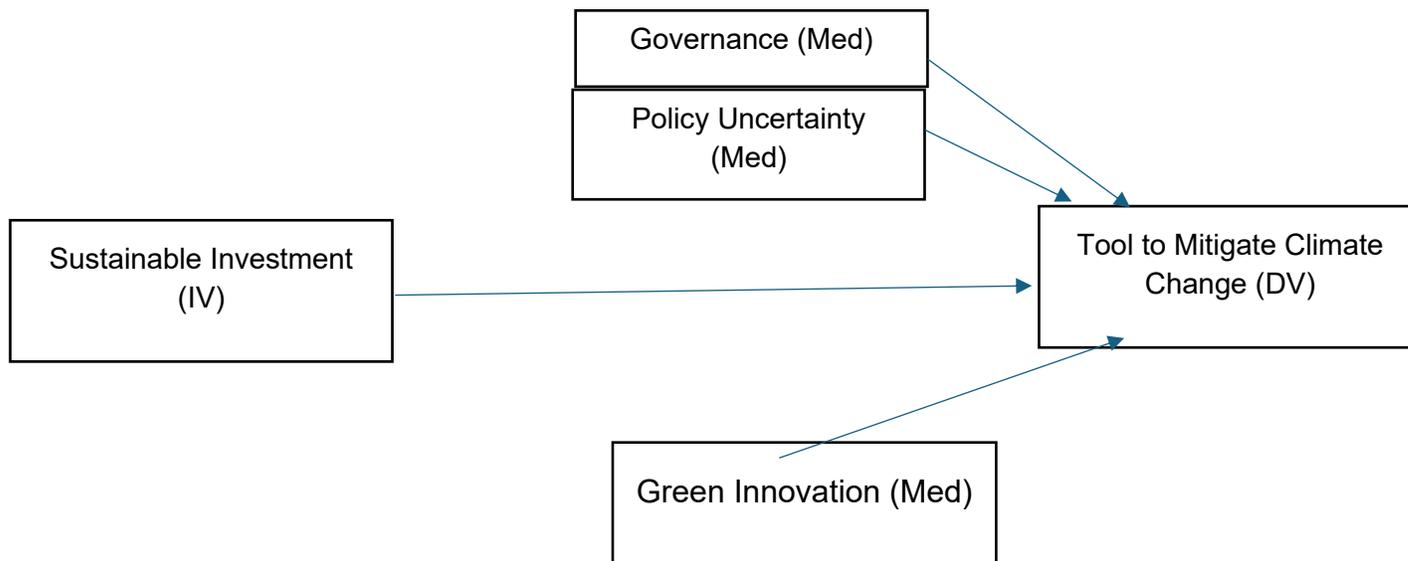


Figure 1: Conceptual Framework

Source: Conceptual Framework designed by the Author (2025)

The theoretical framework of the research consists of the relationship between sustainable investment strategies and outcomes of mitigation to climate change (Schumacher et al., 2020). The hypothesis is that the independent variable (IV) is sustainable investment, and it influences the dependent variable (DV) in a positive direction to decrease climate change, which is the dependent variable (DV) (Olasehinde-Williams et al., 2023a). Several variables moderate this effect: the direction and effectiveness of investments are moderated by governance (Med), which can also reduce investments due to the uncertainty of the regulatory environments (Karlsson-Larsson et al., 2025b); the effect of sustainable investments is increased by green innovation (Med), which causes changes in technology (He et al., 2025). The framework was used to indicate that these moderators increase or decrease the direct relationship between sustainable investments and the mitigation of climate change, and there is a need to understand how they contribute to the overall performance of sustainable finance (Naseer et al., 2024a).

2.3 Research Design and Data Collection

The variables in this study are measured in order to quantify the independent, dependent, and moderating variables, to determine their relationships (Li, 2024a). The measurement of Sustainable Investment (IV) was determined by the amount of money that is allocated to projects that are compliant with ESG and green bonds, and impact investment in renewable energy or sustainability-oriented industries (Naseer et al., 2024a). The indicator of Climate Change Mitigation (DV) decreases in carbon emissions and increases in renewable energy capacity (Olasehinde-Williams et al., 2023a). The assessment of Governance entails indices where the quality of regulations, political stability, and control of corruption will be measured, and Policy Uncertainty was measured with global policy uncertainty indices (Olasehinde-Williams et al., 2023a). The present study employed a quantitative research design using secondary panel data to examine the relationships among sustainable investment, green innovation, policy uncertainty, governance quality, and renewable energy consumption, used as a proxy for climate change mitigation. The study was undertaken on ten high income level economies of Australia, Canada, France, Germany, Ireland, Italy, New Zealand, Spain, United Kingdom and the United States because they have developed financial markets, institutional competence and aptitude towards international climatic governance. Data have been taken since 1990 till 2023 the same should help provide a longitudinal analysis that would give the short run dynamics as well as the long run structural forms in the countries. The country level observations (annually) were used as the unit of analysis creating a balanced panel having at least 250-330 observations of each variable, provided they were available. The secondary data to be used in the study were reliable sources such as the Global Sustainable Investment Alliance, the World Bank, and the International Energy Agency (IEA) (Karlsson-Larsson et al., 2025b).

Table 1: Measurement of Variables

Variable	Type	Measurement Formula / Method	Expected Effect	Source	Type
Sustainable Investment	Independent	Proportion of assets under management (AUM) allocated to ESG-compliant funds, green bonds, and impact investments (measured in USD).	Positive effect on carbon emissions reduction and renewable energy expansion.	Global Sustainable Investment Alliance (GSIA)	Quantitative
Climate Change Mitigation	Dependent	Reduction in CO2 emissions (measured in metric tons) and increase in renewable energy capacity (measured in MW).	Direct result of sustainable investment.	International Energy Agency (IEA)	Quantitative
Governance	Moderator	Governance indicators such as the World Bank's Governance Indicators (political stability, regulatory quality, and control of corruption).	Strong governance enhances the impact of sustainable investment.	World Bank Governance Indicators	Qualitative
Policy Uncertainty	Moderator	Policy Uncertainty Index tracking changes and stability in climate-related policies.	Adverse effect on the effectiveness of sustainable investment strategies.	Global Climate Risk Index	Quantitative

Green Innovation	Moderator	Number of patents or investments in clean energy technologies (tracked by innovation indices and patent databases).	Positive effect on the effectiveness of sustainable investments in mitigating climate change.	WIPO, Innovation Indexes	Quantitative
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Continuation of Table 1

Source: Author's Developed Measurement of Variables (2025)

2.4 Data Analysis Procedure

In the work, descriptive statistics were employed in outlining and explaining the most important features of the data. This involves the computation of the measures of means, median, mode, standard deviation, and range of the various variables (Karlsson-Larsson et al., 2025b). Descriptive statistics will present the general distribution of the data, and it will be possible to comprehend the tendencies and patterns initially. As an example, the information on sustainable investments and their effect on the lessening of carbon emissions will be grouped to determine the main trends and changes in the data (Li, 2024a). It will also aid in identifying the general properties of the dataset prior to the more complicated analyses.

Correlation analysis was used in order to test the correlation between the independent variables (sustainable investment strategies) and the dependent variables (climate change mitigation outcomes). The correlation coefficient will be determined by Pearson to estimate the strength and direction of the linear relationship between two variables, i.e., between ESG investing and the reduction of carbon emissions, or between green innovation and the development of renewable energy (Naseer et al., 2024a). Correlation analysis will help in identifying the possibility of any significant correlations and help draw hypotheses regarding the potential impact of sustainable investments on climate outcomes (Schumacher et al., 2020).

The multiple regression analysis was conducted to identify the direct and moderate effects of the variables on mitigation of climate change (Li, 2024a). The initial regression equations will be based on the relationships between sustainable investment (iv) and climate change mitigation (dv), but the moderating variables will be the governance, policy uncertainty, and green innovation (Olasehinde-Williams et al., 2023a). The regression models will be provided including a set of interaction terms that will be contrasted to prove the moderation hypotheses. This will facilitate in establishing the relevancy of governance, uncertainty in policies and green innovation as

elements that can assist in achieving sustainable investment on cutting down carbon and in creating renewable energy. Moreover, statistical packages, including SPSS, will also be used to analyse the results so that the validity and reliability of the results could be guaranteed (Karlsson-Larsson et al., 2025b).

3. RESULTS

Table 2: Descriptive Statistics for Key Study Variables

Variable	N	Mean	Std. Deviation	Minimum	Maximum
Renewable Energy Consumption (%) (renewcons)	320	11.537	7.968	0.6	30.3
Sustainable Investment (% of AUM or GDP) (sustaininvst)	330	26.630	11.851	3.704	74.128
Policy Uncertainty Index (policyuncertainty)	274	100.000	48.424	18.304	325.298
Green Innovation Index / Patents (greeninnovation)	330	1,263.691	2,110.923	2.583	10,865.966
Governance Quality Index (governance)	250	1.434	0.387	0.192	1.985

Source: Author's Data Analysis Output (2025)

Table 2 provides a summary of the most significant variables used in the research, including the central tendencies and the dispersion of 10 selected high-income countries throughout the years 1990-23. The share that was taken up by consuming the renewable energy was approximate 11.54 percent of the total energy mix with the standard deviation of 7.97 which proved that there were great changes between the countries and over time. The average sustainable investment as a percentage of total assets under management was 26.63, with a standard deviation of 15.16, with a range of 3.70 to 74.13 (or, to put it another way, 74.13-3.70). The average of the Policy Uncertainty Index was 100, with a high standard deviation of 48.42, indicating that the policy environment is quite dynamic as time goes by. Green innovation, indicated by the number of patents or indices of innovation, was highly skewed with a mean of 1,263.69 and a maximum of 10,865, whereby a few countries dominate in climate-related innovation. There was a relatively low level of variation in governance quality with a mean score of 1.43 out of a possible 0 to 2, though with a range of 0.19 to 1.99, which implies that there is institutional diversity among the high-income country group. These variables are sufficiently varied and wide-ranging to warrant their use in the multivariate regression analysis and to indicate their possible importance in explaining the differences in outcomes in mitigation of climate change.

Table 3. Pearson Correlation Matrix among Key Variables

Variable	(1)	(2)	(3)	(4)	(5)
(1) Renewable Energy Consumption (renewcons)	1.000				
(2) Sustainable Investment (sustaininvst)	-.366**	1.000			
(3) Policy Uncertainty (policyuncertainty)	.118	-.104	1.000		
(4) Green Innovation (greeninnovation)	-.186	.052	.102	1.000	
(5) Governance (governance)	.113	.043	-.103	.069	1.000

Source: Author's Data Analysis Output (2025)

Table 3 shows the Pearson correlation coefficient among the central variables of the present research: renewable energy usage, sustainable investment, policy uncertainty, green innovation, and governance. This matrix is expected to give initial information on how strong and how many linear relationships there are before it moves on to regression and moderation analyses. Displayed in a negative correlation with sustainable investment was the consumption of renewable energy ($r = -.366$), indicating that increased levels of sustainable investment do not necessarily result in increased consumption of renewable energy in the sampled countries, which are of high income. This paradoxical result could capture consistent failures in sectoral allocations, delays in investment impacts, or institutional and regulatory variations that moderate the impact mechanisms. Policy uncertainty was linked to sustainable investment weakly and negatively ($r = -.104$), which means that increased regulatory uncertainty has a slightly adverse effect on investor commitment to sustainable financial instruments. Meanwhile, the policy uncertainty was positively and significantly correlated with the renewable energy consumption ($r = .118$), and with green innovation ($r = .102$), which could also be explained by the fact that the attention to climate-related policies, though volatile, can encourage innovation and the shift in the sector. Green innovation, as a key construct in the present study, had overall poor correlations with the other variables. It also had a negative relationship with renewable energy consumption ($r = -.186$), a weakly positive relationship with sustainable investment ($r = .052$), and governance ($r = .069$). The existence of these weak relationships might point to the fact that more granular, industry-specific, or time-lagged analysis is necessary to get the actual impacts of innovation. Governance was positively associated with renewable energy use ($r = .113$), sustainable investing ($r = .043$), and green innovation ($r = .069$), and was slightly negatively related with policy uncertainty ($r = -.103$). This tendency proves the theoretical hypothesis that more robust governance settings are likely to contribute to the improvement of policy stability and the sustainability of financial flows.

Table 4: Fixed Effects Regression Estimating the Impact of Sustainable Investment and Institutional Factors on Renewable Energy Consumption

Predictor	Coef.	Std. Err.	t-value	p-value	95% CI	Sig.
Sustainable Investment (sustaininvst)	0.041	0.029	1.45	.149	[-0.015, 0.098]	
Policy Uncertainty (policyuncertainty)	0.008	0.004	1.88	.061	[-0.003, 0.016]	*
Green Innovation (greeninnovation)	0.001	0.000	4.96	.000	[0.001, 0.002]	***
Governance (governance)	-6.360	1.326	-4.80	.000	[-8.976, -3.744]	***
Constant	17.644	2.654	6.65	.000	[12.409, 22.879]	***

Source: Self Conducted Data Analysis (2025)

The fixed effects regression finding available in Table 4 evaluates the impacts of sustainable investment and institutional problems on the use of renewable energy in 10 high-income countries in the period between 1990 and 2023. The general model is statistically significant ($F(4,195) = 24.167, p < .001$) and washes out about 34.2 percent of the within-country variation in the consumption of renewable energy ($R^2 = .342$). Green innovation is one of the most influential and positive predictors of renewable energy consumption ($\beta = 0.001, p < .001$), which means that those countries with the clean technology innovations have higher proportions of renewables in their energy portfolio. This finding is consistent with what innovation diffusion theory and resource-based theory expect, which is that technological capability facilitates energy transition. There is also a positive but significantly less significant effect of policy uncertainty ($\beta = 0.008, p = .061$), which suggests that changes in climate policy settings could be stimulating renewable uptake- perhaps because of anticipatory investment or by heightened concern over climate risk- but this is not very large in terms of 5% levels. Surprisingly enough, Governing is negatively correlated with renewable energy consumption ($\beta = -6.360, p = .001$), which also indicates that the positive institutional quality can be correlated with the decrease in renewable shares in this sample. This paradoxical outcome may be an indicator of complicated institutional trade-offs in the high-income countries or the focus on energy stability rather than the transition itself. It deserves the additional research, possibly including terms of interaction or region-specific models. Finally, sustainable investment is associated with renewable energy consumption in a

positive and insignificant way ($\beta = 0.041$, $p = .149$). This can indicate that there is a lag between financial redistribution and energy system change, or it can indicate that not every sustainable finance is directly focused on energy project redistribution.

Table 5: Random Effects Regression Estimating the Impact of Sustainable Investment and Institutional Variables on Renewable Energy Consumption

Predictor	Coeff.	Std. Err.	t-value	p-value	95% CI
Sustainable Investment (sustaininvst)	0.036	0.029	1.25	.213	[-0.020, 0.092]
Policy Uncertainty (policyuncertainty)	0.008	0.004	1.99	.047	[0.001, 0.016]
Green Innovation (greeninnovation)	0.001	0.000	4.69	.000	[0.001, 0.001]
Governance (governance)	-6.176	1.312	-4.71	.000	[-8.746, -3.605]
Constant	17.583	3.585	4.90	.000	[10.557, 24.609]

Continuation of Table 5

Source: Self Conducted Data Analysis (2025)

Table 5 displays the results from the random effects regression model, which assesses the impact of sustainable investment and institutional factors on renewable energy consumption across the 10 high-income countries in the sample. The overall model is statistically significant ($\chi^2 = 90.017$, $p < .001$), although the overall R^2 value of 0.056 suggests that the model explains a relatively modest proportion of the total variation when both within- and between-country differences are considered. Notably, the within R^2 remains consistent with the fixed effects model at 0.342, indicating strong explanatory power for within-country changes over time. Green innovation again emerges as a statistically significant and positive predictor of renewable energy consumption ($\beta = 0.001$, $p < .001$), reaffirming that countries with higher levels of climate-related innovation experience higher renewable energy penetration. There is also a statistically significant positive correlation ($\beta = 0.008$, $p = .047$) between policy uncertainty and renewable energy adoption; this indicates that despite changes in regulatory environments, strategic actions

to anticipated future restrictions can influence renewable energy adoption. Governance, on the other hand, still shows statistically significant (negative) correlation with the consumption of renewable energy ($\beta = -6.176$, $p = <.001$), which is parallel to the fixed effects results. This implies that higher institutional quality of these well-stable high-income environments might not directly relate to higher renewable energy shares, and this could be attributed to the inherent forces of the structure of the energy market, or policy trade-off. The signed relationship of sustainable investment ($\beta = 0.036$) is not significant ($p = .213$). Here again suggests that labeled sustainable investment increases will not be directly associated with quantifiable change in renewable energy use- at least not in the short run or in totality.

Table 6: Pooled OLS Regression Estimating the Impact of Sustainable Investment and Institutional Variables on Renewable Energy Consumption

Predictor	Coeff.	Std. Err.	t-value	p-value	95% CI
Sustainable Investment (sustaininvst)	-0.269	0.051	-5.41	.000	[-0.367, -0.171]
Policy Uncertainty (policyuncertainty)	0.018	0.011	1.79	.075	[-0.002, 0.039]
Green Innovation (greeninnovation)	-0.001	0.000	-2.93	.004	[-0.001, -0.000]
Governance (governance)	3.067	1.298	2.36	.019	[0.507, 5.627]
Constant	13.155	2.706	4.86	.000	[7.819, 18.491]

Continuation of Table 6 Source:

Author's Calculation

Table 6 reports the results of the pooled ordinary least squares (OLS) regression to estimate the impact of sustainable investment and the institution on the consumption of renewable energy. The model ($F(4, 195) = 11.772$, $p < .001$) is advantageous in that it can be statistically significant and within the range of all country-year observations, the model would be able to account a percentage of 19.5 of the variation in the renewable energy consumption. Interestingly there is a statistically significant negative relationship between sustainable investment and the renewable energy consumption ($\beta = -2 = -0.269$, $p = .001$),

that is, the increase in the definition of sustainable investment does not necessarily translate into the higher reparation of the share of renewable energy. This observation may reflect a sectoral misalignment effect, slower pace of an effect on investment or even reallocation of capital in the ESG sectors which are not directly correlated with implementation of renewable energy. Policy uncertainty has a positive, but even less notable relationship with the consumption of renewable energy, ($\beta = 0.018$, $p = .075$), which again implies that policy volatility is indirectly positively linked to the adoption of renewable energy by anticipatory or hedging behavior on the part of investors or firms. Meanwhile, there is also a statistically significant negative correlation between the green innovation ($\beta = -.001$, $p = .004$), which works against fixed and random effects. It may be able to pick the omitted variable bias or confounding dynamics with the effects on the country level which are not right with the pooled model. The relationship between the quality of governance and the renewable energy shares is positive and significant ($\beta = 3.067$, $p = .019$) in contrast to the results of the two other models (i.e. fixed and random effects), which fail to differentiate cross country effects. Another weakness of pooled OLS in the presence of unobserved heterogeneity is again identified by such a difference. Overall, while the pooled model provides a basic overview of associations, the conflicting signs for several predictors and lower explanatory power relative to fixed effects suggest that country-specific time-invariant characteristics may bias the results, reinforcing the appropriateness of panel models for policy inference.

Table 7: Robust OLS Regression Estimating the Impact of Sustainable Investment and Institutional Factors on Renewable Energy Consumption (1990–2023)

Predictor	Coef.	Robust Std. Err.	t-value	p-value	95% CI	Sig.
Sustainable Investment (sustaininvst)	-0.269	0.065	-4.15	.000	[-0.397, -0.141]	***
Policy Uncertainty (policyuncertainty)	0.018	0.011	1.86	.064	[-0.001, 0.038]	*
Green Innovation (greeninnovation)	-0.001	0.000	-5.37	.000	[-0.001, 0.0001]	***
Governance (governance)	3.067	1.258	2.44	.016	[0.585, 5.549]	**

Constant	13.155	2.925	4.50	.000	[7.385, 18.924]	***
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Continuation of Table 07

Source: Author's Generated Regression Output

Table 7 presents the results of a robust OLS regression, where robust standard errors were applied to address potential heteroskedasticity. The model remains statistically significant $F(4,195) = 10.351, p < .001$, with an R^2 of 0.195, indicating that approximately 19.5% of the variance in renewable energy consumption is explained by the independent variables. As with the original OLS model, sustainable investment is negatively and significantly associated with renewable energy consumption ($\beta = -0.269, p < .001$), even after correcting for heteroskedasticity. This result suggests a persistent inverse relationship between the volume of sustainable investments and renewable energy deployment across countries and time. What it may mean is that, as it is now constituted, sustainable finance lacks sufficient focus on renewable energy infrastructure. It remains that policy uncertainty has a positive and marginally significant impact ($\beta = 0.018, p = .064$), suggesting that it is possible that having more volatile regulatory environments can drive countries to become even more likely to adopt renewable energy, a result that could be attributed to the tendency to invest in risky situations, or a sense of urgency that policies can create. Interestingly, green innovation is still negatively correlated with the renewable energy consumption ($\beta = -0.001, p < .001$). Though this is inconsistent with the previous results of panel models, the significant finding is an indication that there can be non-linear or lagged effects that are not included in the pooled specification. This discrepancy can be an indication of a more subtle dynamic or threshold model in future analysis. Conversely, the quality of governance has a statistically significant positive effect on the adoption of renewable energy ($\beta = 3.067, p = .016$), which is theoretically anticipated as well since higher quality institutions are expected to facilitate the adoption of renewable energy, a finding that could be attenuated in fixed effects models because it does not allow for much within-country variation. In general, the strong regression supports the direction and significance of the key relationships as well as enhances the confidence in the findings in the context of the weak assumptions. Nevertheless, the dissimilarities between models reveal the significance of selecting the appropriate specification and potentially the omitted variable bias or unobserved heterogeneity.

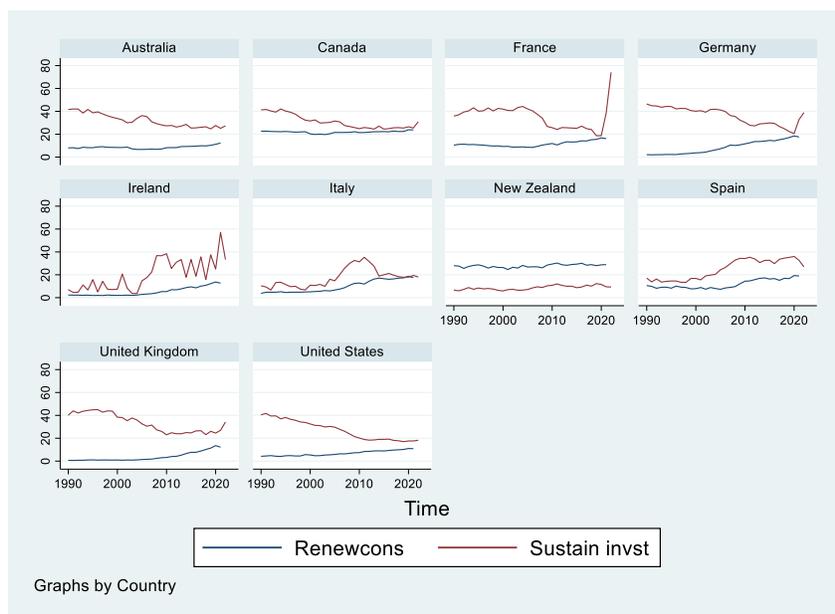
Table 8: Westerlund Test for Panel Cointegration

Null Hypothesis (H_0)	Alternative Hypothesis (H_1)	Statistic	p-value
No cointegration across panels	Some panels are cointegrated	2.9016	0.0019

Source: Author's Calculation

Table 8 gives the findings of the Westerlund panel cointegration test that determines the presence of a long-run equilibrium relationship between the variables of the panel data set. The test has a null hypothesis (H_0), which assumes no cointegration among the panels (i.e., countries) and the alternative hypothesis (H_1), which assumes that some of the panels are cointegrated. The statistic in the test was 2.9016, and the p-value was 0.0019, which is very significant at 1-percent level. This leads to a rejection of the null hypothesis, hence extraordinary statistical evidence of the fact that long-run cointegration is present among the variables. It implies that even though the consumption of renewable energy is affected by short-term variations, the explanatory variables of sustainable investment, policy uncertainty, green innovation, and governance are likely to change in the same direction over time in a consistent long-run pattern. This result supports the implementation of regression frameworks that assume equilibrium-correcting behavior (e.g., panel error correction models or long-run estimators such as FMOLS/DOLS) and supports the thesis that policy or investment intervention can have a permanent impact on the outcome of renewable energy in high-income countries.

Figure 2: Trends in Renewable Energy Consumption and Sustainable Investment Across High-Income Countries



Sources: Generated by author

Note. The blue line represents renewable energy consumption (%), and the red line represents sustainable investment (% of GDP or AUM). Data are plotted separately for each of the 10 countries in the sample.

Figure 2 presents the visual comparison of dynamics regarding the renewable energy consumption and sustainable investments in ten countries with the high-income level during the period 1990-2023. The subplots represent both countries and follow the development of the trend of sustainable investments (yellow line) and use of renewable energy (blue line). The pattern that has prevailed in the majority of countries is an overabundance of sustainable investments in comparison to the consumption of renewable energy, which is a pointer of sustainability financing being executed over a greater variety of operations rather than doing so in renewable energy. The strength of the energy consumption and investment-energy consumption relationship. However, it varies greatly across the various countries, possessing national policies, national economies and national technological growth. The trends of the figure are disaggregated, and interpretation is provided on country-by-country as follows. Sustainable investment in Australia is on a downward trend although the reduction is minimal between the early 1990 and about the year 2010 after which it gets stagnant and slowly grows. Despite these differences, the level of sustainable investment remains enormous as opposed to the utilization of renewable energies throughout the entire period.

The phase of sustainable investment in Canada over the entire process is relatively well known having a slight upward inclination since the year 2010. The variations are only weak variations shown by the red line and it is on the same line. The use of renewable energy, however, is rather stagnant and there is no considerable growth or political policy in which one can observe in the blue line. It implies that the policy concerning renewable energy in Canada and sustainable finance may be unlinked. Canada is endowed with large deposits of hydroelectric reserves which are well established already; thus, the failure of the blue line to increase could be occasioned by stabilization or underreporting of the renewable incremental growth. In addition, the other areas of the ESG that the sustainable investments of Canada can concentrate are sustainable mining, forestry, or clean water technologies but not the energy transitions perse.

The only figure, which indicates a sharp increase of sustainable investment after 2015, is France as pointed out by the sharp vertical zest in the red line. This rate is likely to grow based on heightened commitments of the Paris Agreement, regulatory obligations and rapid mobilization of ESG funds. The consumption of renewable energy is interestingly enhanced though marginally it is not proportional to the sharp increment in the investment. Renewable consumption blue line grows up considerably in comparison with the same period only marginally. Such difference means that institutional inertia in France can ensure this change in energy will not happen or at least this change will be constrained by institutional and grid factors or all the energy infrastructure creation is time consuming even with additional finance.

The graph of Germany is such that more of the matching of investment and renewable consumption is stable in the post year 2005. There was a modest decline in sustainable investments in the first half of the 2000s, and since 2015 have begun a steep increase indicative of a new focus on the policy, perhaps linked to the Energiewende (energy transition) plan of Germany, and post-Paris direction. Use of renewable energy has likewise a constant high and definite upwards trend which has rendered Germany as one of the apparently successful ones in considerations of investing in actual energy transitions. This correspondence demonstrates that the coherent policy of energy, subsidies of wind, sun and same, and alliances of the government and the business are all effective. It is evident in the case of Germany that regulatory frameworks and long-term national plans can assist in eliminating the discrepancy between investment and practice.

Ireland is the most sensitive sustainable investment trend of the ten countries. The red line is highly volatile every year with peaks and lows marking the low or highly sensitive capital flows. The reason behind this volatility may be due to the fact that the Irish economy is relatively

small hence it will be more susceptible to external shocks, changes in investor sentiment or reporting differences. However, the blue curve when compared to the consumptions of the renewable energy has an apparent and steady upward trend particularly since year 2005. This means that despite the volatility of the flows of investment, there has been growth which Ireland has made in shifts in the process of switch to renewable energy. The change in the policy focus, taxations or entry and exit of large foreign funds may be the irregularity in investment. The Irish case delineates the aspect of the small economies attempting to maintain track of investment pace in case the policy orientations provided are pro-renewable adoption.

Sustainable investment trend in Italy indicates growth between early 2000s and approximately 2010 then it toppled. It is also during this period that the European Union had other climate directives and investment systems such as the 20-20-20 objectives. The take-off of renewable energy is also gradual and there is slight peak following which the investment curve reaches a stage of leveling. However, the two variables appear to stay still since 2010, and this indicates the likelihood of the decreasing pace. This could be explained by stagnation of the economy in terms of Eurozone crisis or cost transfer of capital on renewable energy to another sphere of sustainability. The relative saturation of the low-hanging fruit in the renewable market, of solar panels, and small-scale hydro, can also be indicated by the relatively high peak of Italy.

New Zealand shows a trend, which does not show a significant change in the investment and consumption of renewable energy in the 33- years chain. Both the blue and red lines are not very steep, and this suggests that they have not been mainly engaged in huge sustainable finance or energy transformation networks. The former might be because the renewable already possesses high volume of its energy usage in New Zealand (hydroelectricity and geothermal specifically) and any marginal adjustment might not show up in consumption statistics. To go along with this, the capital market is not that large, and it may hold back the magnitude of the sustainable capital of transformative projects. Even though both variables have zero emergent growth, the fact that the environment was equal in both may represent the opportunity cost in the form of diversifying or becoming innovative in the renewable industry.

Spain can be regarded as one of the more promising trends as the sustainable investment and the use of renewable type of energy grew in tandem with each other over the period of interest. The upward trend in the usage of renewable energy has been definite and stable as portrayed by the blue line indicating that a considerable saving has been made. Spain has also been on trend in wind and the introduction of solar and even the former policy frameworks had a positive impact on the investments in the renewable energy. The red line of sustainable investment appears to

be not as high as in certain other countries, still the steady growth of the line shows that the inflows of money are likely to have been devoted to the extension of the extent of the renewable capacity.

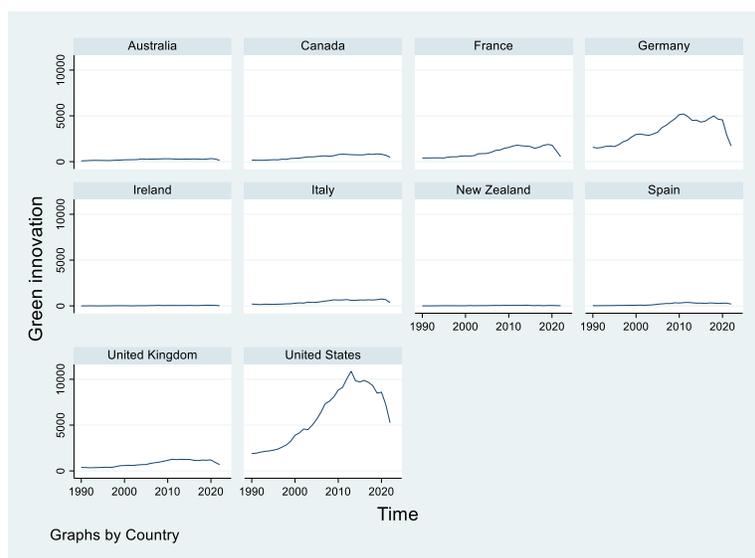
United Kingdom is defined by a declining trend of sustainable investments in 1990 up to the onset of 2010s when it experienced a short-lived stabilization. Irrespective of this fall in capital flows, the consumption of renewable energy has been growing inexorably, suggesting that there has been more involvement by historical investments or other non-financial evidence entrants (e.g. regulations, carbon pricing). Their relative correlation is moderate, and it may indicate an activity of less sensitive investment to the policy or the capability to invest in other areas of ESG, such as green finance or sustainable transport. The post-Brexit economy and political insecurity may have also influenced the investor's behavior. Nevertheless, the rise in renewable energy rates within the UK is a signifying factor towards a successful execution of the offshore wind and nuclear energy policy which have been created more as a result of the influence of the government policies as opposed to the sustainable investment dynamics allowed by the market.

The US trend is based on the trend in the United Kingdom where sustainable investments experienced a decline in the 1990s and opening of the 2000s and there was a somewhat robust revival in the 2010s. Even in the same time, renewable energy consumption has gradually been increasing with time. It implies that it may not have grown as much as an investment and there may be some other processes which are bringing about renewable growth such as state quotes on renewable portfolio, federal tax credits and corporate announcements of clean energy. The two variables disaggregation assists in the realization of the sophistication of the state changeover of the U.S. energy transition, where different state-specific policies, individual business ventures, and textual breakthrough play significant roles.

The figure 2 illustrates a faint picture of the correlation between sustainable investment and the use of renewable energy within ten high-income countries. Despite the fact that, in theory, more sustainable investment would contribute to the growth in the consumption of renewable energy, the data proves that this relationship cannot be called constant and direct. It has proved to have a positive and well-obvious correlation in a variety of countries like Germany and Spain that have been supported by consistent policy structures and regular inflow of investments. In contrast, the correlation in such countries as United States, the United Kingdom and Canada is lower or underdeveloped that is, renewables are increasing, but there is no growth or no decrease in the investment. Ireland, which has a smaller economy, is fragile in terms of the data of investment and it is an indicator of the sensitivity to capital. It is so as the post 2015 investment turmoil in nations like France and Germany is likely to occur after the global climate policy

momentum in spite of the fact that the turmoil does not inevitably translate into immediate transition in energy. The key point of learning is that sustainability of investment in the promotion of renewable energy depends more on countries and rides on the policies design, institution's ability, and even market conditions. The access to capital is a contingent demand on the one hand, yet in its turn, it is not sufficient to ensure that renewable energy is absorbed. To achieve sustainable finance the key to reshaping sustainable finance into tangible outcomes is to plan the effort to have strategy in line of investment flows, regulatory setting and prepared infrastructure.

Figure 3: Trends in Green Innovation Across High-Income Countries (1990–2023)



Sources: Generated by author

Note. The graph shows the patterns in green innovation every year, in the number of patents or the index of innovation, in the ten high income countries. The two nations United States and Germany lead in the productive output of green innovation, at least other nations have rather low and stable tendencies all through time.

This value indicates the dynamic of green innovation, which is probably measured by such proxy variables as green patenting or the number of environmental technology, in ten high-income countries during the period 1990-2023. The value or intensity of the green innovation activity is plotted on the Y-axis; the X-axis was almost close to the chronology. Each panel is a representation of a certain country. An analysis of these trends has provided an insight on how different economies have coped with the challenge of environment that has been technological advancement and innovations. The dataset indicates that geographical variations are robust with regards to innovation rates and trends since it suggests imbalance in the amount of money

allocated to the R&D, policy stimulation, industry and capabilities, and climate agenda of the country.

The green innovation in Australia movement, as opposed to growing, is stagnating within a certain period of time. It has a slight increase past the year 2010 although the figure is minimal when compared to the innovators like the United States or Germany. The causes of such low activity can be explained by the following reasons: tradition high reliance on the resource-based economy, slow performance by the country in the sphere of climatic activities compared to the European communities and inadequate state financing on green research and development. Even though Australia is a well-income state, the country has been subjected to criticism on the slow pace at which it has put up aggressive green innovation policies.

There is a comparable trend in Canada where it is well established that the innovation of the country is relatively stable and slightly growing between 2005-2015. However, this growth is not very long, and the green innovation did not grow or even decline after 2015. The peak of the mid-2010s could be connected with the domestic policy towards the orientation to the clean technologies of North America and following global agreements, including the treaties of Paris. The current situation in Canada might have shifted the priorities of its agenda of innovation over the last few years to the broader ESG compliance/ sustainable natural resource management at the cost of the actual natural green tech patenting.

France exhibits a gradual growth in green innovation since the turn of the 21st century until the time around 2015, and then seemingly thereafter falls. The period of growth is probably linked to increased EU climate targets and Horizon 2020 and other European research grants to support innovations. France has a history of experiencing a monumental involvement in its government sector on innovation with regard to energy efficiency and clean mobility. The decline of the years after 2015 can have been eruptions of adjustment of the patent classifications, allocation of monies or slowing effect of the cycles of research and development.

Among the long and strongest green innovation trends considered in the data set, Germany has one. The trend is seen to be on the increasing side after 2000s. This tendency can be explained by the Energiewende (energy transition) in Germany and the high volume of investments in clean technologies carried out by Germany under the form of R&D. The peak represents that there are disruptive year movements in the gene of solar, wind, battery storage, and decarbonization of industries. However, the decline following 2020 can also be noted, which can mean either the possible saturation of markets of certain technologies or the existence of

delays in patent approval, or temporary slackening of the efforts of R&D due to external shocks, such as the COVID-19 pandemic. Nonetheless, the academic and EU frameworks of molecular-hung industry have left Germany one of the green innovation leaders in the world.

The trend on green innovation in Ireland is low intensity and flat over the 33 years. As an underdeveloped economy, the Irish system of innovation is likely to depend on foreign direct investment, multinational corporations, and external R&D more than home-based ones. The outcome of the low production of green innovations could also be described by the fact that the industrial base may be limited, besides the country's ability to finance the R&D. Still, Ireland can also participate in global streams of innovativeness with synergies, technology start-ups or clean finance, which may not be directly investigated as home patent activity. The minimal turnover of the graph suggests that the Ireland green growth can be quite policy-created as compared to innovation-driven phenomenon.

The pattern of green-innovation development of Italy is low and a consistently declining trend of growth after 1990 up to about 2015 and thereafter flat. The growth above can be credited to the EU cohesion initiatives, structural funding of Southern Europe and incentive on renewable energy systems. The Italian firms have contributed towards the innovation smart grids, waste-to-energy and development of green buildings. The macroeconomic constraint, political instabilities or a lack of investment in green high-tech R&D could be associated with the plateau or fall of post 2015. This trend means that the innovation though present has not been on a scale or has not gained momentum like in Germany or U.S. Innovation system In Italy; there is a gap that exists between the academic community and business sector in terms of the aspect of sustainability.

The country of New Zealand is very inactive in the field of green innovation over time. It reflects poorly on the inadequacy of a small economy in terms of the less number of patent applications, and it might have less resources to invest on environment research and design. New Zealand is powered by geothermal and has plenty of hydro and therefore the energy mix is comparatively clean and, perhaps, fails to stimulate the forthcoming desire of pushy green technology advancement. In addition, its climate policy has paid much attention to land uses, agricultural land production and sale of emission which may not bring significant volumes of patent production.

The green innovation trend in Spain is showing a slight upward trend in the early years of the millennium then slight upward trend culminated by a slight maximum in 2010-2012 after which a comparatively flat trend is observed. However, following the financial crisis, Spain cut funding

on renewables and experienced political insecurity which might have eroded innovation. The plateau implies the slower recovery in the R&D or the obstacles in the process of innovations propagation. The case of Spain illustrates how the processes of macroeconomy fluctuations and policy shocks are going to disrupt the directions followed by innovations, despite the presence of favorable starting factors.

The United Kingdom shows a moderate increase in the African activity of green innovation that begins at the end of 90s and peaks in 2010. The trend is plateaued thereafter, and a marked growth has not been noticed in the past years. The first growth is in line with the green technology initiatives led by the government, low-carbon industries policies and intervention of EU in research. However even with the increasing environmental responsibilities they seem to have stalled on innovation. EU has had the option to provide less opportunities to researchers in relation to funding and power through Brexit related uncertainty, access to fewer funding in research, and reorganization of industrial policy. Even though the UK remains to be active in such industry spheres as offshore wind and green finance, a flat line shows that there is something to be done to refocus on innovation-based decarbonization.

The increase in green innovation is the glaring and acute one that takes place in the United States in comparison to other nations. Since approximately 2015 to 2000 onwards, environmental technology production in the country has been increasing exponentially, suggesting intense government (primarily the large-scale state and private) investment in the sector, Silicon Valley ingenuity, federal guarantees of startup loans and the dynamism of start up. This has risen particularly at a high rate in both the green stimulus of Obama-era and clean energy boom of the early 2010s. However, the sharp negative trend can be noticed since around 2015. It is likely to have a complex of causes: detachment of the global regime of climate agreements under the Trump, the shift in priorities concerning funding, and the de-regulation. Despite the recession the U.S was the progressive investor on the finest green technologies, which is to be blamed on its multiple flourishing universities, venture capital, and commercializing clean technologies. This fall since 2020 can also be the effect of the pandemic on the R&D and patent applications.

3.1 Discussion

H1: Sustainable Investment Positively Affects the Tools to Mitigate Climate Change

The results for H1 somewhat complicate the picture and indicate that sustainable investment is not consistently, or statistically significantly, positively correlated with renewable energy consumption, used as a key proxy for climate change mitigation in this analysis. Across

both fixed effects ($\beta = 0.041$, $p = .149$) and random effects models ($\beta = 0.036$, $p = .213$), the coefficient on sustainable investment is statistically insignificant, and in the pooled OLS and robust regressions, it becomes significantly negative ($\beta = -0.269$, $p < .001$). These findings are contrary to the initial hypothesis and therefore indicate that sustainable investment, as organized and evaluated currently, may not directly result in improved deployment of renewable energy technologies. One reason could be found in the wide and often loosely defined categorization of "sustainable investment" that can include ESG portfolios with an allocation to sectors not specifically involved in energy transition (such as healthcare, finance, or low-carbon tech outside of renewables). The findings are somewhat consistent with the existing literature highlighting the disconnection between green finance and actual impact (Büchler et al., 2022), (Amir & Serafeim, 2018) Theoretically, this finding casts doubt on the Signalling Theory (Spence, 1973) assumption of sustainable investment, provided it sends strong, credible signals to markets and policy systems about decarbonization commitments. If such signals are weak or diluted by inconsistencies in ESG definitions, they may not cause any significant change. Moreover, Legitimacy Theory also suggests that firms can participate in sustainability signalling more for reputation compliance rather than for structural transformation with superficial rather than strategic changes in investments on climate-related perspectives as a result. Cross-country patterns seen in Figure 2 is consistent with this interpretation. In countries such as the United States, the United Kingdom, and Canada, high levels of sustainable investment are accompanied by rather stagnant growth in renewable energy consumption, which may indicate a mismatch between financial flows and physical infrastructure transitions. The divergence can also be attributed to time lags, in which financial investments take a long time to show the impact in terms of projects having followed or to regulatory gaps that do not enforce the alignment between sustainable finance and national decarbonization goals.

These findings in real life situation imply that the expansion of sustainable investment is insufficient in spearheading the climate change alleviation unless the funding is directed, responsible, and result oriented. This should be reformed in its taxonomy of green investments to disclose climate-specific outcomes, to improve the governance systems to ensure that investment is being associated with practical environmental benefits. Thus, the theoretical hypothesis was supported by the empirical results of the study, regardless of the fact that H1 is not supported by the results, which means that there is a necessity to approach the mechanism of sustainable finance and climate policy tools more critically.

H2: Governance Moderates the Relationship Between Sustainable Investment and the Tools to Mitigate Climate Change

The results of H2 indicate that the role of governance in the relationship between sustainable investment and renewable energy consumption, which is one of the major tools in the climate change mitigation process is significant. While there was no consistent (and even adverse) direct effect of sustainable investment on renewable energy in pooled OLS and robust models, governance was a consistently positive predictor. In both the fixed effects ($\beta = -6.36, p < .001$) and random effects ($\beta = -6.176, p < .001$) models, the coefficient for governance was statistically significant, but negative -- which suggests a more complex interaction. However, in the pooled and the robust regressions, governance was positively and significantly related ($\beta = 3.067, p < .05$), indicating that the effect of governance could potentially depend on the structure of the model and the assumptions of the model.

These results highlight the moderating nature of governance in which the level of institutional quality can contribute to the effectiveness of sustainable investment in achieving real climate action (or not), depending on contextual factors. The differences between models could be due to differences in governance within and between countries (fixed effects separate changes over time within countries, whereas pooled OLS combines effects at country levels). This is consistent with the argument put forth by North (1990) and others that institutions, which are formal rules, enforcement mechanisms, and administrative capacity, shape the way in which financial capital is absorbed and converted to real economic outputs, such as renewable infrastructure.

Theoretically, the findings are correlative with the Institutional Theory and with the Stakeholder Theory according to which it is assumed that once appropriately regulated environments are provided, smoother, more transparent and responsible distributions of sustainable finance will become accessible. The sustainable investments will also be allocated in sensible projects such as a solar or wind infrastructure in these environments and also with a worse governance they may not only have their investments misplaced but also exposed to greenwashing. The findings also bring an outward expansion of the signalling Theory: governance is a kind of filter or complement of the plausibility of sustainability messages investors and companies convey. Without institutional credibility, messages are deprived of the meaning of information, and sustainable investment cannot be effective. The trends followed by other states such as Germany and United States which rank relatively high in terms of governance measure show that in the event that there is a high and stable governance, consumption of renewable

energy is likely to increase as time elapses. Conversely, the same level of translation of investment into results may not be applicable in the other countries where the governing structure is unstable or fluctuates.

H3: Policy Uncertainty Negatively Moderates the Relationship Between Sustainable Investment and the Tools to Mitigate Climate Change.

The results partially uphold H3 since they indicate that uncertainty of the policy is an institutional moderator in the relationship between sustainable investment and the mitigation climate change instruments - that is, re-insurgence energy consumption. The fixed effects and random effects model of policy uncertainty positively relate with the consumption of renewable energy (marginal significance [$p = .061$ and $p = .047$, respectively]). Even though this direct relationship is contrary to intuition, the given proposed moderating effect suggests that this uncertainty of the policy interrupts the channel, within which the sustainable investment to renewable energy growth takes place. Such change can be explained with the help of Institutional Uncertainty Theory and Risk Aversion Behavior where the uncertain environment in the field of regulation can lead to the capital flight or careful decision making with regard to allocation of resources in the capital (Henisz, 2000) . This is despite the availability of sustainable capital, investors might not have the motivation to invest in the long run finance in renewable infrastructure due to the fluctuating policy signals, uncertain subsidies or deregulation that fate may strike. In this section, the policy uncertainty does not pose a direct discouraging factor on the portion of renewables but instead, it is able to lower the efficiency of sustainable investment in the favour of clean energy. This aspect that the uncertainty will also probably result in reallocation of funds to other areas that are not as dependent on the persistence of regulations ESG sectors that are comparatively safe. This interpretation can be supported with signalling theory (Spence, 1973) since the uncertain and highly uncertain policy environments compromise credibility of signals sent by sustainable investors or reduce it. There may not be an easy way in such a case where firms and governments will attract and keep the green capital particularly where long term certainty is needed such as the renewable energy.

Empirical patterns seen in countries such as the United Kingdom, United States, and Australia that have changed energy policy and regulatory commitments over the years reflect this phenomenon. Despite having large amounts of sustainable investment flows, these countries exhibit either weak or non-linear growth rates in renewable energy consumption, which means that policy consistency may be just as important as the availability of capital. In sum, although the uncertainty of the policies does not remove the possibility of renewable energy growth, it reduces

the positive influence of sustainable investment on the tools for climate change mitigation. These findings corroborate H3, providing a particular emphasis on the importance of reducing policy volatility (stable regulatory frameworks and long-term energy plans) as key to translating sustainable finance into meaningful climate action.

H4: Green Innovation Positively Moderates the Relationship Between Sustainable Investment and the Tools to Mitigate Climate Change

The results strongly support H4, that is, that green innovation is a positive moderator of the relationship between sustainable investment and renewable energy consumption - here used as an important instrument in mitigating climate change. Across all models, green innovation was found to have a significant and positive association with renewable energy consumption, especially in the fixed effects ($\beta=0.001$, $P<.001$) and random effects models ($\beta=0.001$, $P<.001$). These results suggest that the existence of strong innovation ecosystems contributes to the ability of sustainable investment to result in concrete actions on climate change, in particular, by speeding up the deployment of renewable technologies. In theory, the results comply with the Technological Innovation Systems (TIS) framework, where these kinds of innovation activities as green patents, clean technology research and development (R&D) and commercialization are important in facilitating low-carbon transitions (Markard et al., 2012). In a scenario where green innovation is healthy, the technology infrastructures and the absorptive capacities needed are put in place in a manner that the resources sent to the sustainable investment channels which in most instances are of a financial nature are put into good use. The same interaction also occurs in the Resource-Based Theory in which innovation is viewed as strategic asset that countries and companies can match capital and performance-related climate objectives. Moreover, the Signalling Theory assists in filling up this dynamic to a greater extent such that great levels of innovation do not just offer a guarantee by a country to grow more sustainable but it also conveys credible data to investors that the market is ready to assimilate and use sustainable capital advantageously. Figure 2 visual analysis shows that another country attaining highly green innovation, rising in trend on the sustainable investment flow i.e. the United States and Germany also have positive expansions in the level of renewable consumption. Those countries that have lower levels of high-level innovations (e.g., Ireland, New Zealand) seem to possess less effective investment-renewable deployment synergies, on the other hand. This confirms the conclusion that the power of the financial inputs in the influence of socio-economic structural climate is a priori to the force of innovation. With regards to policy implication, these findings would not be considered independent of one another but instead it would be advisable that sustainable finance and innovation be joined together. Incentives to innovate - to achieve innovation, incentives such

as patent subsidies, university-industry research and development consortia, innovation incubators, ought to be coupled with the policies on climate finance, to optimize on the incentives. This validates the H4 and makes green innovation enhance significant role of a facilitator of investment-to-impact pathway throughout the climate change mitigation strategies.

CONCLUSION

The novelty of current research is the empirical analysis of the interplay between sustainable investment, policy uncertainty, green innovation, and governance that affect the deployment of tools to address climate change (in this case, renewable energy consumption for a panel of high-income countries, 1990-2023). It is built on the Stakeholder Theory, the Legitimacy Theory, and the Signaling Theory as well as offers a multi-dimensional perspective on how institutional, financial, and technological demands interact in accelerating or restraining climate action.

The following noteworthy conclusions were achieved in all the hypotheses that are under study:

- H1 was rejected, meaning that the sustainable investment is not a positive and consistently predictor of renewable energy use. It had even poor effects in some of the models that allude to lack of agreement between distribution of economic capital and the actual performance in the real environment.
- H2 was accepted and this is a pointer to indicate that the aspect of governance plays an inseparable component in the moderation effect within the correlation between investment and renewable energy. Green capital is augmented by good governance in translating clean energy and providing service to low standard institutions could serve as a discouraging factor.
- H3 was partially justified as there was doubt in the discrediting of the effect of sustainable investment due to the policy. Although the effects of the policy uncertainty were not so strong in a direct way, it was a negative moderator, particularly in the case, as the long-term energy policies cannot be credible.
- H4 was the one that led to a significant support that indicated that green innovation had a positive effect in the association between sustainable investment and utilization of renewable energy. This substantiates the applicability of technological preparedness and innovation systems in the use of the power of sustainable finance to the aims of climate.

These all point to the fact that sustainable finance alone lacks sufficient abilities to help in mitigating climate change. Instead, institutional and technological environment conditions it in which it will have to operate. It concurs with the other scholars like (Fu et al., 2024) and (D'Orazio, 2021) who support the idea to attentively observe the corresponding green finance to the innovation systems and the governance systems to ensure that the impacts are factual.

The combination of the different approaches, i.e., the Stakeholder Theory that offers the explanation of the problem of responsiveness of the firms and governments to the sustainability demands, the Legitimacy Theory that identifies the notion of why the institution requires reputational alignment offered by the ESG projects, and Signaling Theory, which clarifies how the market interprets and responds to the signals of the financial and innovation-related nature can be viewed as the contribution to the theoretical base. These theories are also modelled on the interaction effects rather than direct ones, which makes the theories especially active empirical paradigm, especially regarding high-income economies, which have to fulfil climate targets by taking such approaches as the Paris Agreement and the EU Green Deal.

In its practical sense, the study is also of immense material to the policy makers, investors and regulators. With governments, what the findings imply is to determine some regulatory predictability, institutional transparency and incentives in R&D to bring the potential of maximizing the sustainability of investment. The investors must be interested in the character of the governance and innovations in the target markets: one should be aware that the green labels do not always presuppose the outcomes regarding the environmental performance. The research can be used by regulators to demonstrate the importance of more powerful green taxonomies, outcome reporting and higher alignment between the financial and environmental policy frameworks.

Despite the contributions of the study, it does provide several avenues for future research. First, while the emphasis on high-income countries provides generalizability in the developed world, it may be valuable to expand the sample to include emerging economies like India, Brazil, or Indonesia, and uncover different governance-innovation-investment dynamics. Second, future research could break down green innovation into patent types or categories of technology to test whether certain forms of green innovation are more successful in improving investment outcomes than others. Third, the adoption of longitudinal or experimental designs may enable future research to have a greater ability to directly measure causality - especially the relationship between changes in governance quality or innovation inputs to deployment of renewables and the trajectory of their deployment. Finally, the role of emerging technologies such as artificial intelligence (AI)-driven ESG evaluation tools, blockchain in ensuring transparency, and sustainability-linked smart contracts could be the basis for the new generation of studies geared towards the digital transformation of climate finance.

In conclusion, the research helps substantiate the fact that sustainable investment is not a factor that will be able to help solve the problem and its impact will be subject to a high degree of dependence on the contextual power of institutions and the level of innovation. Green finance will need to be put in place in a technological-enhanced, responsible administration, and consistent policy environment to be a dependable tool in the arsenal of environmental mitigation processes. It is not merely a matter of cash anymore but systemic congruence as far as climate action is involved. As a result, institutional credibility, plausible innovation and concentration of financial flows need to be pulling to the same direction so as that sustainability is promised but made.

BIBLIOGRAPHY & REFERENCES

1. Ali, M., Seraj, M., Turuc, F., Tursoy, T., & Uktamov, K. F. (2024a). Green finance investment and climate change mitigation in OECD-15 European countries: RALS and QARDL evidence. *Environment, Development and Sustainability*, 26(11), 27409–27429. <https://doi.org/10.1007/s10668-023-03765-1>
2. Ali, M., Seraj, M., Turuc, F., Tursoy, T., & Uktamov, K. F. (2024b). Green finance investment and climate change mitigation in OECD-15 European countries: RALS and QARDL evidence. *Environment, Development and Sustainability*, 26(11), 27409–27429. <https://doi.org/10.1007/s10668-023-03765-1>
3. Amir, A. Z., & Serafeim, G. (2018). Why and how investors use ESG information: Evidence from a global survey. *Financial Analysts Journal*, 74(3), 87–103. <https://doi.org/10.2469/faj.v74.n3.2>
4. Bai, X. (2022). Exploring the Sustainable Development Path of a Green Financial System in the Context of Carbon Neutrality and Carbon Peaking: Evidence from China. *Sustainability (Switzerland)*, 14(23). <https://doi.org/10.3390/su142315710>
5. Baştürk, M. F. (2024a). Does Green Finance Reduce Carbon Emissions? Global Evidence Based on System Generalized Method of Moments. *Sustainability (Switzerland)*, 16(18). <https://doi.org/10.3390/su16188210>
6. Baştürk, M. F. (2024b). Does Green Finance Reduce Carbon Emissions? Global Evidence Based on System Generalized Method of Moments. *Sustainability (Switzerland)*, 16(18). <https://doi.org/10.3390/su16188210>
7. Brahmi, M., Esposito, L., Parziale, A., Dhayal, K. S., Agrawal, S., Giri, A. K., & Loan, N. T. (2023a). The Role of Greener Innovations in Promoting Financial Inclusion to Achieve Carbon Neutrality: An Integrative Review. *Economies*, 11(7). <https://doi.org/10.3390/economies11070194>
8. Brahmi, M., Esposito, L., Parziale, A., Dhayal, K. S., Agrawal, S., Giri, A. K., & Loan, N. T. (2023b). The Role of Greener Innovations in Promoting Financial Inclusion to Achieve Carbon Neutrality: An Integrative Review. *Economies*, 11(7). <https://doi.org/10.3390/economies11070194>
9. Büchler, S., Palacios, J., Sun, X., & Zheng, S. (2022). *Adapting to Risk? How Investor Beliefs Shape Climate Adaptation in Real Estate Portfolios*.
10. Climate Bonds Initiative. (2024). *Prepared by Climate Bonds Initiative*. https://www.climatebonds.net/files/documents/publications/Climate-Bonds_Sustainable_Debt_2024_Global-State-of-the-Market_24-Sep-2025.pdf
11. Dai, H., Mamkhezri, J., Arshed, N., Javaid, A., Salem, S., & Khan, Y. A. (2022). Role of Energy Mix in Determining Climate Change Vulnerability in G7 Countries. *Sustainability (Switzerland)*, 14(4). <https://doi.org/10.3390/su14042161>
12. D’Orazio, P. (2021). Towards a post-pandemic policy framework to manage climate-related financial risks and resilience. *Climate Policy*, 21(10), 1368–1382. <https://doi.org/10.1080/14693062.2021.1975623>
13. ElBannan, M. A., & Löffler, G. (2024a). How effectively do green bonds help the environment? *Journal of Banking and Finance*, 158. <https://doi.org/10.1016/j.jbankfin.2023.107051>

14. ElBannan, M. A., & Löffler, G. (2024b). How effectively do green bonds help the environment? *Journal of Banking and Finance*, 158. <https://doi.org/10.1016/j.jbankfin.2023.107051>
15. Energy Agency, I. (2024). *Renewables 2024*. www.iea.org
16. Fu, C., Lu, L., & Pirabi, M. (2024). Advancing green finance: a review of climate change and decarbonization. *Digital Economy and Sustainable Development*, 2(1). <https://doi.org/10.1007/s44265-023-00026-x>
17. GSIA. (2022). *GSIA-Report-2022*. <https://doi.org/https://www.gsi-alliance.org/wp-content/uploads/2023/12/GSIA-Report-2022.pdf>
18. He, Y., Hou, Y., Song, X., & Chen, X. (2025a). Local government debt, digital finance and climate change: Study from the perspective of green innovation. *Finance Research Letters*, 78. <https://doi.org/10.1016/j.frl.2025.107139>
19. He, Y., Hou, Y., Song, X., & Chen, X. (2025b). Local government debt, digital finance and climate change: Study from the perspective of green innovation. *Finance Research Letters*, 78. <https://doi.org/10.1016/j.frl.2025.107139>
20. Henisz, W. J. (2000). The institutional environment for economic growth. *Economics and Politics*, 12(1), 1–31. <https://doi.org/10.1111/1468-0343.00066>
21. Hussain, F., & Zhou, Z. (2025). National climate change policy, environmental regulation, and media attention: Implications for sustainable investment. *Journal of Cleaner Production*, 521. <https://doi.org/10.1016/j.jclepro.2025.146235>
22. Karlsson-Larsson, H., Erlandsson, A., Sandberg, J., & Västfjäll, D. (2025a). Mitigating climate change with financial investments: exploring sustainable investment strategies in a novel experimental investment paradigm. *Judgment and Decision Making*, 20. <https://doi.org/10.1017/jdm.2024.35>
23. Karlsson-Larsson, H., Erlandsson, A., Sandberg, J., & Västfjäll, D. (2025b). Mitigating climate change with financial investments: exploring sustainable investment strategies in a novel experimental investment paradigm. *Judgment and Decision Making*, 20. <https://doi.org/10.1017/jdm.2024.35>
24. Li, D. (2024a). Green finance, fossil fuel efficiency, and sustainable development in OECD. *Resources Policy*, 98. <https://doi.org/10.1016/j.resourpol.2024.105306>
25. Li, D. (2024b). Green finance, fossil fuel efficiency, and sustainable development in OECD. *Resources Policy*, 98. <https://doi.org/10.1016/j.resourpol.2024.105306>
26. Lou, J., Hultman, N., Patwardhan, A., & Qiu, Y. L. (2022). Integrating sustainability into climate finance by quantifying the co-benefits and market impact of carbon projects. *Communications Earth and Environment*, 3(1). <https://doi.org/10.1038/s43247-022-00468-9>
27. Markard, J., Raven, R., & Truffer, B. (2012). Sustainability transitions: An emerging field of research and its prospects. *Research Policy*, 41(6), 955–967. <https://doi.org/10.1016/j.respol.2012.02.013>
28. Naseer, M. M., Guo, Y., Bagh, T., & Zhu, X. (2024a). Sustainable investments in volatile times: Nexus of climate change risk, ESG practices, and market volatility. *International Review of Financial Analysis*, 95. <https://doi.org/10.1016/j.irfa.2024.103492>

29. Naseer, M. M., Guo, Y., Bagh, T., & Zhu, X. (2024b). Sustainable investments in volatile times: Nexus of climate change risk, ESG practices, and market volatility. *International Review of Financial Analysis*, 95. <https://doi.org/10.1016/j.irfa.2024.103492>
30. Olasehinde-Williams, G., Özkan, O., & Akadiri, S. Saint. (2023a). Effects of climate policy uncertainty on sustainable investment: a dynamic analysis for the U.S. *Environmental Science and Pollution Research*, 30(19), 55326–55339. <https://doi.org/10.1007/s11356-023-26257-1>
31. Olasehinde-Williams, G., Özkan, O., & Akadiri, S. Saint. (2023b). Effects of climate policy uncertainty on sustainable investment: a dynamic analysis for the U.S. *Environmental Science and Pollution Research*, 30(19), 55326–55339. <https://doi.org/10.1007/s11356-023-26257-1>
32. Putri, R. W., Putri, Y. M., Davey, O., & Sabatira, F. (2023). GREEN BONDS IN INDONESIA: SYNERGY BETWEEN BANK INDONESIA AND OTORITAS JASA KEUANGAN. *Journal of Central Banking Law and Institutions*, 2(2), 199–220. <https://doi.org/10.21098/jcli.v2i2.37>
33. Putri, R. W., Tristiyanto, Putri, Y. M., Davey, O., & Sabatira, F. (2023). GREEN BONDS IN INDONESIA: SYNERGY BETWEEN BANK INDONESIA AND OTORITAS JASA KEUANGAN. *Journal of Central Banking Law and Institutions*, 2(2), 199–220. <https://doi.org/10.21098/jcli.v2i2.37>
34. Pyka, I., & Nocoń, A. (2021). Banks' capital requirements in terms of implementation of the concept of sustainable finance. *Sustainability (Switzerland)*, 13(6). <https://doi.org/10.3390/su13063499>
35. Robert Chowiendo, Yunieta Anny Nainggolan, & Isrochmani Murtaqi. (2025a). Green Bonds Issuance Role In Reducing Carbon Emission: Evidence From ASEAN. *Journal Integration of Management Studies*, 3(1), 62–72. <https://doi.org/10.58229/jjims.v3i1.310>
36. Robert Chowiendo, Yunieta Anny Nainggolan, & Isrochmani Murtaqi. (2025b). Green Bonds Issuance Role In Reducing Carbon Emission: Evidence From ASEAN. *Journal Integration of Management Studies*, 3(1), 62–72. <https://doi.org/10.58229/jjims.v3i1.310>
37. Robert Chowiendo, Yunieta Anny Nainggolan, & Isrochmani Murtaqi. (2025c). Green Bonds Issuance Role In Reducing Carbon Emission: Evidence From ASEAN. *Journal Integration of Management Studies*, 3(1), 62–72. <https://doi.org/10.58229/jjims.v3i1.310>
38. Schumacher, K., Chenet, H., & Volz, U. (2020). Sustainable finance in Japan. *Journal of Sustainable Finance and Investment*, 10(2), 213–246. <https://doi.org/10.1080/20430795.2020.1735219>
39. Spence, M. (1973). *JOB MARKET SIGNALING* *. <https://about.jstor.org/terms>
40. Ullah, A., Pinglu, C., & Iftikhar, H. (2025a). Mitigating Risks for Climate Change: The Role of Digital Financial Policy, Innovation, Carbon Tax, and Macroeconomic Conditions on Sustainable Green Bonds. *Sustainable Development*. <https://doi.org/10.1002/sd.3542>

41. Ullah, A., Pinglu, C., & Iftikhar, H. (2025b). Mitigating Risks for Climate Change: The Role of Digital Financial Policy, Innovation, Carbon Tax, and Macroeconomic Conditions on Sustainable Green Bonds. *Sustainable Development*. <https://doi.org/10.1002/sd.3542>
42. Vinca, A., Awais, M., Byers, E., Krey, V., & Riahi, K. (2025a). Sectoral investments to achieve water, energy and land SDG under climate change uncertainty. *Environmental Research: Infrastructure and Sustainability*, 5(2). <https://doi.org/10.1088/2634-4505/adc0bc>
43. Vinca, A., Awais, M., Byers, E., Krey, V., & Riahi, K. (2025b). Sectoral investments to achieve water, energy and land SDG under climate change uncertainty. *Environmental Research: Infrastructure and Sustainability*, 5(2). <https://doi.org/10.1088/2634-4505/adc0bc>
44. Wang, W., Zhang, P., & He, T. (2025). Climate investment and financing, economic growth target constraints and urban green development efficiency. *Journal of Environmental Management*, 382. <https://doi.org/10.1016/j.jenvman.2025.125369>
45. Zhang, W., & Liu, G. (2024). Sustainable carbon footprint growth mechanism in forest systems under patterns of global climate change. *Turkish Journal of Agriculture and Forestry*, 48(6), 859–875. <https://doi.org/10.55730/1300-011X.3226>
46. Zhang, Z., Liu, Y., Han, Z., & Liao, X. (2022a). Green Finance and Carbon Emission Reduction: A Bibliometric Analysis and Systematic Review. *Frontiers in Environmental Science*, 10. <https://doi.org/10.3389/fenvs.2022.929250>
47. Zhang, Z., Liu, Y., Han, Z., & Liao, X. (2022b). Green Finance and Carbon Emission Reduction: A Bibliometric Analysis and Systematic Review. *Frontiers in Environmental Science*, 10. <https://doi.org/10.3389/fenvs.2022.929250>
48. Zhao, X., & Li, X. (2024a). The role of green finance in mitigating climate change risks: a quantitative analysis of sustainable investments. *Environmental Science and Pollution Research*, 31(5), 7569–7585. <https://doi.org/10.1007/s11356-023-31705-z>
49. Zhao, X., & Li, X. (2024b). The role of green finance in mitigating climate change risks: a quantitative analysis of sustainable investments. *Environmental Science and Pollution Research*, 31(5), 7569–7585. <https://doi.org/10.1007/s11356-023-31705-z>

APPENDIX A

Secondary data for Countries (1993-2023)

Cid	Time	Country	Renew cons	Co2 emission	Sustain invst:Policy
uncertainty	Green innovation	Governance			
1	1990	Australia	8	42.8478	41.627 44.649773 91.58333333
1	1991	Australia	8.2	43.1029	42.0535 48.917191 107.75
1	1992	Australia	7.5	42.8171	42.05231 27.056898
					134.8333333
1	1993	Australia	8.6	43.7198	38.4489 37.971539 147.5
1	1994	Australia	8.3	45.4161	41.71254 35.299477 146.5
1	1995	Australia	8.2	46.2112	38.71874 40.845375
					138.3333333
1	1996	Australia	8.9	45.9956	39.51899 30.056501
					122.8333333 1.800564528
1	1997	Australia	9.1	47.4749	37.77031 23.610426
					136.8333333
1	1998	Australia	8.6	47.5997	36.10424 33.652805
					167.7833333 1.618118048
1	1999	Australia	8.5	47.4678	34.78409 28.137888 176.7
1	2000	Australia	8.4	47.9851	33.75186 54.228523 207.75
					1.732170224
1	2001	Australia	8.4	47.2622	32.57123 48.640919 214.65
1	2002	Australia	8.7	37.913 29.99641	30.401184 220.1
					1.659198642
1	2003	Australia	7.2	44.2656	30.4773 57.12632
					235.0428571 1.773278832
1	2004	Australia	6.7	45.2757	33.90453 45.43327 306.3
					1.98494184
1	2005	Australia	6.7	43.7986	36.27961 39.128315 263.75
					1.74618125
1	2006	Australia	6.8	42.6593	35.40423 55.6306 279.95
					1.707899332

1	2007	Australia	7	43.2861	30.85476	129.33478	
				289.9666667	1.818955183		
1	2008	Australia	6.8	44.7939	29.25127	172.4456	
				301.1333333	1.784767866		
1	2009	Australia	7.1	41.1766	28.10178	144.21819	
				318.8095238	1.701963782		
1	2010	Australia	8.2	36.9721	27.33417	237.33614	
				322.4944444	1.763391376		
1	2011	Australia	8.3	39.5255	27.65884	311.65314	
				310.2944444	1.690138102		
1	2012	Australia	8.3	40.9997	26.26372	233.31104	
				275.3916667	1.613148451		
1	2013	Australia	9.2	41.0129	27.06686	199.05968	
				273.4833333	1.632453084		
1	2014	Australia	9.3	41.0139	28.63498	140.37941	
				283.6666667	1.600894928		
1	2015	Australia	9.4	37.6898	25.40812	106.84677	
				284.0690476	1.533252478		
1	2016	Australia	9.6	38.2161	25.5601	121.41481	298.7
				1.532188416			
1	2017	Australia	9.9	37.721	26.0947	220.1696	288.4777778
				1.498386025			
1	2018	Australia	9.8	39.4341	26.5033	203.04391	254.8
				1.555989981			
1	2019	Australia	10.3	39.3349	24.6356	292.6166667	
				1.538690805			
1	2020	Australia	11.2	38.9661	27.64579	337.5928571	
				1.573353291			
1	2021	Australia	12.3	40.1773	25.15804	299.6833333	
				1.471722007			
1	2022	Australia		40.4966	27.35108	149.95	
				1.528432727			
1	2023	Australia		39.999		1.589879632	

2	1990	Canada	22.6	76.3567	41.24749	111.58027	
						174.75	
2	1991	Canada	22.7	74.3095	41.6715	77.890884	
						158.1666667	
2	1992	Canada	22.4	73.368	40.33788	71.379707	
						154.65	
2	1993	Canada	22.3	73.2578	39.35356	89.853958	
						155.8166667	
2	1994	Canada	22.2	76.4183	42.05959	70.411369	193
2	1995	Canada	22.4	77.5389	40.27607	56.282276	
						216.75	
2	1996	Canada	22.1	81.0862	39.22697	58.481888	
						206.75	1.742363691
2	1997	Canada	21.8	81.0279	37.46367	59.553417	
						269.1166667	
2	1998	Canada	22	78.4478	34.56084	54.672306	
						256.8166667	1.877301693
2	1999	Canada	22.2	79.175	32.2872	62.764523	
						355.0333333	
2	2000	Canada	20.3	82.7003	31.61121	54.190254	366.7
						1.849078655	
2	2001	Canada	19.8	76.7142	32.49442	65.404884	
						391.9595238	
2	2002	Canada	20.1	77.9903	29.8208	140.71887	
						460.4428571	1.860855937
2	2003	Canada	19.7	81.3427	30.03742	52.741917	
						525.202381	1.924679995
2	2004	Canada	20.4	83.427	30.34101	49.701981	
						525.5666667	1.900697708
2	2005	Canada	21.6	69.156	31.55887	59.246498	
						565.0761905	1.882459402

2	2006	Canada	21.5	66.6402	30.82471	79.173363	615.9595238	1.892113328
2	2007	Canada	21.6	67.4095	27.59583	96.473427	637.6178571	1.75481534
2	2008	Canada	21.6	64.9015	26.77905	139.58542	598.6646825	1.782482386
2	2009	Canada	22.2	57.4311	25.83031	89.549774	654.6202381	1.742083311
2	2010	Canada	21.4	61.7761	24.88457	74.667969	784.052381	1.777826786
2	2011	Canada	21.5	66.0373	25.85051	106.21979	819.4952381	1.772545457
2	2012	Canada	21.8	67.1006	25.36108	98.746735	796.597619	1.756970048
2	2013	Canada	22.2	65.2006	24.47824	105.89491	768.9085317	1.780741096
2	2014	Canada	22.2	64.4652	27.07246	99.227028	751.5873016	1.753717661
2	2015	Canada	22.3	65.017	24.46794	165.58049	743.5880952	1.730935335
2	2016	Canada	22.1	69.6469	24.87159	183.8259	756.0797619	1.744541049
2	2017	Canada	22.8	70.8782	25.66502	200.88225	821.6361111	1.815572977
2	2018	Canada	22.3	70.7647	25.76197	325.29785	798.0361111	1.675133944
2	2019	Canada	22.4	70.9947	25.40574	850.8333333	1.697310686	
2	2020	Canada	23.9	63.641	26.51011	817.3	1.598312855	
2	2021	Canada	23.8	67.9494	25.47228	709.9666667	1.561457276	

3	2009	France	11.2	41.2483	26.80305	94.084717	1465.179762
							1.477054477
3	2010	France	11.9	45.1047	25.73005	94.928215	1553.753968
							1.462661028
3	2011	France	10.6	50.2479	24.19506	120.58491	1716.666667
							1.392306805
3	2012	France	12.3	47.7315	25.82583	110.6638	1805.501984
							1.373381257
3	2013	France	13.4	48.8703	25.66978	97.898834	1737.825992
							1.482052445
3	2014	France	13.2	46.2518	25.41127	120.58991	1706.137302
							1.412870884
3	2015	France	13.3	44.6183	25.16199	140.23062	1659.959524
							1.417322278
3	2016	France	14.2	46.2956	27.04403	152.11844	1461.471429
							1.380623579
3	2017	France	14.1	41.3864	24.89115	195.83858	1579.15
							1.308906794
3	2018	France	15.2	40.3554	24.13001	216.05449	1778.07619
							1.419718504
3	2019	France	15.5	38.4407	18.68793		1880.770238
							1.33822
3	2020	France	16.8	35.8942	18.69248		1813.903571
							1.204251051
3	2021	France	16.2	46.131	38.62295	1195.244444	1.228540301
3	2022	France		43.0375	74.12791		550.1416667
							1.165212154
3	2023	France		38.0544			1.14462626
4	1990	Germany	2.1	156.1497	46.46063		1577.166667
4	1991	Germany	2	133.6055	44.91468		1488.75
4	1992	Germany	2.1	124.7748	44.70588		1555.833333
4	1993	Germany	2.1	117.548	43.60608		1674.916667
4	1994	Germany	2.3	117.9432	44.31706		1709.583333

4	1995	Germany	2.3	116.6384	44.20475	266.1506
				1651.416667		
4	1996	Germany	2.2	110.5177	42.13688	49.463512
				1861.583333	1.724676728	
4	1997	Germany	2.8	108.2033	42.62527	18.30448
				2165.45		
4	1998	Germany	3	105.9988	42.3871	74.614243
				2356.344444	1.812501669	
4	1999	Germany	3.3	101.6852	40.65746	60.653141
				2703.766667		
4	2000	Germany	3.7	102.7398	40.12183	76.508133
				2971.542857	1.804531693	
4	2001	Germany	3.9	96.4403	40.58999	51.770859
				3022.109524		
4	2002	Germany	4.4	95.8432	39.27458	84.455635
				2928.592857	1.660018086	
4	2003	Germany	5.4	98.5714	41.69466	88.472862
				2879.685714	1.357405186	
4	2004	Germany	6.3	97.0651	41.83899	70.437996
				3035.592857	1.46714747	
4	2005	Germany	7.3	94.7715	41.21571	89.598793
				3217.683333	1.500524759	
4	2006	Germany	8.6	96.6597	39.85184	42.883591
				3718.985714	1.645976067	
4	2007	Germany	10.5	96.0489	36.34801	73.111435
				3989.633333	1.63131237	
4	2008	Germany	10.2	99.8683	35.5166	66.725021
				4360.212302	1.514055371	
4	2009	Germany	10.7	86.8686	32.27942	69.00975
				4686.479762	1.575109243	
4	2010	Germany	11.6	98.3512	30.38036	79.416275
				5137.556349	1.515693784	
4	2011	Germany	12.5	97.1816	27.80572	161.1826
				5207.311905	1.500138998	

4	2012	Germany	13.6	94.25	27.33026	156.12941	4915.311508 1.530975819
4	2013	Germany	13.6	93.8048		29.03124	208.24815 4497.003373 1.5104146
4	2014	Germany	14	91.2462		29.35546	152.42101 4532.202381 1.664824605
4	2015	Germany	14.6	95.1189		29.86497	146.39581 4328.304762 1.656397581
4	2016	Germany	14.2	93.2194		29.49265	107.39583 4421.024206 1.66018796
4	2017	Germany	15.2	95.1388		26.77815	102.87523 4737.981746 1.613111734
4	2018	Germany	16	98.3399		24.8538	103.77562 4994.338492 1.523563743
4	2019	Germany	17.1	93.4304		22.36422	4631.372619 1.495345831
4	2020	Germany	18.5	93.3577		20.56075	4569.977381 1.313688159
4	2021	Germany	17.6	92.6406		32.83072	2890.5 1.289112926
4	2022	Germany		85.6557		38.92546	1717.891667 1.289299607
4	2023	Germany		78.2833			1.185416698
5	1990	Ireland	2.3	4.118	7.053942	110.87392	3.5
5	1991	Ireland	2.2	4.1968	4.620462	136.45886	8
5	1992	Ireland	2.2	3.8771	4.784689	137.15112	15
5	1993	Ireland	2.1	4.0341	11.11111	157.85474	6.333333333
5	1994	Ireland	2.2	4.2125	6.666667	92.312134	2.583333333
5	1995	Ireland	1.9	4.182	15.78947	64.367119	14
5	1996	Ireland	2	4.0208	5	28.769979	12.41666667 1.670319676
5	1997	Ireland	1.9	4.3375	14.28571	70.09333	16.91666667

5	1998	Ireland	2.3	4.2693	7.317073	80.521065	25.25
		1.736843228					
5	1999	Ireland	2.1	4.4269	7.142857	60.584682	29.13333333
5	2000	Ireland	2	5.1549	7.407407	65.985268	22
		1.592732906					
5	2001	Ireland	2	5.1173	20.68966	115.80804	15.58333333
5	2002	Ireland	2.2	4.7849	8.333333	83.879478	11.45
		1.571493626					
5	2003	Ireland	2	4.94	3.703704	103.2443	26.97619048
		1.496550441					
5	2004	Ireland	2.3	5.0136	3.703704	79.405273	26.6
		1.519247532					
5	2005	Ireland	2.9	5.2025	14.70588	66.376221	26.53333333
		1.730557203					
5	2006	Ireland	3.2	5.1903	17.5	86.567497	39.2
							1.531674147
5	2007	Ireland	3.5	4.7741	22.41379	129.66756	42.83333333
		1.554253817					
5	2008	Ireland	4.2	4.5992	36.76471	159.3	62.4
							1.491493106
5	2009	Ireland	5.3	3.4906	36.66667	111.69212	41.11666667
		1.33218801					
5	2010	Ireland	5.3	3.5847	38.46154	135.83852	48.83333333
		1.344303727					
5	2011	Ireland	7	3.1847	25.5814	117.51886	52.7
		1.45015204					
5	2012	Ireland	6.9	3.2504	30.95238	72.558556	50.39285714
		1.539069533					
5	2013	Ireland	7.7	3.3705	33.33333	56.733494	48.7
		1.504042864					
5	2014	Ireland	8.8	3.6384	17.85714	63.036846	47.52619048
		1.598833084					
5	2015	Ireland	9.5	3.6259	33.33333	110.15768	57.25
		1.520840526					
5	2016	Ireland	8.6	3.7474	18.75	122.86428	43.94444444
		1.329557776					

6	2005	Italy	6.7	66.4678	14.72868	84.77774	396.0166667
				0.556203485			
6	2006	Italy	7.5	61.7613	20.0361	80.799156	459.3333333
				0.356097698			
6	2007	Italy	8.7	60.5409	25.70423	105.47068	531.05
				0.191648334			
6	2008	Italy	10.8	56.9598	29.88357	84.724838	583.8095238
				0.272778869			
6	2009	Italy	12.5	43.2246	32.58036	78.675331	663.9738095
				0.417277068			
6	2010	Italy	12.8	45.7961	31.33047	97.102501	641.5095238
				0.467300355			
6	2011	Italy	11.9	45.0334	35.31438	131.47604	648.3166667
				0.403479129			
6	2012	Italy	14.4	43.3178	31.58845	106.05316	690.3468254
				0.447511166			
6	2013	Italy	16.3	38.0845	27.46823	132.04791	613.5690476
				0.532426715			
6	2014	Italy	17.1	35.1245	18.87477	112.40999	602.0166667
				0.472872227			
6	2015	Italy	16.6	34.8515	20	71.488586	649.8333333
				0.490196675			
6	2016	Italy	16.1	34.6538	21.15385	84.5382	639.675
				0.544244647			
6	2017	Italy	16.4	31.923	19.65714	69.785439	668.0277778
				0.491924196			
6	2018	Italy	17.1	32.2262	18.33521	84.438599	646.2694444
				0.408853263			
6	2019	Italy	17.3	31.171	17.8337	682.9416667	0.450929791
6	2020	Italy	18.7	29.4835	17.98365	752.875	
				0.360754579			
6	2021	Italy	17.5	41.3684	19.44729	685.45	0.325260878
6	2022	Italy		37.9242	18.06616	355.8666667	
				0.448645294			

6	2023	Italy	34.2105			0.611036897	
7	1990	New Zealand	28	5.9171	6.638343	112.55977	8
7	1991	New Zealand	27.6	6.0529	5.980995	82.436798	4
7	1992	New Zealand	25.6	6.0418	7.248397	188.95586	10.5
7	1993	New Zealand	27.3	6.2908	8.830908	52.495476	15.66666667
7	1994	New Zealand	28.2	6.2712	7.359511	76.012749	19
7	1995	New Zealand	28.7	5.9835	8.455181	58.280785	26.5
7	1996	New Zealand	27.6	6.0641	7.709163	50.760334	22.5
				1.771766543			
7	1997	New Zealand	25.9	5.8351	8.037179	35.338573	23.5
7	1998	New Zealand	27.3	5.6022	7.531601	109.68347	20.66666667
				1.628706098			
7	1999	New Zealand	26.4	5.5053	6.418083	137.08255	18.66666667
7	2000	New Zealand	26.4	6.0153	5.87234	93.885002	19.83333333
				1.58685112			
7	2001	New Zealand	24.6	6.4257	7.039047	72.938789	41.16666667
7	2002	New Zealand	26.6	6.7004	7.314329	55.236897	23.5
				1.678446293			
7	2003	New Zealand	25.9	6.2556	6.484946	93.320709	34.58333333
				1.761944294			
7	2004	New Zealand	28.2	5.8328	6.60737	94.736412	36.33333333
				1.940045238			
7	2005	New Zealand	26.8	5.0205	7.142857	92.773033	36.53333333
				1.741362095			
7	2006	New Zealand	27	5.0789	8.542335	126.17319	49.91666667
				1.583402157			
7	2007	New Zealand	27	5.4702	9.490114	161.26003	54.53333333
				1.657784104			
7	2008	New Zealand	26.1	5.5213	8.954289	244.01848	46.9
				1.669064879			
7	2009	New Zealand	28.5	5.1129	10.3779	91.901253	66.53571429
				1.848079324			

7	2010	New Zealand	29.4	5.417	10.86298	107.5768	55.62619048	1.811324596
7	2011	New Zealand	30.3	5.0952	11.98938	104.66969	63.23333333	1.87170589
7	2012	New Zealand	28.8	5.2976	10.75848	95.224907	60.11666667	1.792153716
7	2013	New Zealand	28.3	6.1079	9.985618	85.025002	54.5	1.749987483
7	2014	New Zealand	29	6.8131	10.03025	59.513134	86.85	1.924988627
7	2015	New Zealand	29.3	6.5498	8.73494	59.474285	50.41666667	1.852818251
7	2016	New Zealand	30.1	6.6337	9.304976	52.382252	35.08333333	1.805901408
7	2017	New Zealand	28.4	6.5313	10.9589	154.88326	50.66666667	1.727959037
7	2018	New Zealand	28.9	6.5133	10.1104	151.4005	27.35	1.628719091
7	2019	New Zealand	28	6.8988	12.31203	45.43333333		1.632435799
7	2020	New Zealand	28.7	6.2929	11.57718	49.66666667		1.538743258
7	2021	New Zealand	28.9	6.0479	9.510086	39.45	1.305689335	
7	2022	New Zealand		5.5918	9.326425	26.5	1.340261579	
7	2023	New Zealand		5.6271		1.529976845		
8	1990	Spain	10.6	41.0505	17.15976	28.7		
8	1991	Spain	9.9	42.5807	13.77246	27.16666667		
8	1992	Spain	8.2	39.9942	16.31579	30.91666667		
8	1993	Spain	9.1	38.4482	13.63065	40.5		
8	1994	Spain	9.2	41.7466	14.24984	32.78333333		
8	1995	Spain	8.3	42.6183	14.613	55.41935	43.66666667	
8	1996	Spain	10.1	38.9397	14.56507	35.159966	53.41666667	1.620027184

8	1997	Spain	9.2	44.4877	13.48315	30.194216	53.7
8	1998	Spain	8.9	44.2128 1.597302556	13.37897	59.435371	66.52777778
8	1999	Spain	7.7	41.3424	16.80815	41.116463	70.86666667
8	2000	Spain	7.9	47.1885 1.685757279	16.875	70.999672	75.91666667
8	2001	Spain	8.9	51.1971	15.59285	63.034222	90.25
8	2002	Spain	7.4	51.2799 1.786120415	19.02605	50.391266	69.31666667
8	2003	Spain	8.9	53.9866 1.816807151	19.7668	73.383049	99.13333333
8	2004	Spain	8	54.3937 1.33226645	20.4431	75.866119	121.25
8	2005	Spain	7.3	55.1662 1.501574278	24.34692	66.760941	186.3333333
8	2006	Spain	8.5	43.6661 0.83016777	26.39799	112.37981	226.4595238
8	2007	Spain	9	47.9435 0.987038195	29.70115	121.87409	265.8166667
8	2008	Spain	9.7	44.654	32.84641	133.68607	261.6833333
8	2009	Spain	12.2	37.4012 0.941682339	34.41682	137.42142	344.4595238
8	2010	Spain	14.4	39.372	34.19803	204.26399	317.6119048
8	2011	Spain	14.7	38.4737 0.9724015	35.34362	125.89624	360.7
8	2012	Spain	15.8	35.5302 1.057162166	33.83948	151.18373	381.6488095
8	2013	Spain	16.9	34.9172 1.167685986	30.71253	164.4893	343.6446429
8	2014	Spain	17.3	32.5227 1.173297644	32.53188	151.51195	303.1166667

9	1999	United Kingdom	0.9	62.4548	43.66872	48.352806
		570.7666667				
9	2000	United Kingdom	1	62.3226	38.40831	63.754635
		590.5761905 1.768822312				
9	2001	United Kingdom	0.8	65.9552	38.07531	60.975384
		613.5095238				
9	2002	United Kingdom	1	61.5042	35.36269	58.080776
		595.6261905 1.779725552				
9	2003	United Kingdom	0.9	61.1397	37.70784	70.841621
		652.102381 1.746334672				
9	2004	United Kingdom	1.1	58.1358	35.95092	71.996964
		688.1333333 1.868020773				
9	2005	United Kingdom	1.4	55.0882	32.58222	97.787384
		695.8444444 1.761572123				
9	2006	United Kingdom	1.6	54.3583	30.5492	105.39077
		818.7678571 1.666798234				
9	2007	United Kingdom	1.8	53.4077	31.51635	102.38456
		895.6428571 1.641638756				
9	2008	United Kingdom	2.4	52.2006	27.33813	112.88867
		962.2353175 1.634806633				
9	2009	United Kingdom	3	43.1766	26	116.40865
		1051.569048 1.508096457				
9	2010	United Kingdom	3.2	44.9871	23.01148	127.63744
		1153.421429 1.617997527				
9	2011	United Kingdom	4	40.2179	24.78669	134.82817
		1274.730952 1.604194641				
9	2012	United Kingdom	4.2	40.2536	23.97515	147.78316
		1231.63373 1.591210365				
9	2013	United Kingdom	5.2	40.9082	23.93661	139.08585
		1267.066667 1.512266517				
9	2014	United Kingdom	6.6	40.5421	24.95065	111.95026
		1253.619048 1.623491168				
9	2015	United Kingdom	7.7	39.2392	24.66229	118.77367
		1259.216667 1.705227733				

9	2016	United Kingdom	7.7	33.2072	26.44	161.37778	
						1159.45	1.573777437
9	2017	United Kingdom	8.8	33.6911	26.58495	180.19363	
						1129.777778	1.430928707
9	2018	United Kingdom	10.2	33.0216	23.12261	144.48175	
						1186.336111	1.361698747
9	2019	United Kingdom	11.4	32.7209	26.05347	1169.7	
						1.449825883	
9	2020	United Kingdom	13.6	31.1238	24.49057	1202.6	
						1.332154155	
9	2021	United Kingdom	12.2	33.1947	26.91522		
						924.2833333	1.239673018
9	2022	United Kingdom		32.056	34.25755	695.9	
						1.238090038	
9	2023	United Kingdom		29.3729			
						1.161142707	
10	1990	United States	4.2	604.4447	40.52776	45.178547	1903.2
10	1991	United States	4.5	566.877	41.68343	71.662552	
						1932.95	
10	1992	United States	4.8	517.6393	39.46163	85.472374	
						2049.316667	
10	1993	United States	4.3	532.4218	39.55922	85.273842	
						2131.816667	
10	1994	United States	4.1	534.8524	36.97479	66.748604	
						2181.283333	
10	1995	United States	4.7	486.8017	38.16674	70.501274	
						2264.566667	
10	1996	United States	4.8	485.9246	36.56831	58.765041	
						2379.366667	1.524920464
10	1997	United States	4.5	506.7299	35.70544	70.615242	
						2595.583333	
10	1998	United States	4.5	512.7422	34.24589	53.86121	
						2834.411111	1.698527455

10	1999	United States	5.7	499.3623	33.79202	75.036499
				3244.833333		
10	2000	United States	5.4	567.1249	32.49349	90.483849
				3888.816667	1.724886537	
10	2001	United States	4.7	540.0108	31.23458	114.05898
				4141.859524		
10	2002	United States	4.8	490.816	31.07784	84.616142
				4568.142857	1.620927811	
10	2003	United States	5.3	485.416	29.83983	80.729797
				4506.445238	1.540124536	
10	2004	United States	5.5	511.6738	30.35021	76.40081
				5000.02619	1.740257859	
10	2005	United States	5.8	477.3253	29.68844	86.251541
				5618.420635	1.531012774	
10	2006	United States	6.4	495.8157	27.8622	83.632248
				6393.686905	1.581685543	
10	2007	United States	6.3	486.0106	26.11588	109.65426
				7337.177381	1.643272758	
10	2008	United States	6.8	474.7671	23.80139	122.61497
				7621.417063	1.605075598	
10	2009	United States	7.3	407.5382	21.52817	128.56528
				8089.97619	1.502984643	
10	2010	United States	7.4	466.3256	20.19415	139.7413
				8828.299206	1.552272081	
10	2011	United States	8.4	435.6929	18.92622	110.48341
				9106.892857	1.513798475	
10	2012	United States	8.5	438.5726	18.33908	104.96111
				10058.32817	1.52132237	
10	2013	United States	8.9	434.8862	18.51118	100.52606
				10865.96567	1.516476631	
10	2014	United States	9	437.2563	19.02416	115.10562
				9843.706349	1.461625457	
10	2015	United States	8.9	433.8849	19.0202	124.21082
				9711.692857	1.43219924	

10	2016	United States	9.3	439.0239	19.19986	137.01534
				9873.60754	1.440504909	
10	2017	United States	9.7	429.4054	18.13775	230.72627
				9665.815079	1.51742816	
10	2018	United States	9.9	454.0616	17.78836	177.10687
				9298.071825	1.536972165	
10	2019	United States	10.2	439.0522	17.03395	8485.763095
				1.453415036		
10	2020	United States	11	437.4557	17.61788	8596.753571
				1.274593234		
10	2021	United States	10.9	445.7564	17.62732	7252.533333
				1.297531009		
10	2022	United States		451.4372	18.23354	5254.508333
				1.255495548		
10	2023	United States		444.5117		1.217200994