

**CAPITAL UNIVERSITY OF SCIENCE AND
TECHNOLOGY, ISLAMABAD**



**Nexus between Green Finance and Economic
Growth: Moderating Role of Research &
Development**

by

Osama-Bin-Atta

A thesis submitted in partial fulfillment for the
degree of Master of Science

in the

**Faculty of Management & Social Sciences
Department of Accounting and Finance**

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*Dedicated to my family who dedicated their lives to teach me how to step
forward...!*



CERTIFICATE OF APPROVAL

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Abstract

This study examines the relationship between green finance and economic growth, with a focus on the moderating effect of research and development (R&D) expenditure. By focusing on 53 developing countries from 2000 to 2021, the research aims to provide empirical evidence on how green finance contributes to economic growth and how R&D strengthens or alters this relationship. Panel data for 53 countries over 21 years were analyzed using econometric techniques, specifically the Generalized Method of Moments (GMM), to address potential endogeneity and robustness issues. Variables include economic growth (GDP per capita), green finance (international financial flows supporting clean energy), R&D expenditure, industry value added, and gross national expenditure as controls. The results suggest that green finance has a positive impact on economic growth in developing countries. Moreover, R&D expenditure significantly enhances this effect, acting as a moderator that amplifies the growth benefits of green finance. The interaction between green finance and R&D was found to be statistically significant, highlighting the synergistic potential of financial innovation and technological advancement for sustainable development. This research fills a gap in the empirical literature by not only establishing the direct impact of green finance on economic growth but also by quantifying the moderating role of R&D. The findings offer actionable insights for policymakers, suggesting that coordinated investment in both green finance and R&D is essential for achieving sustainable and inclusive economic growth. For policymakers, the study suggests that enhancing access to green finance and increasing support for research and development (R&D) will yield higher economic and environmental benefits. The research encourages the design of policies that integrate financial innovation with technological advancement to foster resilient, low-carbon economies.

Keywords: Economic Growth; Green Finance; Research and Development; Gross National Expenditure; Industry Value added.

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Abbreviations

EG	Economic Growth
GF	Green Finance
GNE	Gross National Expenditure
IND	Industry Value Added
R&D	Research & Development

Chapter 1

Introduction

1.1 Background of the Study

Economic growth brings progress, but it often harms the environment because using more resources and creating waste can damage nature. New ideas about separating economic growth from environmental harm offer solutions for better development. It is possible to improve living standards in the long term and reduce environmental damage with the help of better technology and policy changes ([Irwin, 2025](#)).

Economic growth is typically measured by Gross Domestic Product (GDP) or GDP per capita as the increase in wealth of a given country and the signifier of better quality of life ([Panayotou et al., 2003](#)). Conventional growth models that major on the use of industrialization and exploitation of resources have led to the emergence of environmental issues like deforestation, air pollution and rise of carbon emissions. Realizing that such approach is not truly effective, there is a general belief that economic development cannot be achieved at the cost of environmental sustainability. Therefore, a key policy priority is finding a balance between development and protecting the environment.

Growth has the historical connection of being accompanied by depletion of resources which explains the emergence of a new approach called green growth. Green growth aims to increase the economy and keep resources, mining emissions,

and habitat intact ([Raihan et al., 2025](#)). It involves sustainable activities in the transport, agriculture, and manufacturing. The most crucial ones are the use of clean technologies, the utilization of renewable energy, and the effective use of resources to reduce environmental risks and foster workplaces and productivity.

Green growth is beyond environmental necessity; it is also an opportunity of economic nature. Empirical evidence shows that clean energy, energy efficiency and sustainable infrastructure investment can present important economic payoffs such as creation of employment opportunities, increase in productivity and competitiveness enhancement. It is estimated by the International Renewable Energy Agency (IRENA) that the global unit of jobs in the field of renewable energy may amount to 42 million by the year 2050 compared to the current number of 12 million in the year 2020. The health benefits of this transition are projected to be significant since it will prevent hundreds of millions of premature deaths every year because of air and water pollution ([Toman, 2012](#)).

Through recent body of knowledge, the flaws of traditional economic models have been highly publicized and governments and financial institutions have incorporated environmental aspects into its strategic plans. The concept of green finance implies investing in projects, technologies, etc. that are environmentally stable and favorable to environmental well being. This principle thus includes the investment programs aimed at reducing the impacts of climate change, the preservation of natural resources, and improvement of the quality of the environment. In the overall context of the discussion of sustainable development, green finance is identified as an avenue that offers the financial framework that is capable of facilitating the shift towards a low carbon economy ([Raihan et al., 2025](#)). It has become increasingly significant along the wayside with global anxieties about phenomena like global warming, air contamination, and ecological impoverishment, and it is therefore necessary to note that financial systems are essential to lead the path to sustainability.

Increased industrialisation as well as urbanisation and growth have put a greater load on ecosystems of the planet than ever before in the last several decades ([Challoumis & Eriotis, 2025](#)). The environment on terra firma has accorded the actualisation of climate change, visible in the rising of sea levels, increasing natural

calamities and fading biodiversity, among others, which has instigated a general acceptance that the old prescription of economic development that focus more on short term proficiency as opposed to ecological stability on the long term is unsustainable.

Green financing aims to invest in a variety of ways, including renewable energy, energy efficiency, sustainable agriculture, and other ways, thus a two fold purpose is achieved, the growth needs to be environmentally and sustainably responsible and sustainable at the same time (Managi, Chen, Kumar, & Dasgupta, 2024). It consists of a range of financial tools green bonds, green loans, and climate finance, which allows channeling funds into activities that will help to ensure low emission development, clean power, and energy efficiency. Such investments are aiding the creation of sustainable infrastructure, a decline in the reliance on the use of fossil fuels, and enhance the change towards a green economy.

Green finance covers both initiatives in the public sector, including the green investment bank of Japan that is government propped, and private sector innovations, including sustainability linked loans, ESG funds, etc. The growth in the importance of the ESG criteria on financial institutions lending and investment decisions is not only an effect of the regulatory demands but also a product of the changes in preferences among consumers and investors who demand a higher level of environmental responsibility among corporations.

The green finance is linked through Research and Development (R&D) as intermedating variable in economic growth. Despite the fact that green finance can provide funds to be used in the development of environmentally sustainable projects, the degree of the growth stimulated with the help of green finance is determined by the degree of the technological innovation and the level of the activity of research. R&D enhances the productivity, expansion, and viability of those undertakings, hence strengthening the association between green finance development and sustainability (Hossain, Rao, Sharma, Dev, & Kharbanda, 2024). R&D will also be part of the drivers of technological revolution and growth of a sustainable economy. It is a result of investment in the R&D, which allows developing new technologies, perfecting current systems, and creating a new industry. In the framework of green finance, R&D takes a specific role in designing green

technologies that are affordable and scalable and help to achieve the sustainability goals. The price of solar power generation in the form of solar cell efficiency has been recently radically reduced. The roughly congruent advances in wind turbine energy, energy storage equipment, and carbon capture techniques now allow scaling clean energy infrastructure in a financially viable manner to reduce the reliance on fossil fuels (Jalil & Feridun, 2011). Green technologies prevent not only greenhouse gas emissions, but also create new markets and thus create new job positions thereby, contributing to the economic growth (Panayotou et al., 2003).

The investment in the research and development of energy related operations triggers not only the advances in the technological environment in the energy and industrial segments but also the creation of responses to nature based operations, such as reforestation, ecosystem recovery, and climate friendly agriculture (Kasztelan, 2017). Investment or capital put in the sphere activates co benefits in the form of increased biodiversity, better water management, and food security. Moreover, dissemination of green technologies along the transnational boundaries, which are usually jumpstarted by international cooperation and the private public alliance, speeds up the process of global shift towards sustainability, especially in developing economies which are hindered by resource and capacity shortages.

In addition to improving the technology, R&D locates the paths towards long run sustainable growth. Such spheres as sustainable agriculture, environmentally friendly production, or waste management all can be managed with an even better efficiency and a reduced impact on the planet that is supported by research based prowesses (Korolchuk, 2021). When the investments are made into circular economy models, focusing on reuse and recycling, it helps both economy efficiency and environmental conservation.

An example is the Circular Economy Action Plan implemented by the European Union to redesign the life cycles of the products, reduce wastage, and increase resource efficiency across the economy (European Commission, 2020). Crucial to such an initiative are the ones connected to the applications of biodegradable materials, high frequency recycling, and digital traceability tools, which continue to be closely connected to R&D activity (Raihan et al., 2024). The linkage between green finance and economic growth is strengthened by the expenditure on Research

and development as well. The advantages of green finance mechanisms have been enhanced by technologic innovation in the form of enhancing the cost effectiveness and productivity of sustainable investments (Ikram, Ferasso, Sroufe, & Zhang, 2021). Therefore, there is a strong R&D that increases the success of green finance initiatives to promote economic growth.

Furthermore, R&D helps reduce the ignorance and risk when dealing with emerging green technologies, which strengthens the confidence of investors and invokes a further volume of capital in sustainable ventures (Hossain et al., 2024). Green finance, technological innovation, and entrepreneurship are synergistic, which makes the environmentally friendly feedback loop that unfolds to support both the environment and the economic prosperity of countries it is an advantage in the global green transition context.

Hence the relationship between green finance with economic growth is multiple is regulated among others by several variables including R&D investment. As a catalyst, green finance promotes an investment in sustainability and innovation tailored project (Indriastuti & Chariri, 2021). Nevertheless, its effectiveness, at enhancing macroeconomic growth, depends on the tech level made possible by a prolonged R&D effort.

The growth in the affordability of green technologies as well as their scalability is already a determined driver of the increase of green finance. This amplification, in its turn, produces productivity advantage, the creation of industries, and generation of employment (Ozili, 2022). It can be assumed to be a feedback loop: green finance catalyzes investment in green projects, and this same investment catalyzes research and development (R&D) on the one hand, and the resulting innovations lead to an even greater investment in green projects on the other. The cycle thus leads to an economy that is environmentally and economically strengthened at the same time (Gao et al., 2023). On the macroeconomic level green finance and innovation carried out through R&D have the power to change whole industries and cause an economic diversification as well as limit structural unemployment through job opening in young industries. On micro level, companies which undertake sustainability and innovation investments tend to create competitive advantages out of the cost savings, new markets available, and formation of positive image of

the brands (Porter & Van der Linde, 1995). Green finance is the trend all over the world as various economies understand that they need to become more environmentally friendly. Just as an example, China has risen to the position of leadership with its supporting policy and heavy investment in renewable energy resources which have made it the biggest producer and consumer of clean energy technologies. Similarly, the European Union has started the European Green Deal initiative that aims at making Europe the first climate neutral continent by 2050. The discussion of these efforts is supported by green finance, which provides the much needed money in a green shift.

Countries have varying capacities in terms of the scope and scale of the green finance initiatives; this is explained by varying economic settings, institutional capability and priority levels of policies. The Inflation Reduction Act of 2022 in the United States appropriated more than 370 billion dollars in investments on issues related to climate and clean energy, which happens to be the largest federal effort in the history of the country concerning green finance investments (U.S. Department of the Treasury, 2023). The government of Japan has also encouraged a Green Growth Strategy to achieve Carbon Neutrality in 2050 comprising of various strategies to encourage the investment of the private sector in clean technologies (Raihan, Tanchangya, Rahman, Ridwan, & Ahmad, 2022).

Green finance is one of the key outcomes of inclusive green growth in Developing Asia, resulting under such challenges as poverty, inequality, and environmental degradation. Other countries, which include India and Indonesia, are faring quite well with regards to investing in renewable energy and green infrastructure (Nappi, 2023). As an example, India has established ambitious goals in relation to solar power, whereas Indonesia is supporting green forestry. These measures are supported by the international capital flows towards the projects of clean energy and sustainable development, which facilitated the obstacle of the resource limits in the developing economies.

In Africa, Kenya, Morocco, and South Africa are some of the states using green finance to scale up the use of renewable sources of energy and create the ability to withstand any climate impact. Capital external to the IEA countries attracted by the creation of regional green bond markets has enabledolar scale solar and wind

projects. The main accepted basis of growth in the country is economic growth since it enhances living standards, raises incomes and goods and services production. As emphasized by the world bank (2023), growth is a vital feature in reducing poverty and enhancing well being of the masses. The growth in economies leads to production of resources that can be channelled to infrastructure developments, education and health thus enforcing developmental paths. The main factors of the long term growth are dispensed with by the Solow (1956) framework which focuses on capital accumulation, technological advancements, and labour productivity. The current debate, nevertheless, emphasizes the need of also making a growth sustainable, such that the environmental and social impacts are not compromised (Spangenberg, 2005).

Growth has always been associated with environmental degradation manifesting in pollution and depletion of resources, but present studies reject this connection. Separation of development to a growth per se and its impacts on the environment contributed to the notion of green growth, which is described as expanding the economy in a way that prevents depletion of natural resources.

According to the professional studies of scholars like (Lucia, Maussion, Dede, & Burdío, 2013), the development of technologies, which will balance the development and ecological care, will be the key to further economic prosperity. Green technologies and renewable energy present viable sources of growth that do not aggravate environmental debts that historically are entailed by industrialization. Thus, today, the expected growth imposes on itself the need to not only promote productivity but also consider the active impact on the environment, so that economic development does not turn against the generations coming after the current ones.

Old models of economic growth have often led to environmental problems, including pollution, deforestation, and increased carbon emissions. These problems harm nature and also threaten the stability of the very systems that economic growth was supposed to improve. As explain, this "growth versus environment" challenge necessitates new approaches to economic growth that also protect the environment. Green growth is a solution, suggesting that we continue to grow economically while also preserving nature and mitigating environmental damage.

Green finance refers to the allocation of capital and investment toward projects, technologies, and services that are environmentally sustainable and beneficial to the environment. This encompasses funding initiatives aimed at mitigating climate change, conserving natural resources, and enhancing environmental quality.

In the context of sustainable development, green finance plays a crucial role by providing the financial framework required to support the transition to a low carbon economy. The term gained prominence as global concerns over issues such as global warming, air pollution, and ecosystem degradation intensified, highlighting the urgent need for financial mechanisms that promote sustainability. In recent decades, the rapid acceleration of industrialisation, urbanisation, and economic growth has placed unprecedented pressure on the planet's ecosystems. As the impacts of climate change have become more evident through rising sea levels, increased frequency of natural disasters, and declining biodiversity, there is a growing recognition among governments, businesses, and civil society that the traditional model of economic progress, which prioritizes short term gains over long term environmental stability, is no longer sustainable.

In 2015, 178 countries signed the Paris Agreement to address the global issue of climate change collectively. The urgency of this problem is underscored by projections that global temperatures could rise by approximately 2.8°C by 2030 (UNEP, 2022). Likewise, according to a report by the International Energy Agency, an estimated \$53 trillion will be needed by 2035 to limit the temperature increase to 2°C (International Energy Agency, 2014). Aligned with the objectives of the Paris Agreement, green finance has emerged as a critical tool for achieving both environmental and economic targets in the 21st century (UNEP, 2022; International Energy Agency, 2014). Countries such as the European Union, China, and the United States have introduced regulatory frameworks, subsidies, and incentives to encourage green investments (S. Zhang, Dou, Ji, Afthanorhan, & Hao, 2024).

This global commitment signals a fundamental transformation in how nations and the financial sector perceive risk, investment, and returns. The Paris Agreement, with its legally binding targets for reducing greenhouse gas emissions, has served as a catalyst for policy innovation and the mainstreaming of green finance across both developed and developing economies.

By supporting investments in renewable energy, energy efficiency, and sustainable agriculture, green finance aims to achieve dual goals: fostering economic growth that is both environmentally responsible and enduring ([Kemp-Benedict, 2018](#)). Green finance encompasses a range of financial instruments, including green bonds, green loans, and climate finance, that channel investments into projects aimed at reducing carbon emissions, promoting clean energy, and enhancing energy efficiency. These investments contribute to building sustainable infrastructure, minimizing dependency on fossil fuels, and accelerating the transition to a green economy.

The spectrum of green finance is broad, extending from public sector initiatives, such as government backed green investment banks, to private sector innovations like sustainability linked loans and environmental, social, and governance (ESG) funds ([Fu, Lu, & Pirabi, 2023](#)). Financial institutions are increasingly integrating ESG criteria into their lending and investment decisions, reflecting both regulatory requirements and shifting market preferences among investors and consumers who are increasingly demanding greater environmental responsibility from corporations.

Economic growth, typically measured by Gross Domestic Product (GDP) or GDP per capita, indicates the increase in a nation's wealth and the improvement in living standards. However, traditional models of economic growth, which heavily depend on industrialization and the exploitation of natural resources, have led to significant environmental challenges, including deforestation, air pollution, and increased carbon emissions ([Baek & Kim, 2013](#)). Recognizing the limitations of this model, there is a growing consensus that economic progress should not come at the expense of environmental sustainability ([Robertson, 2005](#)). Consequently, balancing economic development with environmental protection has become a central concern for policymakers.

The past shows that the growth of economic activities has been inseparably linked to the increasing resource usage and pollution, which suggests the traditional trade off between the growth and the environment. Recent changes in economic theory, above all the notion of the 'decoupling, indicate that such a correlation is not a necessity.

Decoupling hypothesizes that in a given strategy of technological innovation and policy reform, it will be possible to enhance prosperity of living standards in a given time period and thinner ecological footprints. This theoretical change has bred the model of a green growth. Green growth is an economic development, which accomplishes all of these goals at once: natural resources will be preserved, the reduction of emission will be implemented, and the protection of ecosystems will be a reality. To be implemented it will need sustainable practices to be adopted throughout energy, transportation, agriculture and manufacturing: at the forefront will be clean technologies as well as the sources of energy which will rely predominantly on usage of renewable energy sources and the effective stewardship of resources to ensure minimal impact on the environment as well as the creation of employment together with the increase in productivity.

Green growth is not only a green necessity; it is also one of the major economic opportunities. Empirical evidence explains that investment in clean energy, energy efficiency and sustainable infrastructure is associated with high macroeconomic returns such as creation of employment opportunities, high productivity, and increased competitiveness. Indicative of this is the prediction by the International Renewable Energy Agency (IRENA) which revealed that the renewable energy sector is likely to sustain an additional 30 million jobs as compared to the current job figures by the year 2050 i.e., 42 million based on the current situation. A side effect is that it cuts down air and water pollution, which is related to millions of death cases per year.

With the consideration of such savings, the governments and the financial institutions are turning to consider the environment more in their strategic plans and portfolio investments. The green finance plays the key part in this shift, directing the money towards more environmentally viable projects without losing economic bases ([Sertsios, 2020](#)). Green finance will also contribute to the appearance of the industries encouraging environmental preservation and sustainability of the economy because of financing solar power stations, wind farms, and other energy saving innovations. The role of green finance also reaches the strengthening of the economy. The COVID 19 pandemic exposed economies that rely so much on fossil fuel intensive supply chains and thereof a lot of governments have initiated various

stimulus packages using billions of dollars on renewable energy, public transport, and sustainable agriculture (Espinosa, Alonso Neira, & Soto, 2021). The type of investment is not only pursued to resuscitate the economy but to create a resilience against shocks in the future, such as shocks related to climate change and biodiversity loss. Research and Development (R&D) are integral to driving technological innovation and sustainable economic growth. R&D investments enable the development of new technologies, improve existing systems, and foster the creation of new industries (Acemoglu & Restrepo, 2018). Within the context of green finance, R&D is particularly vital for developing affordable and scalable green technologies essential to meeting sustainability targets.

The latest technology in the reduction of the efficiency of solar panels has significantly reduced the price of producing solar energy. Similar innovations in wind power, energy storage, carbon capture technologies have also reached the level at which the clean energy alternatives can be widely introduced and reduce dependence on fossil fuels. These innovations also reduce the amount of greenhouse gas emission, enhance a new market, and create jobs, hence provoking economic growth. Long term research and development have the ability not only to promote innovation in the technology of energy and industry, but also to fund wildlife based solutions, including forests, nature recovery and climate resilient food production (Cassiman, Perez-Castrillo, & Veugelers, 2002). The green finance allows access to co benefits by directing financial capital into such areas as improved biodiversity and water management, as well as increased food security. Moreover, international cooperation and partnerships involving the public and the private sector have increased the pace of the world towards sustainability as the cross border flow of green technology has been a key to growth in this area in both developed and developing parts of the world where resources and capabilities are limited.

In addition to the technical progress, R&D finds ways to a sustainable long term development. Such industries as sustainable agriculture, green production and wastes recycling benefit of R&D which reduces the burden to the environment and increases efficiency. Financial investments in the aspects of circular economy models, with the focus on the reuse and recycling, contribute to economic optimization, at the same time preserving the ecological integrity. An example includes

Circular Economy Action Plan by the European Union that aims at reshaping the design, production, and consumption patterns of products, consequently reducing the waste and maximizing the use of resources across the economy European Commission 2020. This project is impossible to complete without R&D driven innovations such as biodegradable materials and advanced recycling technologies as well as tools that would allow tracking products on digital platforms.

In addition, investments on R&D strengthen the combination of a relationship between green finance, and macro performance. On the one hand, the technological advancement enhances the effectiveness and cost efficiency of the green investments and hence it raises the possibilities of the positive financial outcomes. Therefore, R&D is a key part of the proper green finance plans. One more uncertainty related to new green technologies that is resolved by R&D is the risks and uncertainties, which contribute to the strengthening of investor confidence and bringing more funds carried to the sustainable projects (Ning et al., 2023). This synergy between green finance, innovation and entrepreneurship ultimately ends up establishing a self renewing cycle of enhancing environmentalism goals as well as economic growth making countries to be at the frontline in the global green shift.

The green finance and economic growth nexus are complicated and dependent on many factors of which include research and development (R&D) investment. The green finance acts as a facilitator of the flow of capital into sustainability focused and innovation advancing project. Nevertheless, it reflects on the growth of economic growth as long as the improvements in technology are all possible because of R&D. When combined, the R&D increases the impact of green finance, creating productivity gains, creating industries, and new jobs by enhancing the accessibility and flexibility of green technologies (Mazzucato, 2013). Such connection creates the so called feedback loop: green finance enhances the investment in environmentally sound businesses, and the latter triggers research and development, the products of which attract even more green financing. This cyclicity facilitates sustainable environmental friendly and economically sound economies.

International trends of green financing are the evidence of the understanding that the shift towards more sustainable economic patterns is required. An example is China, which has developed favorable policies and allocated considerable resources

to clean energy, thus becoming the world leader in clean technologies production and consumption. On the same note, the European Union has presented the European Green Deal in a bid to realise a climate neutral state in 2050 report UNEP, 2022. The foundations of these initiatives constitute green finance that provides the much needed funding of a low carbon transition.

The extent and depth of green financing varies greatly among countries, with the heterogeneity of economic capabilities and institutional capacity and focus on policies. The current major investment is the Inflation Reduction Act of 2022, which includes about \$370 billion in investment by the United States government in climate and clean energy, the largest federal investment thus far (U.S. Department of the Treasury, 2023). A green growth strategy of achieving carbon neutrality in 2050 has been promoted in Japan, comprising plans aimed at encouraging the investment of clean technology in the private sector (METI, 2021).

Green finance is a critical element of Inclusive green growth in Developing Asia where long running problems of poverty, inequality, and environmental degradation exist (Eren, Taspinar, & Gokmenoglu, 2019). Nigerian countries like India and Indonesia are showing improvement in terms of the purchase of renewable energy and sustainable infrastructure growth. India has ambitious solar energy plans, whereas Indonesia is positively pursuing the implementation of green forestry practices. These programs enjoy the service of international capital invested in clean energy projects and sustainable development projects that reduce the resource limitations found in advancing economies.

In Africa, a number of country economies, such as Kenya, Morocco, and South Africa, are using the instruments of green finance to expand availability of renewable power and climate resilience. Green bond markets in these jurisdictions have secured significant levels of cross border capital financing and covered the installation of large solar and wind projects in the regions (Zerbib, 2019). On the macroeconomic, green finance and innovation resulting in R&D have the potential to reorganize whole sectors, diversify the economy, and reduce structural unemployment upon creating new possibilities in the emergent sectors. At the microeconomics stage, companies using sustainability and innovations tend to gain competitive advantages in terms of reduced costs, opening of new markets, and

improved brand name. Green finance has become an important tool due to the necessity to stimulate solid environmental policies and innovation trend in the context of economic growth sustainability reconciliation.

1.2 Theoretical Background

Green finance, research and development (R&D), and economic growth, this is the relationship that needs to be studied in detail; particularly, concerning the long term attitude towards the strategy of development. In this area, the author will present the summaries of the theoretical materials which will be the foundations of study according to already provided theoretical principles of economy and interpretation of empirical data to form a theoretical structure which will present the research.

Moreover, these constructs must be understood holistically in order to investigate the way in which they interact to develop sustainable economic pathways. By bringing together the theory and the empirical evidence, this research is intended to bridge the gap between theory and practice. This two pronged approach is not only strengthening the theoretical perspective but also provides a glimpse into what green finance and R&D can accomplish in the long term, from an economic stability standpoint.

1.2.1 Endogenous Growth Theory

Theory of Endogenous Growth The endogenous growth theory also considers long term economic growth to be caused by internal drivers in an economy, ranging between the accumulation of human capital, technological advances, innovation, and the formulation of policies, and as opposed to the classical models, such as the Solow Swan model, where technological progress is seen as an exogenous factor, the endogenous growth theory focuses on how the growth is caused by purposeful economic activity, meaning investing in innovation and the process of knowledge creation (Lucas Jr, 1988; Romer, 1986). In this hypothetical context, the aspects of R&D and that of green finance are critical as well as complementary. Research

and development (R&D) has been visualized to be a major instrument of innovation creation and productivity (increase) and long term economic growth (Romer, 1986). The knowledge which is enlarged through R&D investments contributes not only to development of knowledge but also to the development of green technologies that may be used to meet the global environmental challenge. Green finance supplements this in that it focuses capital on environmentally sustainable investment, including renewable energy, sustainable infrastructure, and climate adaptation strategies (S. Zhang et al., 2024). Factoring environmental impacts in the economic growth, green finance contributes to reducing time to a low carbon economy, supporting productivity increases by funding the eco innovations and green technologies, therefore integrating environmental objectives to the economic growth process. So the correlation between green finance and R&D leads to a feedback loop in the situation which runs in accordance with the endogenous growth model.

Since green finance enables innovation, R&D can increase the efficiency and effectiveness of green investments further. This integration of policy, innovation, and capital is a carrier of endogenous growth or a new idea that gives a sustainable economic growth by using only internally generated forces (Lucas Jr, 1988; Romer, 1986)

1.2.2 Sustainable Development Theory

According to the Sustainable Development Theory whose definitions were introduced in a report Our Common Future by the Brundtland Commission in 1987, sustainable development is defined as the development that delivers the needs of the present without subordinating the capacity of the future generations to satisfy their needs as well (Brundtland, 1987).

Such a framework recommends a balanced development model which does not only engage in economic growth, but at the same time environmental concerns as well as social inclusion. The precepts of the Sustainable Development Theory are strongly connected to interdependent functions of R&D, green finance and economic growth. Innovation R&D is essential in developing environmentally friendly

technologies and systems that minimize ecological degradation and enhance long term resource sustainability and this applies in line with what the theory envisages in terms of intergenerational equity (Brundtland, 1987). These innovations are backed by green finance that makes investments available to projects that focus on clean energy, efficient resource use, and environmental protection and that economic activity within ecological constraints (United Nations, 2015). In such a way, green finance becomes a certain mediator between technological advances and environmental awareness so that the development could be increased without the imposition of demands on the generations that will live in the future. In those cases, in which the economy starts growing based on environmentally oriented research and development (R&D) and undergoes support of green financial instruments, it finds itself aligned with leading goals of sustainable development. An inclusive strategy, in turn, allows achieving a high level of economic progress both with reference to environmental protection and social sustainability, thus building a sustainable and universalistic development prototype (Brundtland, 1987). This synchronization will make sure that the growth of the economy does not interfere with the ecological balance that will be in place to assure future prosperity. It also brings out the need to have policy frameworks that combine financial support and scientific innovation. This balance between environmental targets and growth aspirations makes green finance critical towards developing robust economies Resilience in developing economies It is also through investments in R&D that can contribute to long-term competitiveness through continual technological restructuring. These aspects combine to form an integrated pathway that considers economic, environmental, and social aspects of sustainability.

1.3 Research Gap

Achieving robust and equitable economic growth is a fundamental objective for nations worldwide. However, the pursuit of such development is increasingly hindered by the mounting challenges of environmental degradation and accelerating climate change. Traditional economic models often overlook the urgent imperative of ecological sustainability, highlighting a significant gap in integrating innovative

financial mechanisms, most notably green finance, into strategies for sustainable development (Zhou, Tang, & Zhang, 2020; Y. Wang & Zhi, 2016). Green finance, encompassing investments in renewable energy, eco friendly infrastructure, and sustainable business practices, has rapidly gained recognition as a cornerstone for balancing economic advancement with environmental stewardship OECD, 2017. While the potential of green finance to support sustainable economic growth and mitigate ecological risks is widely acknowledged, a pronounced gap remains in the empirical literature regarding its precise impact, particularly within emerging economies. These regions frequently face resource constraints and evolving regulatory frameworks, which further complicate the integration of green finance into national economic agendas. Adding another dimension to this issue is the moderating role of research and development (R&D). R&D acts as a catalyst for technological innovation, enabling the creation of cleaner, more efficient production processes and novel green technologies that can amplify the positive impact of green finance on economic growth. Despite its significance, there is a limited amount of empirical research examining how R&D can strengthen or moderate the relationship between green finance and sustainable economic outcomes. As a result, policymakers are often left without clear, evidence based guidance to design effective interventions that maximize the synergistic effects of green finance and R&D (Ulku, 2004).

This study aims to bridge these critical gaps by systematically investigating the impact of green finance on economic growth, with a particular focus on the moderating effect of R&D in this relationship. By providing new empirical insights, the research aspires to inform both scholars and policymakers about effective pathways for sustainable, innovation led economic development in the face of global environmental challenges.

1.4 Research Questions

This research will answer the following questions:

1. What is the impact of green finance on economic growth?

2. What is the impact of research and development (R&D) on economic growth?
3. What is the role of R&D in moderating the relationship between green finance and economic growth?

1.5 Research Objectives

Objectives of the study are as follows:

1. To examine the impact of green finance on economic growth..
2. To analyze the impact of research and development (R&D) on economic growth.
3. To investigate the moderating role of R&D expenditure in the relationship between green finance and economic growth.

1.6 Problem Statement

The mounting global imperative to address environmental degradation has propelled green finance to the forefront of sustainable development discourse. As a mechanism designed to channel capital toward environmentally responsible initiatives, green finance is increasingly regarded as a cornerstone of the low carbon economic transition. However, the promise of green finance is not universally realized. Outcomes vary, often falling short of expectations. Such variance suggests that the relationship between green finance and economic growth may not be linear or uniform but instead contingent upon the presence of key contextual factors. One such factor, Research and Development (R&D) expenditure, warrants particular attention. R&D acts as a catalyst for innovation, offering the technological tools and capabilities necessary to magnify the effects of green investment. However, existing scholarship has essentially treated green finance and R&D as parallel rather than intersecting domains. The extent to which R&D amplifies, constrains, or otherwise moderates the impact of green finance remains insufficiently theorized and empirically explored. This gap holds implications not only for academic

understanding but also for policy and practice. If R&D expenditures serve as a moderating mechanism, their omission from prevailing green finance frameworks may undermine efforts to foster sustainable economic outcomes. To address this oversight, our study aims to explore the interplay between green finance and R&D, specifically examining how R&D influences the relationship between green finance and economic growth. In doing so, we contribute to a more nuanced understanding of the structural and strategic foundations of environmentally responsible development.

1.7 Significance of the Study

This study examines the impact of green finance on economic growth, with a specific focus on the moderating role of research and development (R&D) expenditure across 50 countries. The research aims to explore how green finance initiatives contribute to sustainable economic practices and how research and development (R&D) expenditure can enhance the effectiveness of these initiatives.

The study contributes to the existing body of knowledge by analyzing the relationship between green finance, R&D, and economic growth. It expands theoretical understanding by highlighting how R&D serves as a moderator, strengthening the positive effects of green finance on sustainable development. This research offers a conceptual framework for understanding the dynamic relationships between financial innovation, technological advancements, and environmental sustainability.

1.7.1 Policymakers

To the policymakers, the outcomes of the present study reflect the necessity of intertwining the principles of green finance with the policies of innovation to support the fulfillment of sustainability development. The identification of the key importance of the matching between the fiscal, environmental and research agendas will direct the creation of the law and approvals leading to the creation of the sustainable and beneficial long term and inclusive environmentally friendly development. Policymakers may use these observations to create regulatory frameworks, tax

reliefs, and subsidies that encourage investment in renewable energy, energy efficiency, and sustainable infrastructure, which in turn will allow them to switch to a low carbon economy. These efforts can also enhance the involvement of the business sector; hence, increasing the magnitude and pace of the sustainable changes. Moreover, the adoption of R&D priorities in the national financial policies makes it possible to keep innovation consistent with the environmental policy. This will not only ensure that there are direct ecological gains but also resiliency to shocks in the future of the economy and environment. The sum of all these strategies will eventually give a roadmap to attain sustainable development and to protect intergenerational equity.

1.7.2 Environmental Advocates

These insights may be used by environmental advocates to encourage more accountability and transparency in the public and the private sector. The study gives the campaigners tangible evidence to use in campaigns favoring stringent efforts against environmental crimes and massive investments in green projects. This is by meeting stakeholders and sensitizing them to the benefits of green finance and green innovation so that they can be at the epicenter of driving towards the future being sustainable. The findings can also guide policymakers to design more effective regulatory structures that can deliver financial benefits and environmental results. The findings can also guide policymakers to design more effective regulatory structures that can deliver financial benefits and environmental results.

1.7.3 Organizations Businesses

To the organizations and non profits, as well as businesses, the research article offers effective strategies in institutionalizing sustainability and innovation in the business models. Organisations can not only meet the emerging regulations, but are also able to achieve competitive advantage in global economy, by prioritising green research and development, implementing cleaner production approach, along with practicing the circular economy. In addition, with cooperation with the government and the financial sector, organisations may speed up changes towards

green technologies and foster national and global sustainability targets (Porter & Van der Linde, 1995). With the implementation of sustainability into business strategies, companies become more viable in the long-term perspective and lower their environmental risks. It also has the benefit of enhancing stakeholder confidence because consumers and investors are becoming more and more attracted to environmentally friendly businesses. Industrial cooperation also brings an increased speed of knowledge sharing and spread of innovative green solutions. These concerted measures in the long term will lead to the creation of strong markets that can flourish not only in economic terms but also in terms of the environment.

1.7.4 General Public

The populace at large will be the biggest beneficiary of green finance and sustainability mainstreamed practices since they will translate to cleaner air, good environment and better living standards. The benefit of having sustainability awareness and education among people is that people can make good decisions as consumers and citizens. The majority of people can help the common cause of making the society more sustainable and resilient by buying eco friendly businesses and lobbying policy changes (Lee, Wang, & Chang, 2023)

1.7.5 Financial institutions

The study emphasizes the need to develop and implement financial products and risk evaluation methods tailored to green and sustainable investments. Incorporating green finance requirements and leveraging innovation in credit analysis can help banks and investors better direct capital toward projects with favorable environmental outcomes. These findings imply that financial institutions are critical to mainstreaming the green finance trend by issuing green bonds, sustainability linked loans, and ESG (Environmental, Social, and Governance) funds, as well as supporting the development of new c through financing (Acemoglu & Restrepo, 2018).Also, the process of standardized disclosure frameworks will contribute to the transparency and investor trust in sustainable finance markets. The incorporation of environmental risk-based care into the lending practice can be used to

guarantee the alignment of financial flows and climate resilience, as well as low-carbon objectives. These actions are also a way of promoting values over the long run by lessening exposure to assets that are harmful to the environment. Finally, the active engagement of financial institutions will be able to make the world shift towards a more sustainable and inclusive economic system faster.

Chapter 2

Literature Review

The chapter provides the literature review of the effects of green finance on the economic growth and the moderating role of research and development (R&D). Even according to the gap analysis already defined in the first chapter and in the literature review, the discussion then continues with the help of the theoretical mapping and the hypothesis development.

The chapter opens with proper definition of such fundamental variables so as to make it clear how green finance can have an impact on the economic indicators and development, especially in a scenario where there are differences in terms of the research and development activities. It highlights the importance of the fact that higher rates of R&D and innovations and the development of technology can increase the effects of green financing activities dramatically since it is much more likely to improve economic growth rates positively. On the other hand, the debate also touches on the fact that the existence of minimal R&D might limited the extent of benefits that can be brought about by green finance.

In an attempt to give a rich description of these variables, the chapter has come to the end by presenting a conceptual model which explains how these variables relate. Besides, it offers a series of hypotheses to be proved against the background of the economy's development of 53 countries. Both theoretical and empirical research initiatives are put in place so as to widen our comprehension of such dynamics and their implications to sustainable development and policy making in this region.

The study attempts to give an insight into practical financial and innovation strategies that the country could pursue by concentrating on the particular issues and opportunities that this national environment has to offer.

The traditional definition of economic growth states that economic growth comes in terms of growth over time in the output of a given country. This production is usually quantified by such indicators as Gross Domestic Product (GDP), or Gross National Product (GNP). The ability to grow economically is a major indicator that one country is faring well as well as developing. It covers the rise in living conditions, the level of employment and technological development and is considered to be the key to the soundness of the nation population. Solow Growth Model (1956) (Durlauf, Kourtellos, & Minkin, 2001) is still one of the fundamental theories that have been able to correlate economic growth with the accumulation of capital, improvement in technology and increase in labour force. It states that there will be increased growth rate in the countries that invested in capital and technology. This model has elevation in the latest arena by the incorporation of the sustainable investment, including green finance, where it implies that long-term economic development may be attained by environmentally-friendly investments.

Empirical studies have been carried out on the correlation between economic growth and sustainable environment with studies showing that there is significant positive relationship between green investments and economic performance. As explained by (Sorrell, 2010) , with the combination of environmental sustainability in national economies through the creation of renewable energy and green technologies investments, the positive economic growth will be made possible due to the creation of efficiency and decrease of the risks of environmental destruction. On the same note, (Walsh, 2014) established that had attained economic growth at a faster and more stable rates.

Green finance is financing of operations that are meant to promote environmental sustainability. These may include the building up of renewable-energy sources, energy-saving drives, pollution-abating schemes, and other projects, which have a sustainability agenda. Against the backdrop of the worldwide increasing problems of the climate change, there is an urgent necessity to ensure the compatibility of the economic-development objectives and environmental-protection interests, and the

green finance can contribute to this Riddle. The growing interest of scientists in the topic can be seen in the emergence of certain financial instruments, primarily green bonds, sustainable-investment funds, and green loans, which provide resources allocation to projects directly producing positive environmental effects.

The impacts of green finance on the economic growth have been researched in many studies. According to the results mentioned by (Sheraz, Deyi, Ahmed, Ullah, & Ullah, 2021), the direct effect of green finance on long-term economic growth is positive because green finance finances environmentally sustainable long-term projects. Such positive relationship is explained by the capability of green finance to lure investments into most important sectors, i.e., renewable energy and green infrastructure, thereby contributing to the growth in number of jobs and technological advancements, as well as diversification of the economy. (Eren et al., 2019) examined the aspect of green bonds and how they are used in developing economies. They determined that the green finance is especially the effective approach to attract investment in so called clean energies and thereby make a contribution to job creation, infrastructural development, and economic stabilization. On the same note, Banga (2021) emphasized an equally important point of how green finance supports low-carbon growth pathways by indicating that economies with the more incorporation of green finance will be expected to have a higher growth rate of GDP. The reason is that the green investment does not only contribute to the mitigation of environmental risks but also encourages innovation within the industry that eventually leads to the economic growth in a sustainable way.

The Research and Development (R&D) is very instrumental in promoting innovation and technological improvement. It is also acknowledged that it is one of the sources of economic growth especially longterm because it helps in building up new products, services, and technologies. R&D in the context of green finance is very important in coming with sustainable technologies which can be financed using the green finance tools. R&D allows building renewable energy technologies, energy-efficient devices and production and other solutions that are friendly to the environment which are also essential in attaining sustainable development and economic growth. This is especially topical because the world is beginning to become

greener in its operations, which can solve environmental concerns and become economically prosperous at the same time. (Nchofoung, Edoh, & Monkam, 2024) discovered in the case of developing countries that green finance plays an essential role in the promotion of an industrial innovation and growth of GDP. According to their study, green finance projects, where the money is directed to the sphere of sustainability, interact in a direct and positive way with the economic development course of nations, particularly, renewable energy and ecologically friendly transportation.

The issue of the correlation between R&D and economic growth has been investigated in the literature a lot. (Sheraz et al., 2021) contended that the long-term effects of technological advancements made as a result of R&D are positive and this is because of high productivity and the development of new opportunities in the market. Another point that (Schuhmacher, Gassmann, McCracken, & Hinder, 2018) has emphasized is that apart from the technological improvement, open innovation and R&D investments will also result in expanded economic development through the introduction of new industries and sectors. As (Mazzucato, 2013) observed, R&D programs initiated by the government play an especially important role in facilitating green technologies development, since these are not likely to be developed by the business itself, based on individual investment, due to the excessive risks and the lengthy process of recouping investment. Her people were claiming that the government needs to make investments in R&D widely because, without these investments, green innovation could not be achieved and sustainable technologies should not be commercialized. This fact was further supported by (Popp, 2019) who indicated that the investments made by the government in terms of research and development in green technologies has a potential to result in great progress in production of renewable energy that will eventually sustain economic growth without jeopardizing the environment.

Gross National Expenditure (GNE) is a measure of all goods and services consumed in an economy including domestic and international expenditure. It is also a sensitive macroeconomic indication since it gives an idea on how much the economy is spending and this is also a factor that determines the overall growth of the economy. GNE is a favorite in measuring the level of economic performance

of the country because it incorporates the level of consumption and investment. The correlation between GNE and economic growth is important in realizing the varying factors that intersect in influencing the economic direction of a country owing to variation in expenditure by the government and the private sectors.

Several studies have been conducted as regards the role of GNE in the growth of the economy. (Maddison, 2001) stated that GNE was also a good indicator of long-term economic performance since there was a tendency of rising consumption and investment to be followed by the rise of outputs and growth. The importance of GNE has also been reiterated by (Espinosa et al., 2021), especially to the developing countries, whereby more investment expenditure is essential in the processes of industrialisation and the growth of the economy. According to (Kuznets, 1971) the cyclical impacts of GNE were focused upon which observed that changes in level of expenditure generally come at times when an economy is either in boom or bust. According to his work, it is possible to state that surveillance on GNE could give very useful information concerning the dynamics of growth in a country and enable policymakers to learn those factors that either expedite or dampen the economic developments. The GNE and economic growth have also been supported by the fact that most of the times, national expenditure may rise thus increasing the productivity, employment and output which are all important aspects of economic growth.

The industry value added (IND) refers to the influx of the industrial sectors in the economy of a country after taxes and subsidies removed. It works as a gauge of the evaluation of the industrial performance and gauges the contribution of the sector to the aggregate growth. The connection of the industrial growth and the economic growth has been well recognised and rich literature has confirmed that industrialisation enhances productivity, creates jobs and provides technological advancements. Since the industries are generally sources of growth, because they provide goods and services in the domestic and the international markets, the relationship that exists between IND and the overall growth is of particular importance.

(Yuan, Ren, & Chen, 2017) emphasizes the central importance of industry in trying to promote the process of economic growth, especially in the developing

economies. His empirical evidence shows that the elevated IVA is synonymous with augmented productivity, increase in the GDP and technology. Such results have special significance to nations that are striving to properly diversify so as not to be a nation that is reliant on agriculture or natural resource production. According to (Kaldor, 1968), a strong dependency between the general growth and industrial growth has been evolved which assumes that growth in the industrial sector leads to the creation of employment opportunities and complementary forces in other areas of economy. (Sadie, 1969) agrees and asserts that industrialisation cannot be missed in the economic development process and that increase in manufacturing and production of energy in a national system has significant boost to the GDP of a nation. (Silverberg & Verspagen, 1994) also comes to a similar conclusion and claims that industrial development plays a key role in realizing long-term economic growth especially in instances where the industrial sector absorbs green technologies that enhance performance and reduced environmental wastes.

2.1 Impact of GF on EG

Climate change and environmental depreciation are also burning issues in the global community that require specific financial and economic solutions (Zerbib, 2019). Green finance is described as financial capital, in the form of loans and investments provided to those projects that protect the environment and prevent pollution (Ma, Zhu, Liu, & Huang, 2023). The greatest examples are the investment in solar energy, wind power, electric cars and farming activities demanding less water usage and less use of prohibited material (H. Chen, Jin, Wang, Guo, & Wu, 2023). It has been stated that the general purpose of green finance is to create a win-win situation of both the environment and the economy to prosper (Ameli et al., 2021).

The economic growth traditionally refers to the rise in annual production of goods and services of a country and is characteristically correlated with the greater access to employment, rise in income, and quality of life (World Bank, 2022; (Romer, 1986). In the past, the right focus was much on increasing production capacity, employing more people, and discovering new technologies, but nowadays, the analysts

also underline the necessity to make changes in the perspective on environment stewardship and conservation of resources so that in the future, when the natural capital would be exhausted, it might not lead to losses of the future generations Sachs, 2015.

The importance of green finance can be explained by the fact that it is a way to combine environment protection and economic growth (Nguyen & Khominich, 2023). It is possible to adopt public policy programs and institutional settings like the government-specific plans and control mechanisms to direct the capital to the ecologically responsible enterprise, thus, be certain that financial resources will bring real environmental costs (Y. Wang & Zhi, 2016).

Green finance must thus be well governed and efficiently reported and endorsed by the governments and corporations to bring sustainability by flipping investment into long-term results, such as cleaner air, cleaner water, and stronger communities (Taghizadeh-Hesary & Taghizadeh-Hesary, 2020).

Green finance takes the center stage in aligning national economies with the international sustainability roadmap, especially the United Nations Sustainable Development Goals (SDGs), specifically Goal 7 (Affordable and Clean Energy), Goal 9 (Industry, Innovation and Infrastructure), Goal 13 Climate Action. Some of the mechanisms available on the instrument to enable states to advance on a low-carbon path are green bonds, sustainability-linked loans, etc. (H. Chen et al., 2023; Aghion, Bergeaud, Lequien, & Melitz, 2024)).

As a definition, green finance aims at accommodating the mitigation and adaptation methods: the decrease in pollution and population tolerance to the climate-related pressure, correspondingly (H. Chen et al., 2023). As an example, one can speak about solar photovoltaic installation, which prevents the emission, and resilient agricultural practices, which enable the producers to overcome harsh environmental conditions.

The combination of the two strategies has highly been appreciated as a potentially good move towards climatic protection and better economics (Sorrell, 2010). Green finance has shown a remarkable performance in urban energy transition in some of the developing countries, mainly South Asia and Sub-Saharan Africa.

Microfinance organizations are giving out rural solar home systems known as the microgreen loans in Pakistan and Bangladesh to increase electrification in those countries and they are spreading out to meet the unmet energy demand and the reduction of the diesel-generators and the carbon emissions on these poor countries.

That is why extensive empirical research continues to reveal that green finance has come to show a positive spur to macro-economic performance, especially with strict regulatory support and institutional encouragement (Walsh, 2014; Nguyen & Khominich, 2023; Taghizadeh-Hesary & Taghizadeh-Hesary, 2020). Based on case evidences, it has been observed that when sovereigns support green projects through green bonds or renewable energy funds within a country, they create more employment, spur technological advancement and achieve sustainable growth in the country. To illustrate, the issue of clean energy green bonds which rolled out in the Asia region was demonstrated to encourage further growth of national GDP and yet decrease levels of pollution at the same time. Similarly, the green finance was closely associated with the lines of a fast Chinese rise in the renewable-energy sector and provided cleaner power and enhanced quality of air as well as substantial economic growth (Wu, Wang, & Liu, 2023).

Efforts like the Green Credit Policy in China, which was realized in 2007, are some examples of how the regulations can guide the financial institutions into environmental stewardship. According to analytical analysis, it has been revealed that, under the policy, 20-30% of the capital of the high-polluting industries was withdrawn, and excellent inflows, the growth and development of workforces, and technological progress of the green economy were recorded (Zhang et al., 2024). In addition to its direct economic effects, the green finance transforms the very form of economic activity. Migration of capital out of carbon-intensive sectors (e.g., fossil fuel production) into renewable technologies makes the economy more efficient and competitive, and, in many cases, triggers other subsequent so-called green spillovers of capital across other areas, similar to the impact of dominoes, leading to the overall increase of the economy resilience (Ameli et al., 2021).

This process of reallocation of capital, often terms as transition finance, is an approach towards an investment model that would see to it that channels shift

firms that are high emitters to those that are low emitters, but without the shocks to a system. Stocks and bonds like sustainability-linked bonds, which reward any organizations, which show objective improvements toward climate goals, are being tested in the European Union, Japan, and Brazil, and the first case studies validate positive outcomes in higher industry and manufacturing.

Intellectual literature emphasises that green finance, and such innovation that it finances, is able to cause economic growth. By allocating resources to research and development of renewable energy sources, as one example, companies will be able to make or sell low cost and highly efficient technologies and this will contribute to increased productivity in a country in the long run (Romer, 1986).

Empirical evidence in recent times indicates that green venture capital, which is investment specifically aiming at small, early-stage clean-technology startups, is of exceptional importance in the commercialization of young innovations and the growth of green goods and green services markets (Bilbao-Osorio & Rodríguez-Pose, 2004).

Institutional arrangements have a very significant impact on the success of the green-finance efforts. Open pricing systems on carbon, policy frameworks that require low-carbon to disclose environmental risks along with policy tools in the form of subsidies or tax breaks in low-carbon investments all increase the appeal of green projects to independent investors. The faster, cleaner economic development thus tends to be recorded in regimes that have extensive oversight, definite goals, and achievable principles and regulations in comparison to that of jurisdictions that lack such crucial elements (Khalili, Duecker, Ashton, & Chavez, 2015).

The legal benchmark that the European Union has introduced in 2020 is its Green Taxonomy, which establishes a regulation framework that helps to classify investments as environmentally sustainable. This structure has fast tracked the growth of the global green-bond market to a USD 500 billion issuance, an amount that analysts believe will continue to grow by the year 2021 by reducing ambiguity in the market place.

In addition to the macroeconomy implications, green finance ameliorates the socio-environmental effects of the climate change and pollution. Inventions in clean

air, safe water and sustainable agriculture do not only protect the ecosystem but also preclude in the future costly externalities-health problems, food security and infrastructure destruction- that hinder long-term path of development (Bansal, 2019). However, there are some challenges that prevail. The early implementation of environmental responsibility may increase immediate costs; besides, capital can not be properly allocated in case of the reporting standards being not strict enough or the supervision being insufficient. To add to it, the issue of greenwashing (deception in the form of projects that pose as being sustainable) makes the responsible allocation of funds a complex task. To eliminate these concerns, we will have to consider a mixture of effective governance, detailed disclosure regulations, and active technological advances .

There are two main frameworks that are brought forward by the analytical models as to how transition finance can be perceived to have an effect on growth. The Endogenous Growth Theory assumes that innovation, human capital and creation of knowledge are the main sources of growth and focuses on the long-term investments in education and technical advancement (Romer, 1986). Green finance overlaps with this school of thought in that it assists in funding of the emerging clean technologies and training of the workforce (M. Zhang, Zheng, & Xie, 2023). The Sustainable Development Theory, however, argues that economic growth should not be at the expense of the ecological integrity; green finance works as the driver of capital into the ones that preserve the biodiversity and preserve natural resources (WCED, 1987).

The combination of these two paradigms brings in a more wholesome explanation of how green finance can always promote improvement. Both the Endogenous Growth as well as the Sustainable Development framework explain why narrowly focused financing that minimizes the costs associated with innovations is so crucial to the future of jointly developed growth; the problem lies in the fact that this growth must be equitable as well as ecologically sustainable, in that development today must not lead to the emergence of harmful effects tomorrow (S. Zhang et al., 2024). In the research on green finance, two analytical perspectives that are interlinked with each other are frequently used to gauge the potential of this tool to support the process of economic development and protect environmental

integrity (Taghizadeh-Hesary & Taghizadeh-Hesary, 2020; Baek & Kim, 2013). First, the macroeconomic aspects are taken into consideration on the stimulus on an economic activity, more efficient allocation of resources, and the relaxation of liquidity constraints. Second, the micro-level approaches focus on firm-specific results with an accent on the contribution of green finance to the company decision-making, innovation, and environmental performance of firms.

2.2 Impact of R&D on Economic Growth

The term Research and Development (R&D) expenditure refers to the investment that is made by (government agencies, individual companies, and or research institutions) in terms of producing new scientific knowledge, output, and processes. The spectrum of this phenomenon relates to a continuum running between simple laboratory research to applied project aimed at resolving certain issues and or commercializing them. The focus of R&D is to develop technology, hence creating competitiveness of the firms and develop the society (Griliches, 1998).

Investing companies usually want to discover some new goods, improve on the available ones or come up with a better production system (Coccia, 2012). The sources where the money can be found are diverse: government grants and university endowments provide the amount of funds labeled as the public ones, whereas the corporate budget is a source of the same funds on the part of the private sector, however, this aspect may be combined with other spheres of investment.

In a knowledge-based economy R&D is commonly considered to be the source of sustainable, long-time growth. The argument behind this evaluation is that the technological advances and not the mere accumulated capital or increased labour characterize the frontier of a nation.

In general, R&D brings about intellectual capital, facilitates operations, reduces production and overheads as well as discovering new market opportunities all of which have a positive gain on macroeconomic performance. One of the traditional measures of the similarity between R&D intensity on the state level is the ratio of the portion of Gross Domestic Product (GDP) to this expenditure (World Bank,

2022). South Korea, Japan, Sri Lanka and Israel are good examples of how the economy tends to funnel very high proportions of the GDP to R&D activities, as compared to the developing countries that tend to allocate considerably less funds to these activities. Such dissimilarities are inclined to be in association with different rates of technological and innovative progress (Coccia, 2012). The national governments often fund the R&D by sponsoring universities, national laboratories, and research institutes thinking that such work will eventually establish the industrial development. At a similar time, R&D is funded by the private companies in an attempt to preserve the competitive advantages, service with new products or acquire more cost-efficient ways of production (Griliches, 1998).

Just look at South Korea and India: in 2020 the former spent over 4.8 % of its GDP on R&D which is among the largest in the world, whereas the latter only 0.7 %. Therefore, these differences have produced opposite paths, and among the most representative companies in South Korea in the field of technology stand Samsung and LG, whereas India is stocked with a mainly imported technology.

Conventional definition of economic growth, how a given economy is growing, in terms of an increase in output and productivity of a particular economy is measured by the growth of GDP, i.e. the value of all goods and services produced (Romer, 1986). Improved growth is normally linked to improved rates of employment, increased pay and living conditions (Romer, 1986). The growth may be fuelled by growth of the labour force, use of more capital (Machinery, structures and fixed assets), spread of education or being innovative in terms of implementation of new technologies (Howitt, 2000). Whereas classical economists had put emphasis on the use of resources and labour as a key factor, the modern-day discussion of how innovation and knowledge creation play an all-important central role in continuing the long-term growth has gained more momentum (Griliches, 1998).

Economic growth at a high level is likely to dampen poverty, create more jobs and free up funds needed to make essential investments in health, education, and infrastructure (World Bank, 2022). That being the case, there is an interrelationship on perspectives of the R&D to be a key policy instrument towards technological advancement and sustainable development. Correlation between economic growth

and R&D expenditure is evident as investment in research and development (R&D) makes an economy more productive, enables superb production, and supports competitiveness in an international field of players (OECD, 2022). Based on empirical evidence, it has been suggested that increased public and private investment in R&D encourages innovation which consequently spurs economic growth at a high rate (J. K. Hall, Daneke, & Lenox, 2010). This has made the policy makers to constantly take R&D as one of the key drivers in economic growth and an almost necessary avenue towards an improved quality of life (Romer, 1986).

This relationship is supported by a whole literature. An example of pure positive association between R&D intensity, and GDP per capita growth, is in a study carried out in OECD economies (Wahyuningrum, Ihlashul'amal, Utami, Djajadik-erta, & Sriningsih, 2024);(Coe & Helpman, 1995) record this kind of high spillovers of international stocks of R&D by easily revealing that even those countries that have low domestic research capability grow significantly as a result of international flows of knowledge, once such country is open to trade and foreign direct investment. Surveys of researchers made on econometric basis also enlighten the relationship between the R&D expenditure and growth. (Griliches, 1998) discovers that those nations that invested more in R&D are more likely to reach high levels of income and stronger paths of growth. (Coccia, 2012) confirms this finding on investment in R&D and its stimulating effect on productivity and competitiveness and the important role of the generation of new knowledge in increasing national income. According to (J. K. Hall et al., 2010), the spending in R&D leads to innovation, which promotes advances in productivity, technological potential and employment.

The effects on R&D are especially relevant to the developing economies in which it is capable of alleviating structural constraints of the energy supply, agricultural inefficiency, and public health complications. The agricultural research program of Ethiopia, Ethiopian Institute of Agricultural Research, has developed drought resistant crop varieties that can directly impact incomes and food security of rural people (Bahmani-Oskooee & Cheema, 2009).

Another way in which investment in R&D accelerates growth is through total factor productivity (TFP), which measures the rate at which output grows while

inputs such as labor and capital remain constant. According to (Aghion et al., 2024) and (Howitt, 2000), the majority of the gap in living standards across countries can be attributed to differences in TFP growth. Innovations in production processes (based on R&D) contribute to the overall efficiency of the economy, whether through new equipment, improved manufacturing processes, or better business practices (Aghion et al., 2024; Howitt, 2000; J. K. Hall et al., 2010; Jones, 1999, 2002). In short, it is evident in modern studies that there is a strong correlation between economic growth and development with regards to a long-term R&D investment in any environment.

The national research and development (R&D) activity as well as the enterprise-level research and development (R&D) activity can produce such spillover effects, where the value of the scientific activity of a particular company or a country creates benefits to a broader range of actors. When a firm makes the effort to invent new technology say, the rivals are capable of acquiring the knowledge and subsequently advancing it to generate other products that are of higher quality (Coccia, 2012). Similarly, researchers or engineers who acquire knowledge in the course of R&D undertakings may transfer to other organizations and spread their knowledge, hence, increasing the pace of total invention and performance in the economy (J. K. Hall et al., 2010)).

Such spill over mechanisms is observed more intensively in the university industry partnerships. An example of this is the role that was played by the University of Stanford, which aided in the creation of the Silicon Valley both as a source of talent and a strategic research partner. Similar processes are at the basis of innovation ecosystems in China People zones and the Bangalore technology cluster in India (Subrahmanya, 2017).

Accessible R&D offers an opportunity to smaller businesses with limited budgets because, in such cases, external R&D activity is beneficial to them. The APIs or adoption of the emerging technologies and processes by smaller firms when they are funded by large corporations or government agencies can increase the efficiency, guarantee growth, and create new jobs (Griliches, 1998; J. K. Hall et al., 2010). In turn, many governments funds R&D efforts of the private sector in terms of subsidizing, decreasing as well as guiding loan.

In the European Union, close to €80 billion was channelled to the Horizon 2020 programme that involved collaborative R&D projects in which small and medium enterprises (SMEs) significantly participated. The results indicate positive changes in employment patterns and exportation, especially in business destinations of clean technology, artificial intelligence, and biotechnology (European Commission, 2021) (Silander, 2023). An empirical-based perception also shows that long-term commitment to R&D to help find solutions to problems affecting the society at large, such as climate change, and health emergencies. In the case of the COVID-19 pandemic, high speeds of medical research contributed to their development of vaccines in a short period of time (J. K. Hall et al., 2010). In corroboration, the cost-effectiveness of long-term investments on the wind turbines and solar panel has made the technology cheaper and easier to afford, thus, granted rapid macroeconomic growth and sustainable environmental management (Griliches, 1998; Romer, 1986). Finding such points out the necessity of considering R&D as a tool of bringing social good and not just a source of profit.

Even though investment in research and development (R&D) is commonly believed to be the key to long-term economic sustainability, the returns are seldom short term. In a regular project, it often takes years up to decades before certain pre-commercial stages such as producing commercially viable product or technology can be generated. Some of these projects or programs do not work and the respective funds are washed away and hence this increases inherent risk (Griliches, 1998). As a result, the government subsidy is frequently essential, especially in the case of basic research the economic benefits of which may not be reflected within the nearest years (OECD, 2022).

Several countries are trying to manage this uncertainty and adopt a portfolio approach with a balance between fundamental and applied research and to maintain transmission with mission orientation innovation policy. The Defense Advanced Research Projects Agency (DARPA) of the United States, which is dedicated to financing risky, promising applications of defence technology, acted as a model to similar agencies in many countries. The strength of the macroeconomic effect of R&D depends on policy systems and institutional capacity. States that have strong education system, a good governance of public policies and proper ownership rights

can easily convert R&D to significant economic growth. Informed labour force will be able to absorb newly emerging technologies and legal certainty enables the protection of innovation, leading to further innovation (Goos et al., 2019). On the contrary, corruption, inefficient regulatory systems and educational achievement reduce the expected returns of investments in R&D (OECD, 2022). A number of selective interventions have been used in order to encourage R&D and innovation. Among these are investments in research universities, stimulation of concentration in technology, and invention of collaboration between industry and academia (Coe & Helpman, 1995). The cooperation in the international level also supplements the role and conditions have been created to give information about the results, exchange knowledge, and find concentrated solutions to complicated health and environmental issues (Ekonomou & Halkos, 2023).

The association between the R&D spending and economic growth is best examined in Endogenous Growth terms (Romer, 1986). The main theme inherent in this school of thought is the belief that it is endogenously generated growth which is fueled by the creation of wealth in the economy via knowledge, innovation and technology investment. Unlike the exogenous models, which explain growth either in terms of labour or capital input, the Endogenous Growth framework argues that a long-run productivity growth emanates out of sustained investment in research and development (R&D) spendings (Aghion et al., 2024; Romer, 1986; Gao et al., 2023; Anser, Ali, Umair, Javid, & Mirzaliev, 2024).

In this context, investment in R&D is not a pure cost but a very important source of economic progress. The fact is that commercial units and governments that invest in research produce goods and technologies on which the overall increase of productivity is based. Furthermore, the information, created as result of R&D lacks the rivalry and exhaustibility characteristics; it may be replicated and shared throughout the whole economic system (H. Chen et al., 2023). The Endogenous Growth paradigm therefore provides the following in its line of thinking; that full-scale and sustained innovation is essential to wellbeing of highly advanced societies.

The theory also focuses on the externalities or so-called spillovers of the R&D, which is that such discoveries by one firm or agency have the power to bring

benefits to its competitors and the entire economy (Arslan, Khan, Latif, Komal, & Chen, 2022). Such spillovers are moderate by governments by investing in education, enforcing intellectual property rights and financing basic research. In such a way, the theory explains why the R&D funded by the state has the ultimate benefit to benefit the whole population rather than only to the company which started the research (Howitt, 2000).

2.3 Moderating Role of R&D Between Green Finance and Economic Growth

The three seminal constructs in the modern economic discourse include green finance, economic growth, and research and development (R&D) expenditure (S. Zhang et al., 2024). Green finance refers to investments directed at environment friendly projects, such as renewable energy, clean transport systems, and energy efficiency devices (Lenihan, Mulligan, Doran, Rammer, & Ipinnaiye, 2024). The goal is the reinforcement of national economies without compromising the ecological integrity on the large scale (Chen et al., 2023). Conversely, economic growth can be characterized by an increase in the production of goods and services, and it is usually realized into improved labour market opportunities, increased pay, and high standards of living (World Bank, 2022).

R&D means spending money on research, scientific and creative development; it is usually funded by states, universities, and companies (OECD, 2022). These investments are the basis of development of new products, optimization of existing equipment and the development of new methods (Griliches, 1998). This is central in R&D since it brings about new ideas, which enhance organisational and national competitiveness (Ulku, 2004). When R&D interferes with the relationship between green finance and growth, it is seen to be in a position to either increase or to decrease the strong association of green finance and growth, based on the level of R&D investment (Baron et al., 1986). Empirically, the level of R&D spending can be expressed using interaction terms that occur in the regression model such as hierarchical multiple regression or structural equation modelling. In theory, the

level of green finance depends upon the level of R&D investment and this is a moderate degree variable.

Green finance puts a wide range of financial tools to use to invest in environmentally friendly projects- e.g., the establishment of solar or wind plants, the energy conservation of buildings and industries by investing in reduced energy consumption solutions, or spending on the development of young green companies (M. Zhang et al., 2023; Z. Chen & Xing, 2025). Useful policies and funds have been established in several jurisdictions and top banks to promote the growth of green finance (Zhou et al., 2020). The goal of green finance is to assist in preventing climate change and environmental destruction and also spread economic growth by allocating funds to clean activities (Taghizadeh-Hesary & Taghizadeh-Hesary, 2020). Its main hypothesis is that the allocation of capital to the environmentally sound investments can create the employment and can drive new businesses. As an example, a state-sponsored loan to a company which makes solar panels can allow the company to increase its production and absorb more workforce, facilitating the macroeconomics and green awareness (Schuhmacher et al., 2018)

Even though the growth of green finance can be viewed as an important opportunity to recapitalize and mobilize investment to serve environmental and development objectives, output in terms of economic performance is not discrete. The empirical evidence shows that nations, which manifest a strong research and development (R&D) intensity, are in a distinct place of transforming their monetary contributions to concrete and innovative environmentally friendly technologies. These jurisdictions produce custom-made technical solutions, increase cost-effectiveness, and present more best footing in embracing changes in the new environmental standards.

Traditionally, macroeconomic growth can be evaluated in terms of an increase in the overall output compared to an earlier threshold; such a threshold is implemented by means of the indicator of Gross Domestic Product (GDP). With the increase in GDP, the top economists assume that there is an improvement in employment opportunities, families gain more disposable income and overall purchasing power increases (Romer, 1986). Such development in terms of growth

patterns is appreciated as being vital in solving poverty as well as improving human well-being (Aghion et al., 2024).

However, the modern literature at the same time emphasizes the need to align the development paths with ecological sustainability. With this imperative, green finance is envisaged as a way of doing business that allows economic growth and protecting natural assets (Silander, 2023). Functioning as one of the main instruments of the sustainability architecture, green finance is defined as the active redirection of capital to the environmentally friendly goals (Desaiegn & Tangl, 2022).

Research and development (R&D) is the system in which governments, universities, and more commercial organizations allocate resources (systematically) to science, technology, and innovation. Through such process, the present-day pharmaceuticals, computational systems, automobile systems and renewable energy solutions come to reality (Coccia, 2021; J. K. Hall et al., 2010)). In this model of analysis, the R&D spending is considered as a part of the state investment and therefore the policy-makers are interested in reaping the returns in the form of increased productivity of labour and organisational competitiveness. An advanced R&D system is visualized as an absorptive capacity (Cohen, Levinthal, et al., 1990), which provides companies and governments with technical expertise necessary to absorb, commercialize and streamline green capital. Without such capacity, the money can be spent in outmoded technologies or policy regimes that are incompatible with environmental goals, thus reduced the role that green finance will play in economic development.

According to empirical evidence, the R&D is able to increase the effectiveness of the green finance investments; two imaginary countries are subjected to equal amounts of allocation of green capital, wherein the difference gives light to the disparity. One invests more funds into its R&D and, thus, helps to develop new green technologies, say, an improvement of solar modules or more efficient wind turbines. These innovations enable a better use of the distributed capital and speed up growth (Z. Chen & Xing, 2025). In comparison, the country that has insignificant R&D capabilities can only adulate the implementation or retrofitting of technologies that are relatively outdated or reduce in efficiency. Thus, the

development dynamics in the framework of green finance is rather subdued. The fact denotes R&D as a catalytic mechanism that increases the economic returns of green finance.

Some empirical studies support this process; e.g., (Wu et al., 2023) report that, in China, the administrative regions with a higher innovation infrastructure achieve much better performances of green credit programs, based, in particular, on significantly greater improvements in the introduction of clean energy and GDP growth, of green credit initiatives as compared to those manifested in the poor innovation input.

Such an analysis, which is systematic and theoretical in character, sheds additional light on the connection between R&D spending and the growth patterns based on the green finance. According to Endogenous Growth Theory, education, research and innovative activity becomes the chief drivers of lasting growth on the domestic stage (Romer, 1986; Aghion et al., 2024; Baek & Kim, 2013). In this context, investing in R&D can be raised as one of the most active means of extending the growth rate.

Complementary to it, the Sustainable Development Theory underlines the need of developmental models that promote the integrity of the environment and the well-being of subsequent generations. Through research and development, technological and scientific solutions to environmental issues like pollution, accumulation of wastes, and climate variability are thus provided.

Green finance, in its turn, directs the capital to the implementation of such innovations, thus increasing both the economic and environmental returns of long-term R&D investment (Aw, Roberts, & Xu, 2011). In terms of firm-centric view, the resource-based framework places R&D capability as strategic resource that creates competitive edge. In this case, green deployment and high R &D capacity are linked together with economic performance and sustainable viability (Romer, 1986).

These theoretical propositions are backed up with empirical data. The literature always states that greater the R&D investment made by a nation the better will be the results achieved by implementing green finance. In China, as an example,

high R&D expenditure is associated with a favorable environmental and macroeconomic performance due to green financing tools, but also restrains the effect of a similar initiative if its R&D movement is low . Similar trends can be observed in the context of Europe: Germany and Sweden, having invested a lot in R&D and green finance, develop a new industry, wind power generation, and electric vehicle production, which bring an income stream and job opportunities (Nguyen et al., 2022). Similarly, numerous years of state funding of R&D and green finance in South Korea has promoted the development of a vigorous clean technology industry (Coccia, 2012).

Literature based on empirical findings shows that in the private sector, companies with an increased spending on research and development (R&D) have more capabilities to use green finance instruments to commercialise new products and to enhance growth (A. R. Hall, 2003). A good example of this phenomenon is large automotive conglomerates: implementing the capital to focus on more efficient electric vehicles and related batteries, it then mobilises green financing to invest during the expansion of the factories and to sell the resulting advances in the global market .

The case study of Tesla further shows that. Tax incentives and other environmentally friendly subsidies auger well with the firm indepth and in house research and development programme (the R&D) to create a heavy pace of scaling, disruption of the markets and setting new records of industrial measures of electric mobility. The developing economies are usually faced with other bottlenecks, such as lack of funding and manpower to support intensive research and development endeavor (Sachs, 2015). However, as it has been revealed, augmented R&D expenditure yields a relatively stronger payoff when paired with the means of green finance (Xu & Yao, 2023). The impact of international cooperation, be it official development assistance or multilateral efforts, is thus a very significant one in this respect (OECD, 2022).

On this response, global monetary establishments like the world bank, the GCF (the green climate fund) and numerous local development banks have integrated the support of R&D in green finance schemes that focuses on closing the capability gaps across low revenue territories. The relationship between R&D and

green finance can be especially noted in the appearance of new, inexpensive solar panels, windmills that work more efficiently and new, energy saving methods of architecture. When advancements in research and development ready for market technologies, green finance may be used to support their implementation on the national scale thus expanding the access to sustainable technologies both by consumers and firms (Bi, Jin, Ling, & Yang, 2017).

On the other hand, without long term dedicated R&D efforts, green finance will be unintentionally funding other legacy technologies that have sub optimal performance, which results in higher costs and reduced environmental benefit (Taghizadeh-Hesary & Taghizadeh-Hesary, 2020; Acemoglu & Restrepo, 2018). Therefore, R&D acts as a vital driver of effective deployment of green finance and the overall economic growth.

Moreover, R&D provides countries with the ability to tackle emerging uncertainties, including the COVID-19 pandemic or climate disaster related crises that come in handy in development of green finance solutions to sustainable economic resilience (S. Zhang et al., 2024).

Policymakers are consequently recommended to look at green finance and R&D as complementary columns that require investment at the same time. Support measures can stretch between particular grants and soft loans and the different types of tax reliefs and regulatory incentives that will force financial institutions to shift their priorities in favour of green financing (OECD 2022).

On the other hand, the investment on science and technology education by governments in the society is also a key to achieving human capital in cutting edge innovation.

In conclusion, the effectiveness of the efforts of combining green finance and R&D should be considered by the public authorities (Hall et al., 2010). Such appraisal will have to include the information about new inventions, the number of people employed, the quality of air and water, and other indicators of success . Under these circumstances, the government should know how to adjust the strategies when inefficiencies were found, and the means of the population should be utilized with prudence (Zerbib, 2019; Anser et al., 2024).

2.4 Hypothesis Statements

The study is composed of a set of hypotheses. These hypotheses are designed to examine the relationships among green finance, R&D, and economic growth.

H1: Green finance positively affects Economic Growth.

H2: Research and development have a positive impact on Economic Growth.

H3: Research and Development moderates the relationship between green finance and economic growth.

2.5 Theoretical Framework

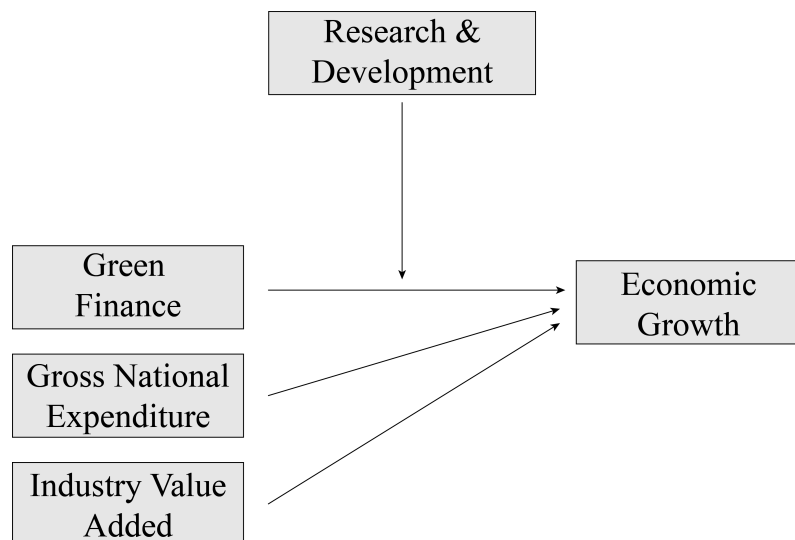


FIGURE 2.1: Research Model

This highly researched model is used to investigate the role of green finance in affecting economic development, where, research and development (R&D) is taken as a moderator. The theory of green finance (financial practice in green areas and eco friendly projects) is that this effectively drives an economic growth by directing capital into feedback friendly areas and assessments. In its turn, R&D is suggested to moderate this relationship. Based on this assumption, the hypothesis shall state that the positive effect of green finance on economic growth is reinforced with in the environments where R&D investment is more popular. Particularly, a healthy level of R&D strengthens the role of green finance in spurring economic developments since the latter allows translating improvements and innovations through

the effective use of financial resources in terms of sustainable development. On the contrary, where R&D spending is low, the positive influence of green finance on economic growth is also likely to be limited. Overall, the research model shows that when support R&D by strong efforts, green finance can bring significant contributions to the sustainable economic growth and development. It also provides the policymakers and organizations with invaluable information on the need to both acknowledge green financing mechanisms and invest in research and development in efforts to witness optimal results on the growth of an economy. Such a combined point of view highlights the significance of ensuring that the practices of financial performance go hand in hand with the innovation strategies.

Chapter 3

Research Methodology

The data for 107 countries was initially collected from two sources: the World Bank and Our World in Data. This data covers various factors like green finance, research and development, economic growth, and some control variables such as Gross National Expenditure and industry value added, for a period of 22 years, from 2000 to 2021. However, due to missing information or unavailable data for certain countries and variables, the number of countries in the dataset was reduced from 107 to 53. The control variables, including Gross National Expenditure and industry value added, are important because they have a significant impact on economic growth.

The primary focus of this analysis is to assess the relationships between various macroeconomic variables while ensuring the robustness of the model and addressing common econometric challenges inherent in panel data. Initially, a descriptive statistical analysis is conducted to explore the overall characteristics of the data, including mean, standard deviation, and range, thereby offering a preliminary understanding of the underlying financial and economic trends. This step is essential for identifying potential outliers and anomalies, which may distort the analysis if left unchecked. Subsequently, correlation analysis is performed to examine the strength and direction of relationships between key variables, providing insight into potential linear dependencies. To ensure the reliability of the results, a series of diagnostic tests are employed. First, a unit root test is conducted to examine the stationery of the data, addressing the possibility of incorrect relationships.

Next, the study assesses multi-collinearity through variance inflation factors (VIF) to ensure that the independent variables are not highly correlated, which could undermine the validity of the regression models.

Based on the outcomes of these preliminary tests, the Difference Generalized Method of Moments (GMM) model is employed for the empirical analysis. GMM is chosen due to its efficiency in addressing endogeneity and potential simultaneity biases, especially in panel data settings with heteroscedasticity and autocorrelation. This methodology enables a more accurate estimation of the relationships between variables, ensuring the robustness and reliability of the findings in the context of financial analysis across multiple countries.

3.1 Research Data

The dataset used in this study consists of panel data, focusing on developing countries. It covers a time period of 22 years, from 2000 to 2021, and includes 53 countries in total. This results in 1,113 observations. In this research, green finance is taken as the independent variable, while R&D expenditure serves as the moderating variable. Economic growth is considered the dependent variable, as it reflects the main outcome of the study. Additionally, gross national expenditure and industry value added are included as control variables to ensure more reliable and unbiased results. This framework allows the study to clearly examine the direct and indirect relationships among the variables while keeping other important economic factors in check.

3.1.1 Dependent Variable

In this research, the dependent variable is economic growth. It can be defined as growing in the total value of the goods and services that are produced by an economy over any given time frame usually via changes in GDP. To measure economic growth, two key indicators are employed: GDP per capita and total GDP. GDP per capita provides an average measure of economic output per individual, helping to adjust for differences in population size across countries. This study builds

upon earlier works, such as those by (Awan & Azam, 2022) and (Bickenbach, Bode, Nunnenkamp, & Söder, 2016), with the aim of examining the variations in growth rates within and between countries over time using an econometric model based on panel-data estimation. The Natural Log of GDP per capita is used as a measure of economic growth (Ayana, Demissie, & Sore, 2024).

3.1.2 Independent Variable

Green Finance in its turn is functioning as the independent variable. The standard logic of digitalizing all international financial flows that go to clean-energy efforts in developing countries is the proximal indicator, which is also aligned with (Kirikkaleli & Adebayo, 2024)) and complemented by Open World Data sets. Green Finance per se involves those financial and capital flows that had spur sustainable development.

Sustainability-linked loans and green bonds belong at the heart of its mandate, for these are such instruments that have a direct connection to climate risk mitigation and environmental integrity protection (Tang, Gao, & Zhou, 2024). Empirical evidence shows that this kind of financing does not only kick-start economies on a low-carbon development path; it also supports the diffusion of innovative technology and improves resource use efficiency (Campiglio, 2016).

The Natural Log of “International financial flows to developing countries in support of clean energy and renewable energy production” is used as a measure of green finance (Hossain et al., 2024).

3.1.3 Moderating Variable

Research and Development (R&D) is an important economic indicator that measures the portion of a country’s total output allocated to the development of new technologies, innovations, and knowledge (Pegkas, Staikouras, & Tsamadias, 2019). This variable reflects the nation’s investment in improving its technological and scientific capabilities, which can drive economic growth and competitiveness. This indicator data, which is provided by World in Data, indicates the amount of

R&D spending in a country as a proportional amount of the GDP in the country (% of GDP). Increased R&D expenditure reflects its intense focus on innovation and developing the future. It also shows how nations spend in the present in order to establish economic power in the future.

In third world countries, there is often a lack in technological advancement due to insufficient investment in research and development, which reduces the pace of competitiveness. Conversely, highly developed economies that have high investment in R&D tend to be more productive and sustainable in their economic growth.

3.1.4 Control Variables

3.1.4.1 Industry Value Added

Industry Value Added (including Construction) in Current US\$ is the total value of goods and services produced by the industries, including manufacturing, mining and construction and utilities, but do not include the value of the input that industries use in the production process.

It demonstrates the share these industries have to the economy. The information is given in Current US\$ by agency World in Data. As these values were too high, natural log transformation was done in order to simplify the analysis of the data ([Hossain et al., 2024](#)).

3.1.4.2 Gross National Expenditure

Gross National Expenditure (GNE) is a significant indicator of the economy of a country. It indicates how much all the persons who live in the country spend on goods and services which includes domestic and imported goods.

GNE covers expenditures on consumption, investment and government activities, however, the expenditures on net exports (that is export minus imports) ([Sarfraz, Naseem, & Mohsin, 2023](#)) is not included in GNE. GNE data is often presented as Total National Expenditure in units of local currency of the country (LCU).

3.2 Data Analysis

3.2.1 Descriptive Statistics

Descriptive statistics helps to describe an understandable summarization of the data. It helps us to systematically arrange data and display significant aspects such as average, middle and most prevalent value in a cluster of data. Descriptive statistics also describes the extent to which data is dispersed.

Mean, median, mode, a range, variance, standard deviation are some of the important measures of the descriptive statistics. Such statistics does not assume or make any predictions or guesses about the future, but just describes what data is readily available to us. Probability, on the one hand, deals with the likelihoods of occurrence and is applicable in inferential statistics.

3.2.2 Correlation Analysis

Correlation analysis is a statistical measure that describes the strength and direction among variables. It indicates how the change in one variable is associated with the change in another variable. Correlation analysis among variables demonstrates positive and negative connections among distinct variables. Its range is between -1 and +1.

The value that is close to the -1 means that the connection between the variable is perfectly negative. The values that are close to the +1 means that the connection between the variable is perfectly positive. The value that is 0 or close to 0 are showing that the connection between the variable is weak or no connection between them. The likelihood of multicollinearity is lower when there is low correlation between two variables and higher when there is significant correlation between two variables.

3.2.3 Unit Root Test

It is likely to have unit root in the panel data as there are large number of observations in the data set. It can cause the results to be biased and can results in

spurious regression so Panel Unit Root tests are conducted to check the stationarity of the variable. To measure the unit root in the data set, this study employs a variety of unit root measurements. (Im, Pesaran, & Shin, 2003) and (Levin, Lin, & Chu, 2002) have been utilized. The two factors used by the approach to make its judgement are the p value and the t statistics. Also, the tests give a sound basis in establishing whether the data series are time and country stationary. This is necessary to ensure that data is not non-stationary since one can draw incorrect correlations and inferences. When these panel unit root tests are applied, the study will ensure that the regression findings are strong and confirm the actual economic relationship. This measure also helps to increase the validity of the results and make the conclusions made after the analysis statistically sound.

3.2.4 Multicollinearity: Variance Inflation Factor (VIF)

In cases where the associations between independent variables are very high, this can give rise a multi-collinearity effect that can cause misleading results of regression analysis. In order to analyze the possible multi-collinearity issue in the research, the Variance Inflation factor (VIF) values were also determined. According to the previous literature, it is necessary to have a VIF less than 5 and the value of the tolerance greater than 0.10 in general in order to assume that this value is acceptable (Anand et al., 2021; Daoud, 2017; Duanet al., 2023; Field, 2013; Hair et al., 2011; Sedgwick, 2015). Considerations have as well been done that it would be enough to apply less keen cutoff (that is, VIF less than 10 and tolerance greater than 0.20) (Henseler et al., 2009; Hair et al., 2010).

3.2.5 Wald Test

Wald test is a statistical test used to determine the endogeneity. It determines the significance of the variable. It examines if the model's independent variable has a statistically significant effect on the dependent variable. A crucial value from the chi-square distribution with degrees of freedom equal to the number of limitations being tested is compared to the test statistic. In our study, the Wald test is used to determine whether the coefficients of the variables of our study are statistically

significant. For Wald test, first there is the use of FEM. In order to check the endogeneity, the f-stat value is observed. When the f-stat value of the Wald test is less than 0.05 or (typically $p < 0.05$), it means that problem of endogeneity is present.

If there is endogeneity in one variable, it means that it will affect the whole model. So, GMM will be used to solve this problem. This guarantees that the estimates that are arrived at are consistent and accurate. It can also give a more valid insight into the association between variables of interest. Therefore, the use of GMM following Wald test enhances the strength of the entire econometric analysis.

3.2.6 Generalized Method of Moments (GMM)

A statistical method called the Generalized Methods of Moments (GMM) is used in econometrics and other study domains to estimate parameters in statistical relationships or econometric models, ([Hansen & Hodrick, 1980](#); [A. R. Hall, 2003](#)).

A major problem in dynamic panel models is endogeneity, which occurs when past values of the dependent variable are related to the error terms. This can lead to biased results.

This issue can be resolved by using Generalized Method of Moments (GMM) which provide consistent result. GMM helps by using special instruments variables that are connected to the problematic regressor but not to the error term. These instruments allow for more reliable and accurate results.

In this study, research employed Generalized Method of Moments to estimate the results. GMM is a well-known statistical method that can handle complex models with problems such as endogeneity and heteroskedasticity.

The study found the correct instruments and exercised the orthogonality conditions under the GMM model to give robust parameter estimates. These estimates can hence be used as reliable measures of how changes in one variable bring about changes in another variable.

In addition, GMM accounts for unobserved heterogeneity across countries, which is a common issue in panel data studies. The method also allows for flexibility in

handling different error structures, making it particularly useful in macroeconomic research.

By exploiting internal instruments, GMM reduces reliance on external instruments that may be weak or unavailable. Consequently, the estimations derived are not only consistent but also more efficient compared to traditional estimation techniques.

3.3 Econometric Models

The relationship between green finance and Economic growth is the main focus of this study.

In order to look deep at the link between the variables, the following model has been created.

3.3.1 Equation 1

$$EG_{it} = \beta_0 + \beta_1 EG_{it-1} + \beta_2 GF_{it} + \beta_3 IND_{it} + \beta_4 GNE_{it} + \epsilon_{it} \quad (3.1)$$

The original model for dynamic panel is This model includes lagged dependent variable to estimate the current value of dependent variable.

Model 1: Green finance impact on Economic Growth.

3.3.2 Equation 2

The model explains the direct effect of R&D on Economic Growth.

Lag of Economic Growth is used as regressor in this model to analyze the current Economic Growth from the past Economic Growth.

$$EG_{it} = \beta_0 + \beta_1 EG_{it-1} + \beta_2 (R\&D)_{it} + \beta_3 IND_{it} + \beta_4 GNE_{it} + \epsilon_{it} \quad (3.2)$$

Model 1: Research & Development on Economic Growth.

3.3.3 Equation 3

This model explains the moderating role of R&D in the relationship between Green Finance (GF) and Economic Growth (EG). It also analyzes the direct effects of GF and R&D on EG, and includes control variables such as Int, IND, and GNE to better understand their combined impact on economic growth.

$$EG_{it} = \beta_0 + \beta_1 EG_{it-1} + \beta_2 GF_{it} + \beta_3 (R\&D)_{it} + \beta_4 (GF \cdot R\&D)_{it} + \beta_5 IND_{it} + \beta_6 GNE_{it} + \epsilon_{it} \quad (3.3)$$

Model 3: Research and Development expenditure moderates the relationship between green finance and economic growth.

Whereas:

- EG is Economic Growth
- GF is Green Finance
- IND is Industry Value Added
- R&D is Research and Development
- GNE is Gross National Expenditure
- β_1 is the coefficient for Economic Growth
- β_2 is the coefficient for Green Finance
- β_3 is the coefficient for Research and Development
- β_4 is the coefficient for Green Finance * Research and Development
- β_5 is the coefficient for Industry Value Added
- β_6 is the coefficient for Gross National Expenditure
- i is the cross section
- t is the time period

TABLE 3.1: List of Variables

Variable Type	Symbol	Indicator	Source	References
Dependent variable: Economic Growth	EG	GDP per capita	WDI	(Anser et al., 2024)
Independent variable: Green Finance	GF	International financial flows to developing countries in support of clean energy R&D and renewable energy production, including hybrid systems (millions of constant 2020 USD)	Our World in Data	(Lee et al., 2023; Gao et al., 2023)
Moderator: Research & Development	R&D	Research and Development expenditure (% of GDP)	WDI	(Hossain et al., 2024)
Control variable: Industry Value Added	IND	Industry (including construction), value added (current US\$)	WDI	(Hossain et al., 2024)
Control variable: Gross National Expenditure	GNE	Total National Expenditure (current LCU)	WDI	(Hossain et al., 2024; Sarfraz et al., 2023)

Chapter 4

Results and Discussion

4.1 Descriptive Statistics

A descriptive statistic is critical in the summarization and interpretation of basic nature of data of a study. They give conception of the central tendencies, variability and the form of distribution of the variables being studied in the sample. It is important to use the mean, median, mode, standard deviation and range which comprises the maximum and minimum values, because they are the most common type of descriptive statistics. The statistics assist the researcher to have clear understanding of the general behavior of the data; outliers are detected and different variables in the data are compared.

The [Table 4.1](#) table below outlines the descriptive statistics for five key variables in this study: Economic Growth (EG), Green Finance (GF), Research and Development (R&D) expenditure, Industry Value Added (IND), and Gross National Expenditure (GNE). These measures reflect how each variable behaves in the dataset, including their central tendency (mean and median), the extent of variation (standard deviation), and the range between the smallest and largest values observed.

Economic Growth (EG) has a mean value of 7.702442 and a standard deviation of 1.116319, indicating that the average economic growth across countries and over time may vary by approximately 1.12 units.

The values range from a minimum of 4.119990 to a maximum of 9.917810. The skewness is slightly negative (-0.394433), indicating a minor left tail, and the kurtosis (2.404011) suggests a distribution marginally flatter than usual.

Green Finance (GF) has a mean of 16.26353 and a standard deviation of 3.126338, showing a spread of approximately 3.13 units from the average value. The minimum value is 5.963000, and the maximum is 23.38200. The distribution is negatively skewed (-0.554608) and slightly platykurtic (kurtosis = 2.567138).

Research and Development (R&D) expenditure has a mean of 0.494401 with a standard deviation of 0.285982, indicating a relatively small variation in R&D spending across observations. The minimum value is 0.001215, and the maximum is 0.999909. It shows low skewness (0.036901) and low kurtosis (1.809819), indicating a relatively symmetric and flat distribution.

Industry Value added (IND) has a mean of 23.44356 and a standard deviation of 1.824227. The data ranges from a minimum of 19.32370 to a maximum of 29.57719. The distribution is slightly positively skewed (kurtosis = 0.407231) and mesokurtic (kurtosis = 2.916661).

Gross National Expenditure (GNE) has a mean value of 28.07807, with a standard deviation of 3.060237, ranging from 20.45800 to 37.33318. The distribution is almost symmetric (skewness = 0.129800) and slightly peaked (kurtosis = 2.917245).

The findings in this study strongly suggest a relationship between Green Finance and Economic Growth. Previous research supports this idea, highlighting that green finance initiatives can be a significant driver of economic growth. For instance, studies like the one conducted by (J. Wang, Tian, Kang, & Guo, 2023) have demonstrated that countries that allocate more resources to green finance, particularly towards sustainable practices and green technologies, experience an upward trajectory in economic growth. These initiatives not only boost immediate economic activity but also contribute to long-term, sustainable growth by fostering innovation, job creation, and investment in green industries.

Furthermore, (Tariq & Hassan, 2023) found that countries that focus on green finance have a stronger capacity to transition toward green development, which positively influences their economic growth. Green finance acts as a catalyst for

the development of environmentally sustainable industries, creating jobs in sectors like renewable energy and clean technology, while also improving the resilience of economies to environmental shocks. Similarly, (Flachenecker & Rentschler, 2019) concluded that increasing green investments leads to better economic performance by reducing risks associated with climate change and improving resource efficiency.

TABLE 4.1: Descriptive Statistic

Column	EG	GF	R&D	IND	GNE
Mean	7.7024	16.2635	0.4944	23.4435	28.0781
Median	7.9443	16.7640	0.4916	23.2879	28.0739
Maximum	9.9178	23.3820	0.9768	29.5771	37.3312
Minimum	4.1199	5.9630	0.0121	19.3223	20.4580
Std. Dev.	1.1163	3.1263	0.2859	1.8242	3.0602
Observations	1113	1113	1113	1113	1113

This trend is reflected in the descriptive statistics of the study, where a positive association between Green Finance and Economic Growth is evident. Green Finance (GF), with a mean value of 16.26 and a standard deviation of 3.13, displays significant variability in its distribution. This variability, paired with a relatively strong economic growth rate (mean of 7.7), suggests that countries that invest in green financial instruments tend to achieve higher economic outcomes.

This sample size ensures that the descriptive statistics accurately represent the population being studied, providing confidence in the reliability and generalizability of the findings. In conclusion, the descriptive statistics presented in the methodology section of the research provide a clear and concise summary of the data's distribution, central tendencies, variability, and sample size. They serve as foundational information for subsequent statistical analyses and interpretations in the study, guiding researchers in understanding the characteristics and nuances of the variables under investigation.

4.2 Correlation Matrix Analysis

The Pearson product-moment correlation is a common statistics measure used in determining the correlation between two variables and how strong the relationship is in regard to the linearity of the variables. The correlation coefficient is also written as r and its highest and lowest values are -1 and $+1$ respectively and the nearer the coefficient is to $+1$ the stronger is the positive relationship hence as one variable goes higher the other one also tends to go higher together. On the other hand, a value close to -1 indicates strong adverse relationship, and thus an increment in one variable is accompanied by decreasing the other. The value 0 means no linear correlations between the two variables exist. The strength of the relationship is categorized as follows: a correlation between 0.10 and 0.29 signifies a weak relationship, 0.30 to 0.49 indicates a moderate relationship and 0.50 to 0.80 reflects a strong relationship.

A correlation coefficient of 0.80 or higher indicates a strong relationship. However, when the correlation exceeds 0.80 , it may lead to multicollinearity. In this statistical issue, the variables are so closely related that they may be treated as one, potentially distorting the results of regression analysis. To address multicollinearity, additional tests, such as variance inflation factor (VIF) analysis, are necessary to ensure the accuracy of the findings and avoid affecting the relationships between other variables (McNeish, 2014; Gogtay & Thatte, 2017).

TABLE 4.2: Correlation Matrix

	ES	FI	GT	DIG	GF FDI
EG	1.0000				
GF	0.1765	1.0000			
R&D	0.1867	0.2014	1.0000		
IND	0.5352	0.3364	0.2023	1.0000	
GNE	0.1731	0.2589	0.0301	0.0083	1.0000

The [Table 4.2](#) correlation analysis reveals several key relationships among the variables. Economic growth (EG) has a moderate positive correlation with industry value added (IND) at 0.5352 , suggesting that industrial expansion is strongly

linked to financial performance. EG also exhibits weak positive correlations with green finance (GF) at 0.1765.

While research and development (R&D) at 0.1867, and gross national expenditure (GNE) at 0.1731. Green finance (GF) demonstrates moderate correlations with industry value added (IND) at 0.3364 and Gross national expenditure (GNE) at 0.2589, suggesting some interdependence between financial policies and these sectors. Research and development (R&D) exhibit a negligible correlation with Gross national expenditure (GNE) at 0.0301, indicating a minimal direct relationship, while maintaining a weak positive link with industry value added (IND) at 0.2023.

The strongest overall correlation is observed between gross national expenditure (GNE) and industry value added (IND) at 0.5071, highlighting a significant connection between public spending and industrial growth. With all correlation coefficients below 0.55, multicollinearity is not a significant concern in this analysis.

However, it is essential to note that variables such as interest rates, inflation, and exchange rates are not included in this dataset, limiting the scope of the analysis. Further investigation into the statistical significance of these correlations and their contextual implications would provide deeper insights into their meaning.

4.3 Unit Root Test

In order to effectively analyze time series data, it is necessary to check whether the data is stationary. A time series can be said to be stationary if the statistical characteristics of the series, like mean and variance are not changing with time. Nevertheless, when these properties vary over time, the series is termed as non-stationary, which brings analysis and forecasting issues.

If the test detects the presence of a unit root, it indicates non-stationarity. When these occur then some procedure has to be done to the time series usually by differencing and then rendering it stationary so that further analysis can be performed. Thus, this study applied unit root test by first differencing variables and then checking whether the series turned out to be stationary. Levin, Lin & Chu (LLC) and Im, Pesaran and Shin (IPS).

These tests were conducted on the following variables: Economic Growth (EG), Green Finance (GF), Research and Development expenditure, Gross National Expenditure (GNE), and Industry value added (IND). The ?? test statistics from both LLC and IPS are highly negative, and the corresponding p-values 0.0136, 0.0386, and 0.0000 are all below the commonly accepted significance level of 0.05. These results indicate that the time series for EG, GF, R&D, GNE, and IND are stationary, meaning their statistical properties remain stable over time. Therefore, these variables do not require further transformation and are suitable for subsequent analysis and modeling.

TABLE 4.3: Pannel Unit Root Test at 1st difference

Variables	Levin, Lin&Chu		Im, Pesaran& Shin W-stats	
	Statistic	Prob.	Statistic	Prob.
EG	-9.24832	0.0000	-5.03842	0.0000
GF	-10.4769	0.0000	-10.3351	0.0000
R&D	-4.81679	0.0000	-4.45762	0.0000
IND	-7.26713	0.0000	-0.71084	0.0000
GNE	-9.41302	0.0000	-2.20752	0.0000

4.4 Multicollinearity Test

Multicollinearity: Variance Inflation Factor (VIF)

The Variance Inflation Factor (VIF) is applied to test whether there is multicollinearity in the independent variables. Hair et al. (2019) state that when the value of VIF reaches 3 or above (but under 5), then a certain issue may occur related to multicollinearity. A serious multicollinearity issue exists when the VIF value is 5 or higher. It is preferable if the least number of VIF values are 1 or much lower indicating that there will be no case of multicollinearity.

The [Table 4.4](#) indicates that the VIF values are less than 3. This implies that there exist no problems of multicollinearity between the independent variables in this research. The regression model can use all the variables together without any problem. Additionally, the low values of VIF also suggest that each independent

variable within the model is contributing a unique share of the variance in the dependent variable without superfluously coinciding with other variables.

This assumption contributes to the stability of the regression analysis through reduction of the possibility of bias or unstable coefficient estimates. Moreover, there is no multicollinearity that ensures the statistical value and meaning of the estimated parameters, which lead to the interpretability of the model. It also increases the level of correctly measured standard errors that lead to effective hypothesis test and valid statistical conclusion. In general, these findings validate the idea that the chosen independent variables can be included in the model and contribute to significant empirical results.

TABLE 4.4: Multicollinearity: Variance Inflation Factor (VIF)

Variables	VIF	1/VIF
GF	1.17	0.855
R&D	1.08	0.929
IND	1.48	0.676
GNE	1.38	0.726
Mean VIF	1.28	

4.5 Wald Test

The Wald Test was conducted to assess the significance of the Green Finance variable in the model. The test results are presented below:

Green Finance is a highly significant predictor in the model. The t-statistic value of 8.6009 with a probability of 0.0000 confirms the significance at the 1% level. Similarly, both the F-statistic (73.9761, $p = 0.0000$) and the Chi-square value (73.9761, $p = 0.0000$) further support that the effect of Green Finance on the dependent variable is statistically significant.

TABLE 4.5: Wald Test

Test Statistic	Value	df	Probability
t-statistic	8.600938	1118	0.0000
F-statistic	73.97613	(1, 1118)	0.0000
Chi-square	73.97613	1	0.0000

These findings provide strong evidence that Green Finance plays an important and significant role within the proposed model. Thus, it can be concluded that Green Finance is a significant factor influencing economic growth in this study. The Wald test statistics also validates the fact that the model is statistically sound. It reveals that the coefficients of the variables are not zero and they have real effect. This is to say that this model is not just important in theory, but also in practice. Thus, when Green Finance is put to the test in this way, the impact of the economic growth becomes even greater.

4.6 Results of GMM Estimation

4.6.1 Impact of Green Finance on Economic Growth

In this study, we aim to analyze the determinants of economic growth using a Panel Generalized Method of Moments (GMM) model. The primary focus of the model is to measure how green finance (GF), industry value added (IND), and gross national expenditure (GNE) impact economic growth (EG). Specifically, we want to assess the dynamic relationship between these variables and how past economic performance and these economic factors can influence current economic growth.

The ?? shows results from the panel GMM model show that all explanatory variables have statistically significant positive impacts on economic growth (EG).

The lagged value of economic growth (EG (-1)) has a coefficient of 0.0769 ($p < 0.01$), indicating that past economic growth positively influences current growth. Green finance (GF) shows a significant positive effect with a coefficient of 0.0507 ($p < 0.01$), meaning a 1% increase in GF leads to a 0.0507% increase in EG. industry Value added (IND) has the strongest impact with a coefficient of 0.4225 ($p < 0.01$), highlighting its crucial role in driving economic growth. Gross national expenditure (GNE) also demonstrates a positive and significant effect (coefficient = 0.1489, $p < 0.01$), though smaller than IND's impact.

The model diagnostics confirm its validity, with a J-statistic p-value of 0.3527 indicating proper instrument specification. AR(1) test ($p = 0.002$) indicating expected

first-order autocorrelation in differenced residuals. The insignificant AR(2) test ($p = 0.135$) validates the model by confirming the absence of second-order serial correlation, ensuring the reliability of the instruments used. These findings collectively suggest that policies promoting green finance, industry Value added, and Gross spending can effectively stimulate economic growth, with industry Value added being the most powerful driver among these factors. The results emphasize the importance of maintaining consistent growth policies over time, given the persistent effect captured by the lagged dependent variable.

TABLE 4.6: Impact of GF on EG

Variables	Coefficient	Std. Error	t-Statistic	Prob.
EG (-1)	0.0768***	0.00338	22.7218	0.000
GF	0.0507***	0.00574	8.8328	0.000
IND	0.4225***	0.01982	21.4127	0.000
GNE	0.4225***	0.01632	9.1013	0.000
Mean Dependent Var	0.058145	S.D. Dependent Var	0.366689	
S.E. of Regression	0.336980	Sum Square Resid	115.3723	
J-Statistic	50.06462	Prob(J-statistic)	0.352739	
AR(1)	0.002	AR(2)	0.135	
No. of Observations	1113			

The findings from the panel GMM model provide strong evidence for the positive impact of green finance, industrial output, and national expenditure on economic growth. Green finance, in particular, emerges as an important but slightly smaller contributor, with a coefficient of 0.0507. However, industry value added remains the most significant driver of economic growth, with a coefficient of 0.4225, emphasizing the importance of industrial development in sustaining growth. Gross national expenditure also has a notable effect, albeit smaller in magnitude. These findings align with existing research that demonstrates the positive influence of green finance on economic growth. For instance, (S. Zhang et al., 2024) found

that green finance makes a significant contribution to economic development by supporting sustainable business practices.

Similarly, (Buglio et al., 2025) highlighted that green finance is positively correlated with economic growth and renewable energy consumption. Additionally, the OECD and UNDP (Cheema, 1994) report suggested that green finance and climate action can lead to higher global GDP growth. The results from this study provide strong evidence for the positive role of green finance, industry value added, and gross national expenditure in boosting economic growth, supporting the hypothesis that green finance is a key driver of sustainable economic development. These findings reinforce the importance of integrating green finance into national economic policies to foster long-term growth. In conclusion, the study confirms that green finance has a positive impact on economic growth, consistent with the broader literature on the subject. The findings highlight the critical role of industry value added as the strongest driver, with green finance also making a significant contribution. These results underscore the importance of sustained investments in green finance, industrial development, and national expenditure to drive economic growth. Given these positive effects, the study suggests that focusing on green investments and industrial development can promote sustainable, long-term economic growth, urging policymakers to continue integrating green finance into their economic strategies.

4.6.2 Impact of Research and Development on Economic Growth

In this study, we aimed to investigate the impact of research and development (R&D), industry value added (IND), and gross national expenditure (GNE) on economic growth (EG). This means that a country or region's economic growth depends on its growth in the previous year, the money it spends on research and development, the strength of its industry sector, and its total national spending and below table shows the result of how R&D is impacting on economic growth. We employed a statistical method called the panel GMM model, which is particularly useful for analyzing data collected from multiple locations over extended

periods and yields reliable results even when variables are interdependent. Our results, presented in the ?? below, indicate that all three factors R&D, industry, and spending have a significant positive impact on economic growth. R&D has the most significant effect, with a coefficient of 0.6328, indicating that investment in research and development yields the greatest increase in economic growth.

TABLE 4.7: Impact of R&D on EG

Variables	Coefficient	Std. Error	t-Statistic	Prob.
EG (-1)	0.1173***	0.00549	21.3692	0.000
R&D	0.6328***	0.11964	5.3293	0.000
IND	0.4414***	0.02351	18.7761	0.000
GNE	0.1836***	0.02148	8.5446	0.000
Mean Dependent Var	0.058145	S.D. Dependent Var	0.366689	
S.E. of Regression	0.366662	Sum Square Resid	136.592	
J-Statistic	49.72857			
Prob(J-statistic)	0.365172			
AR(1)	0.001	AR(2)	0.066	
No. of Observations	1113			

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Industry value added is also very important, with a coefficient of 0.4414, suggesting that a strong industrial sector is crucial for a growing economy. Gross national expenditure also helps, with a coefficient of 0.1836, but its effect is smaller than that of R&D and industry.

Previous economic growth also matters (coefficient 0.1173), showing that growth often continues from one year to the next, though this effect is more negligible. AR(1) test ($p = 0.001$) indicating expected first-order auto-correlation in differenced residuals. The insignificant AR(2) test ($p = 0.066$) validates the model by confirming the absence of second-order serial correlation, ensuring the reliability of the instruments used. All these results are statistically significant, and the model

passed the validity tests, so our findings are reliable. In summary, policies that focus on increasing R&D, supporting industry, and encouraging national spending will help boost economic growth, with R&D offering the most significant benefit. In short, R&D investments have the most significant positive impact on economic growth, followed by industry and then overall national spending. Growth from the previous year also helps, but not as much as R&D or the industry itself. The model and results are statistically sound, allowing us to trust these findings.

4.6.3 Moderating Role of R&D Between Green Finance and Economic Growth

In this study, we aimed to investigate the impact of green finance (GF), research and development (R&D), industry value added (IND), and gross national expenditure (GNE) on economic growth (EG), as well as whether R&D influences the effect of green finance on growth. To analyze this, we employed a panel GMM model, which is particularly useful for data collected from different countries or regions over several years, as it helps us obtain more reliable results by accounting for the complex relationships between these variables.

According to our findings, all the main factors green finance, research and development, industry, and national spending have a significant positive effect on economic growth. The [Table 4.8](#) below presents the estimated coefficients for each variable in our model. Green finance (GF) has a positive but smaller effect (coefficient 0.0533), indicating that eco-friendly financial actions support growth, albeit with a limited impact compared to other factors. Research and development (R&D) also has a positive effect (coefficient 0.1015), though smaller than expected, which could mean that R&D takes time to show its full benefits or needs better management. The interaction term (INT) between green finance and R&D is positive (coefficient 0.1152), indicating that combining R&D with green finance enhances their impact on growth. Industry value added (IND) has the most significant effect (coefficient 0.4472), highlighting the importance of a strong industrial sector for the economy. Gross national expenditure (GNE) also contributes to growth (coefficient 0.1196) but to a lesser extent than industry. The

previous year's economic growth (EG-1) also supports current growth, showing persistence in financial performance.

TABLE 4.8: R&D Moderates the Relationship Between GF and EG

Variables	Coefficient	Std. Error	t-Statistic	Prob.
EG (-1)	0.0675***	0.009260	7.2967	0.000
GF	0.0532***	0.002231	23.8482	0.000
R&D	0.1014***	0.014981	6.7467	0.000
GF*R&D	0.1115***	0.008957	13.0926	0.000
IND	0.4471***	0.019567	22.8534	0.000
GNE	0.1196***	0.017243	6.9376	0.000
Mean Dependent Var	0.058145	S.D. Dependent Var	0.366689	
S.E. of Regression	0.336096	Sum Square Resid	114.5421	
J-Statistic	46.7976			
Prob(J-statistic)	0.399244			
AR(1)	0.002	AR(2)	0.114	
No. of Observations	1113			

All these results are statistically significant, and our model passed the diagnostic tests (as shown in the lower section of the table), which means our findings are reliable. In short, our study suggests that while industry and spending are the strongest drivers, green finance and R&D primarily when combined can further support economic growth, and maintaining steady, long-term growth policies is essential for success. AR(1) test ($p = 0.002$) indicating expected first-order autocorrelation in differenced residuals. The insignificant AR(2) test ($p = 0.114$) validates the model by confirming the absence of second-order serial correlation, ensuring the reliability of the instruments used. Based on the results obtained from the panel GMM model, both the research objectives and the research questions have been successfully achieved. The research objective aimed to investigate the moderating role of R&D expenditure in the relationship between green finance

and economic growth, and the findings clearly demonstrate that R&D does indeed play a significant moderating role.

The positive and statistically significant interaction term between green finance and R&D (coefficient of 0.1152) indicates that when R&D is combined with green finance, its impact on economic growth is enhanced. This supports the hypothesis that R&D strengthens the relationship between green finance and economic growth. Therefore, the research question regarding the role of R&D in moderating this relationship has been answered affirmatively. The study confirms that R&D not only independently contributes to economic growth but also magnifies the positive effects of green finance, making the combined approach more effective in driving economic development. Thus, both the research objective and the research question have been fully addressed and achieved.

Therefore, the research question regarding the role of R&D in moderating the relationship between green finance and economic growth has been answered affirmatively. The study confirms that R&D not only independently contributes to economic growth but also magnifies the positive effects of green finance, making the combined approach more effective in driving economic development. This finding adds to the growing body of literature suggesting that green finance and R&D together offer a powerful mechanism for promoting sustainable economic growth. Thus, both the research objective and the research question have been fully addressed and achieved.

Chapter 5

Conclusions

5.1 Conclusion

The study highlights the significant roles of green finance and Research and Development (R&D) in promoting sustainable economic growth, particularly in developing countries. Green finance promotes economic growth through sustainable investments through capital to sustain investment and promote innovative and environmentally friendly practices. Innovation, technology, and productivity are promoted through R&D that further raises the development of an economy. Importantly, R&D enhances the green finance work with a synergetic response, increasing its growth exponentially.

The overall effect of the green finance and R&D works very efficiently to support sustainable progress and reach the goal of sustainable development and move towards economic growth. These results pinpoint to the necessity to incorporate green finance and R&D within the economic policies so as to guarantee sustainable and inclusive future in the developing economies. These insights can be used in policy making to develop approaches, which interpolate financial mechanisms and technological advancements as a means of economic development. The three objectives of the study have been fulfilled. To begin with, the paper has explicitly confirmed the positive effect of green finance on economic growth where investment is directed to sustainable and productive roles in the case of the developing economies.

Secondly, it has been proved that research and development (R&D) have a very positive impact on economic growth due to the fact that research and development promote the level of innovation, technology and productivity.

Above all, the third goal which explores the moderating effect of R&D expenditures has been achieved. As the results indicate, as well as supporting the economic growth by itself, R&D also augments positive impacts of green finance. This checking factor is important since it brings out synergy and long-lasting and sustainable economic growth suffers. Therefore, the research comes up with sufficient pieces of evidence as to the significance of both green finance and R&D in ensuring robust economic growth. A moderating framework employed in a study diversifies the analysis, which reflects the multidimensional aspect of investment and innovation. The findings give an insightful idea of how green finance and R&D separately and in combination can be used to deliver sustainable growth. This study provides a detailed factual and contextual meaning of enhancing green finance and research and development in policy context by the developing countries. The primary concern was to present the significance of green finance as an accelerator of the economy growth and reveal the essential control of the R&D spending regulation. The results point out that R&D investment is important in order to raise the efficiency of green finance initiatives of developing countries. There should also be an emphasis on sustainable approaches and higher research and development (R&D) investment in green finance by policymakers to encourage innovation and productivity in green finance that induce not only environmental and economical sustainability but also result in financial stability. Although this study targeted particular countries, as developing countries, future researches ought to put into consideration other regions or categories of countries in order to get wider generalization and validity.

5.2 Policy Implication

The study has important policy implications especially to the developing nations, which are interested in enhancing sustainable economic development with the help of green finance and research and development (R&D). Knowing how the green

finance, the R&D, and the economic growth interact, policymakers can consider appropriate interventions that lead to innovation, sustainability in the environment and the capacity to grow in the long-term. To improve green finance to the business and individual the governments and policymakers ought to intensify accessibility of green financing. This can be done through establishing special programs, giving out easy money through loans or giving out tax relieves in projects protecting the environment and growing the economy. The increased availability of green finance to the number of individuals and businesses will stimulate the creation of more projects that will bring profit to the economy and generate less harm to the environment. Research and development (R&D) should be increased.

More funding should be addressed to R&D by governments, universities and companies, as it results into production of new ideas and technologies. These emerging technologies will lead to secure solutions of the problems and the effectiveness of industries, and green-finance may be enhanced even more. Through R&D, countries can enhance their capacity to rise and become competitive to others. Third, green financing and research and development (R&D) should be crucial towards an optimal outcome. When combined they lead to the high and sustained positivity of the effects of economic growth.

By way of example, green finance is capable of aiding in the creation of novel clean energy inventions based on the process of R&D, and in its turn R&D can do the significant job of locating the superior methods to make use of green finance in a multiplicity of areas. Clearly defined regulations and subsidization of the initiatives that promote green finance along with research and development (R&D) should be facilitated by the policymakers. This may include issuance of research grants, development of innovation centers or streamlining the process of forcing companies to access finances to fund green projects. The more the rules and programs are helpful and straightforward the more the organizations and people will act. These steps are also helpful for developing countries. Many developing nations need to grow their economies while also protecting the environment. By increasing green finance and investing in R&D simultaneously, these countries can grow in a balanced manner, create new jobs, and retain their natural resources for future generations. This strategy is also effective in enhancing their competitiveness

in the global market through embracing sustainable industries. It will lead to less reliance on non-renewable resources and will help maintain economic stability in the long-term.

5.3 Limitations and Future Directions

Our study covered various research gap but there are few limitations. First, the study only uses data from 2000 to 2021. Due to this, any changes or new developments occurring after 2021 are not included in the results. Future research with more recent data could give updated findings. The study utilizes country level data rather than data from individual companies or industries. This means some detailed effects within different sectors may not be shown. Analysis of data on a company or industry when conducting future research may provide results that are more detailed. Second, another limitation entails using only green finance and research and development (R&D) as key variables. It is also possible to add other significant variables, including the government policy, education, access to technology, or culture. This could give a detailed explanation in future research by including them. Third, the results mainly concern developing countries, and so they might not be applicable to the developed economies. These pairs of countries may have different dynamics of green finance, R&D and economic growth because their economic structures are different, their technology capacity is different and their financial system is different. Future study may go further to involve developed nations and compare the outcome in different groups of nations. This would offer a more in-depth insight into the role of green finance and R&D in the economic growth process across varied economies and assist in the establishment of relatively specific policies in the background of differing economic development situations

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Appendix A

S.No	Name	S.No	Name	S.No	Name	S.No	Name
1	Argentina	16	Ethiopia	31	Mongolia	46	Thailand
2	Algeria	17	Georgia	32	Morocco	47	Tunisia
3	Azerbaijan	18	Guatemala	33	Mozambique	48	Turkey
4	Bangladesh	19	Honduras	34	Myanmar	49	Uganda
5	Bosnia and Herzegovina	20	India	35	Nepal	50	Ukraine
6	Brazil	21	Indonesia	36	Nicaragua	51	Uruguay
7	Burkina Faso	22	Jordan	37	North Macedonia	52	Zambia
8	Chile	23	Kazakhstan	38	Pakistan	53	
9	China	24	Kenya	39	Peru		
10	Colombia	25	Lebanon	40	Philippines		
11	Costa Rica	26	Libya	41	Serbia		
12	Cuba	27	Madagascar	42	South Africa		
13	Ecuador	28	Malawi	43	Sri Lanka		
14	Egypt	29	Malaysia	44	Tajikistan		
15	El Salvador	30	Moldova	45	Tanzania		