

***Exploring The Impact of Carbon Credits Control on
Environmental Performance with Moderating Role of Green
Innovation***



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ABSTRACT

Environmental sustainability is now a big problem around the world because rising carbon emissions are threatening the balance of ecosystems and long-term growth. So, it's very important to know and consider the policy, economic, and financial factors that affect how well our environment works. The primary goal of this study is to examine the impact of regulating carbon credits on the environment, with green innovation playing a moderate role. This research also examined important macroeconomic variables such as GDP growth, foreign direct investment, and interest rates. Carbon intensity is also a way to measure how well something is working for the environment, carbon emissions are a way to control carbon credits by reducing CO₂ emissions, and patents can be used to measure green innovation. Data used for the study is balanced data from specific SAARC nations, encompassing the years 2013 to 2023. A quantitative research methodology is used, implementing panel data regression techniques. A fixed effects regression model with Driscoll–Kraay standard errors is used along with a Prais–Winsten regression model with panel-corrected standard errors as a robustness check. This is based on diagnostic tests and the model's suitability. The study empirical results tells that carbon emissions have a considerable adverse effect on environmental performance, indicating that increased carbon usage will devalue the environmental quality. Green innovation has a positive impact on how well the environment works, and it also creates a relationship between carbon emissions and environmental performance much weaker by decreasing the bad effects of emissions on the environment. GDP growth has a positive effect on the environment, while foreign direct investment has not a positive impact. This suggests that the countries in the sample have pollution-intensive investments. The effect of interest rates is not very strong and varies from one requirement to the next. This research will serve and add value to the existing research by bringing together carbon credit control, green innovation, and macroeconomic factors into a single framework for SAARC countries. The results have important policy recommendations. This study mainly emphasized the need to improve green innovation and make sure that carbon credit systems are according to the strategies for sustainable developments in economies to enhance environmental performance.

Keywords

Environmental performance, Carbon credits, CO₂ emissions, GDP, FDI, Interest rate

ACKNOWLEDGEMENTS

First, I thank Allah Almighty for His countless blessings, which made the completion of this research possible. I am also deeply grateful to my family and friends for their continuous support, encouragement, and patience throughout this research work.

I would like to express my sincere gratitude to my thesis supervisor, Dr. Asma Zeeshan, for her valuable guidance, constant support, and kind supervision throughout this study. Her clear explanations and helpful feedback helped me develop a way to better understanding of the research topic and reinforce my interest in academic research. Her guidance at every stage played an important role in the successful completion of this thesis.

I'm very grateful for her time, effort, and support, which helped me a lot in my studies and research. I will always be thankful for her help and guidance during my time in research.

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CHAPTER 1

INTRODUCTION

1.1. Background

Climate change is one of the main and problematic things in the world now. Many different countries have set up carbon credit systems to reduce carbon emissions and promote more sustainable and environmentally friendly industrial practices.

These systems within the economies give the ability to spend money in low carbon products, giving them resilience to meet environmental goals and buy pollution permits. As these carbon markets grow, these credits become more and more important as regulatory tools and impact the way firms try to manage their operations, budgets, and plans, grow in substance. Carbon credit control is thought to have a direct impact on the environment by pushing companies to use greener technologies and produce fewer carbon emissions. (Rahmani, Naeini, & Mashayekh, 2024)

Green innovation, which refers to the use of new technologies and eco-friendly ways to get better and essential environmental results, is one of the most significant things that can change this relationship. Businesses that invest their monies into environmentally friendly technology may have a better chance of making both their profits and their environmental impact better through carbon credit programs. As a result, green innovation can act as a moderator and stabilizer, making the effect of carbon credits on different results stronger or weaker. (Batool & Mohsin, 2025)

Additionally, these policies' effects are not very independent. Larger macroeconomic factors like GDP, inflation, FDI, interest rates, and CO₂ emissions levels have a significant effect on sustainability measures, feasibility, and usefulness. Generally, increased FDI can provide more funds and technology to support technologies which can improve environmental performance, but increased inflation or interest rates, for instance, would make environmentally friendly investments more expensive. Priorities for economic developments and environmental pressures are also displayed in economic growth and CO₂ emissions. Higher levels of GDP often mean that there is more focus on reducing emissions and protecting the environment. On the other hand, Foreign Direct Investment (FDI) can either help or hurt green initiatives, depending on what it is. Inflation and interest rates, as parts of monetary policy, can affect investments in green technologies and the

cost of meeting carbon compliance standards. This can influence the overall environmental framework. (Irina Alexandra Georgescu, 2024) (Muhammad Ali, 2025)

This study purpose is to create a complete, mechanism-based model that provides strong proof for designing effective climate policies that support growth by looking at the direct effects of CO₂ emission and the moderating effect of Green Innovation within the defined economic framework by GDP, FDI, and the Interest Rate. While other previous research mainly focusses at the individual relationship, like the simple CO₂ link with sustainability or the macroeconomic factors on their own, it often misses the synergistic pathway that turns following the rules into real environmental improvement. This study will measure how much investments in Green Innovation either lessen or increase the pressure that carbon markets put on companies (as shown by their output of CO₂). This is an important test in a real-world, differential setting. The study also makes sure that the separate effects of carbon policy and innovation on Environmental Performance are correctly identified by carefully controlling for the possible confusing or helpful effects of GDP (the level of economic development), FDI (the flow of international technology and capital), and the Interest Rate (the cost of capital for long-term green projects). Ultimately, this mechanism-based approach offers policymakers a clear understanding of the optimal policy mix: identifying whether market constraint is sufficient, or if it must be strategically coupled with incentives for Green Innovation to ensure the national pursuit of environmental targets (better EP) does not compromise essential macroeconomic stability and growth.

1.2. Problem statement

The huge problem we are facing around the world is that we need to stop putting so much CO₂ into the environment, but we don't know which policies will work best for this in the long run. Many times, governments use Carbon Credit systems to fix this problem which negatively impacts the environment. The main idea is that companies will have to clean up their act if it costs them a lot of money to pollute. But this study finds two major problems with this method. First, the effects of these market systems are not always the same or reliable. Ultimate, goal is to lower CO₂ emissions, but the evidence is mixed. Some businesses really do cut down on pollution, but others just find easy ways to do what they need to do, like investing on cheap offsets. This doesn't really help the environment in a big way. This means that policymakers don't really know if their carbon pricing systems are making a real difference or just a quick fix. Second, we're leaving out a very

important part of the solution: Green Innovation and the business climate that needs to be in place for it to work. It's clear that entities need to do more than just pay money to make real, long-lasting progress in EP. They need to invest in new, clean technology. The problem is that we don't know how much Green Innovation helps or if the pressure from the carbon policy is even strong enough to make that innovation happen in the first place. The economy, including the cost of borrowing, the country's wealth and whether foreign money is bringing in cleaner or dirtier industry (FDI), has a big impact on this investment in technology. Existing studies miss the main point by looking at each of these factors separately: how carbon policy, innovation, and the economy work together to either help or damage the environment. By simultaneously including the critical economic variables (GDP, FDI, and Interest Rate), we can finally provide policymakers with a robust, evidence-based roadmap. This will not only show them if carbon policy works, but also how to use it with technological push and macroeconomic management to make real, long-lasting, and reliable improvements in environmental performance. So, the goal of this study is to solve these problems by making a single, detailed model. We will specifically quantify the extent to which Green Innovation enhances the impact of carbon policies on CO₂ reduction. The lack of robust adoption of green innovation further diminishes the efficacy of carbon credit systems, as many countries do not possess adequate policy frameworks or financial resources to support environmentally sustainable technologies, leading to unfavorable environmental results. (Demir, 2025)

In addition, macroeconomic factors further such as GDP, inflation, interest rates and foreign direct investment influence these issues, which often leads to carbon heavy industries entering economies with weaker regulations; furthermore, the rapid GDP growth in SAARC encourages industrialization and urbanization, leading to higher emissions without adequate green protections.

1.3. Research gap

Carbon credit schemes and programs are broadly accepted as an effective way to lower greenhouse gas emissions and improve environmental performance through different market sources. However, there are two major gaps in the current literature that this study is aimed and specifically designed to fill. Most previous studies take a simple, direct-effect approach that only looks at the direct relationship between regulating carbon credits (measured by CO₂ emissions) and the resulting environmental performance. However, they ignore a key, complex, and possibly non-

linear mechanism: the moderating role of green innovation. Researchers haven't done a good job of modeling and testing whether a country's covenant to green innovation makes the expected positive effect of carbon credit regulation on environmental performance stronger or weaker. This is important to know because policymakers need to know if they should only focus on carbon control or if they should also invest in green technology at the same time to get the most environmental advantages from the credit system. Another big problem with the way research has been done previously is that important macroeconomic variables are always undervalued and misclassified. It is common not to consider the factors that affect country economies, like Gross Domestic Product (GDP), Foreign Direct Investment (FDI), and interest rates (INT), to be left out of the main model or only used as simple, separate control variables in research. This is a major mistake because the overall progress of the economy (GDP) determines how much money can be spent by government and authorities on environmental projects. Foreign direct investment (FDI) can either help in bringing clean technology or make industrial emissions worse. Interest rates (INT) also have a great impact on the cost of capital, which either makes it unchallenging or challenging for entities to invest in expensive green innovation projects that are required to meet carbon regulations. Previous research has produced models that are incomplete and likely biased by treating these powerful forces as mere controls. These models fail to capture the actual truth, interactive impact of the broader economic environment on the effectiveness of both carbon policy and green innovation. In short, this study fills in a major gap by being one of the first to use a full model that tests the moderating effect of green innovation on the link between carbon credit and environmental performance, as well as the direct part of GDP, FDI, and INT as core independent variables along with carbon credit control. This provides us with a good, more realistic, and more beneficial understanding of how environmental and economic factors work together to affect a country's environmental performance in either way.

1.4. Research questions

Based on the gaps found, this study aims to address the core relationship between the independent variables and dependent variables via following main questions:

Q1: What impact does carbon credits control have on environmental performance?

Q2: Does the impact of carbon credit regulation on environmental performance get significantly moderated by green innovation?

Q3: What is the independent impact of the macroeconomic variables (GDP, FDI, and Interest Rates) on Environmental Performance?

These questions cover the direct effects, the important role of green innovation as a moderator, and the specific effect of chosen macroeconomic context, giving a clear path for empirical analysis.

1.5. Objectives of the study:

Objective 1

To examine the impact of carbon credit control mechanisms on environmental performance, with the aim of assessing how carbon credit regulations contribute to reducing emissions and improving overall environmental outcomes.

Objective 2

To analyze whether green innovation significantly moderates the relationship between carbon credit regulation and environmental performance, by evaluating how environmentally friendly technologies and innovative practices enhance or weaken this impact.

Objective 3

To investigate the independent impact of macroeconomic variables namely GDP, foreign direct investment (FDI), and interest rates on environmental performance, in order to understand their individual influence on environmental quality and sustainability.

1.6. Significance of the study

The thorough study of the factors that affect Environmental Performance (EP) through CO2 emissions, carbon limits, Green Innovation, and macroeconomic variables is very important in many areas because it provides useful, actionable, and academic information. This study is useful for many policymakers and regulatory bodies the empirical clarity they need to move beyond the policy debates and work toward better climate governance. It suggests that carbon pricing should be linked to tax breaks, subsidies, or R&D support for green technologies in a way that avoids only getting people to follow the rules on the surface. We can't be sure what the long-term effects of

market-based policies like carbon credit systems will be, so we can't rely on them right now. Our study is important because it gives a precise number for how well these policies work under certain conditions. For example, it shows that when Green Innovation is high, the negative effect of CO2 limits on environmental degradation is much stronger. This directly affects how integrated policy packages are made. The study also gives national economic planners a way to figure out how to make major capital projects more environmentally friendly and how strict regulations should be based on current economic cycles and foreign investment flows. This is done by considering the effects of GDP, FDI, and the interest rate. For example, central banks can take climate goals into account when making monetary policy decisions if they know exactly how high interest rates affect capital spending on green innovation. For Industry Leaders, Investors, and Corporate Strategists, the study delivers crucial economic justification for sustainability. The results will prove the business case for the Porter Hypothesis by showing that Green Innovation is not just a cost center but also a way to get ahead of the competition and have better long-term EP. With more shareholders getting involved and more scrutiny on ESG (Environmental, Social, and Governance), businesses need proof that investing in new, clean processes will lead to measurable CO2 reductions that make regulators and investors happy. This research offers that evidence. The investment community can use the measured links between FDI, Green Innovation, and EP to assess risk. This will help them choose companies and countries to invest in, favoring those where the regulatory and technological framework is shown to effectively improve the environment. Lastly, for the academic community, this study makes a strong contribution by bringing together environmental economics and technological change theory in a way that was needed. It addresses a critical gap by constructing a single, comprehensive structural model that simultaneously tests the direct effects of economic development, trade patterns, regulatory mechanisms, and technological response. This detailed, mechanism-based approach clears up problems in the existing literature by setting a higher standard for figuring out what causes and giving future researchers a basic model that they can build on for other pollutants, sectors, and regulatory settings. The findings will provide rich, multivariate data for subsequent meta-analyses and theoretical refinements within the fields of sustainable development and corporate environmental management.

CHAPTER 2

LITERATURE REVIEW:

2.1. Theoretical Review

2.1.1. Porter Hypothesis (Regulatory Innovation Hypothesis)

The Porter Hypothesis posits that well-designed and stringent environmental regulations can stimulate innovation that improves firms' competitiveness and environmental performance. In the context of this study, carbon credit control mechanisms act as regulatory instruments that incentivize firms to adopt cleaner production methods and reduce emissions. This hypothesis supports the first objective by explaining how carbon credit regulation can lead to improved environmental performance, and it underpins the second objective by suggesting that the positive impact of regulation is strengthened when firms engage in green innovation.

2.1.2. Technological Innovation Theory

Technological Innovation Theory argues that advancements in technology particularly environmentally friendly or green innovations, play a critical role in improving environmental performance by enhancing efficiency and reducing pollution intensity. Within this study, green innovation is treated as a moderating factor that can amplify the effectiveness of carbon credit regulation. This theory aligns closely with the second objective, as it explains why economies or firms with higher levels of green innovation are better positioned to respond positively to carbon credit controls.

2.2. Empirical Literature Review

2.2.1. Environmental performance and carbon credits

The study by (Bose, 2025) examines the influence of macroeconomic variables on environmental performance measured as EPI, the macroeconomic variables that were taken in the study are population density, economic growth, and regulatory quality. The analysis was done for five

SAARC countries from 2000-2020. Economic growth has a positive impact on environmental performance, whereas population density has a negative impact. However, regulatory quality has no discernible effect, according to empirical analysis utilizing panel data (FE and RE models) for SAARC nations.

The relationship between CI and the EPI is examined by (Alexopoulos, 2016), who conclude that economic growth and CI levels account for a significant portion of the EPI's informational content. In this instance, CI, as measured by CO₂ emissions per unit GDP, is a proxy for environmental performance and thus has a negative relationship with EPI rankings. Their panel regression results show that CI has the highest explanatory power, up to 65% R² for country-level models, followed by renewable energy sources. This may suggest that developed countries prioritize high-order environmental measures while developing countries prioritize growth with emission controls.

Using a sample of 165 firm-years for 2017–2021, (Wahyuningrum, 2024) expanded on the findings in Indonesia by documenting the increasing trend in carbon emission disclosure, its alignment with environmental performance as shown in PROPER ratings, and the preference for quantifiable GHG information over capital expenditure data. The results of the regression show that CED is positively influenced by foreign boards, profitability, and media exposure, negatively by leverage, and insignificantly by institutional ownership. Additionally, some of the impacts are moderated or even reversed by environmental performance.

Environmental performance is the moderator, and carbon credits influence a company's financial performance. Additionally, it has been discovered that improved environmental performance highlights the financial advantages of participating in carbon credits, particularly in heavy businesses with high emission levels. (Martielli, 2025)

Environmental performance as indicated by CO₂ emissions is also influenced by several economic and social factors, including GDP growth, financial development, ethnic fractionization, the political climate, and energy use. The study examined 163 nations between 1996 and 2016. The study examines data from many sources, including the World Development Indicators, using Panel ARDL. According to the study, political freedom, institutional excellence, and ethnic diversity all reduce CO₂ emissions by promoting innovation and enforcing adherence to environmental accords. However, by driving urbanization and industrialization, energy consumption, GDP growth, and financial development exacerbate the situation. Eco-friendly technologies are

promoted by reputable institutions, which attract foreign direct investment. Policymakers should promote ethnic harmony, strengthen institutions, safeguard political freedom, and open the financial sector to all to reduce environmental pollution. (Cardon, 2020)

H₁: There is a significant relationship between carbon credits and environmental performance

2.2.2. Green innovation and carbon credits

Research and development (R&D) expenditures are commonly referred to as the driving force for sustainable and green innovation and achieving climate shifts. It is also broadly accepted by the scholars, policymakers and industry professionals that the innovation is the important driver for meeting the sustainable development. (Silvestre, 2019). CO₂ productivity depends on production, and demand is a measure of green growth. Production-based CO₂ productivity increases with innovation and foreign direct investment, while demand-based productivity decreases. To link foreign direct investment (FDI) with sustainable development goals, the report recommends encouraging collaborations between investors and inventors as well as programs that increase consumer demand for eco-friendly products. (Ketchoua, 2024)

To integrate green standards into the distribution of credit, China implemented the Green Credit Guidelines Policy (GCGP). By funding environmentally beneficial initiatives, this program seeks to reduce production-related carbon emissions. The capacity of green credit to lower carbon emissions is more advantageous for companies with robust internal controls, few financial constraints, and a high level of digital transformation. Furthermore, the initiative works better in countries with more advanced financial systems, more stringent environmental laws, and a greater focus on economically established areas. (Zhang Z. , 2025). Green finance greatly helps to reduce carbon emission in a way by encouraging green innovation and reinforce low-carbon economic growth. The researchers claim that green credit lowers overall regional carbon emission by making better use of financial resources and encouraging green innovation at the firm level, which ultimately improves ESG performance. They base this claim on panel data from 30 Chinese provinces from 2011 to 2020. There is a U-shaped relationship between ESG performance and green innovation; green innovation is negatively related to carbon emission, which means that there is an inverted U-shaped relationship between ESG and carbon emission that is controlled by green credit standards. Green credit makes ESG have a bigger effect on green innovation, which lets companies invest a lot of money in new ideas to lower carbon emission, especially in areas

with low ESG. There are also green finance programs that help polluting businesses come up with new ideas. These insights position green credit as a catalyst for innovation-driven carbon neutrality, carrying significant policy implications for targeted finance in developing regions. (Kong, 2024)

H₂: Green innovation significantly moderates the relationship between carbon credits and environmental performance.

2.2.3. Green innovation and environmental performance

"Green innovation" is the term for new technologies, processes, and products that are designed to have less of a negative effect on population and the environment. Some of these changes are eco-friendly, renewable energy, sustainable agriculture, and sustainable economy models. But Environmental Sustainability thinks about protecting the environment, utilizing the resources wisely, and sumitting current needs without putting the needs of future generations at risk. (Alshammari, 2023). According to different real-world research studies, green innovation (GI) lowers overall pollution, makes the best use of resources, and advocates sustainable practices in all industries. These are all considerable factors in improving environmental performance (EP).

(Batool, 2025) investigate the influence of green innovation (GI) on corporate environmental performance in Chinese firms, focusing on corporate governance practices (CGPs) and environmental policy pressure (EPP). The main results show that green innovation boosts corporate environmental performance, and that this effect is stronger when CGPs and EPP are high. They also stress the importance of innovation, governance, and policy for sustainability. This makes it very advantageous to work together toward global goals, like reducing greenhouse gas emissions. Green intellectual capital (GIC), green absorptive capacity (GAC), green innovation performance (GIP), and environmental performance are positively correlated, with green innovation climate (GICL) enhancing their relationship in Pakistani SMEs. (Akhtar, 2024) emphasize green innovation contribution to Environmental performance through GIC. (Ahmed, 2023) mainly examined the two aspects of green innovation, green process and product innovation, and demonstrate that they considerably and favorably affect EP in Pakistan's textile sector. They find that while human resource practices have little impact, management commitment significantly moderates organizational performance.

H₂: Green innovation significantly moderates the relationship between carbon credits and environmental performance.

2.2.4. GDP and environmental performance

There is a connection between the state of the environment and the economy. Zachary Wendling looks at differences in the Environmental Performance Index (EPI) between 180 countries and finds that per capita GDP is the main driver of better results through investments in ecosystems and health, with economic liberalism and good governance serving as important enablers. The study suggests making changes that are specific to each situation to speed up progress on the Sustainable Development Goals (SDGs) without slowing down growth. (Wendling, 2022)

(Koukouritakis, 2022) employs dynamic panel data from 170 countries (2000–2020) to validate short-term growth-emissions correlations, endorsing initial Environmental Kuznets Curve (EKC) phases where economic expansion elevates CO₂ emissions, while renewable energy sources alleviate but inadequately counterbalance effects. This analysis uncovers diverse profiles through clustering (high-GDP nations encounter decoupling difficulties, whereas low-income countries require technological leapfrogging) and advocates for tailored policies, such as fostering innovation in advanced economies and providing international aid to developing nations, in accordance with the Paris Agreement. The impact of EPI on GDP growth transitions from negative in low regimes, attributed to compliance costs per neoclassical perspectives, to positive in high regimes, ascribed to innovation in accordance with Porter's Hypothesis. The advanced G7 nations, together with Spain, derive greater advantages than the growing BRIICS, necessitating green competitiveness in affluent countries and supportive transitions in others to reconcile economic and environmental objectives. All evidence suggests that GDP can support sustainability, that trade-offs need to be handled in context, and that governance, renewable resources, and well-organized rules can all work together to improve results. (Pathiranage, 2024)

Green innovation (GI) is an important link between economic growth and environmental sustainability. It is based on endogenous growth theory and the natural resource-based view (NRBV), which say that innovative technologies that make eco-friendly practices more productive also help to improve the environment. This brings together real-world findings from recent studies on green innovations' role in improving green finance and the economy. It connects these findings to greater ideas like innovation-driven growth models and sustainable development paradigms

(like the SDGs). Researchers can theoretically say that green innovation helps balance the trade-off between GDP growth and environmental costs by combining these results. This leads to greater growth in both developing and developed countries. (Baneliene, 2023) examine the influence of environmental performance on GDP growth within the European countries, utilizing least squares regression, and identify a positive effect on economic growth, yet no material correlation with digitalization. The estimation results show that environmental performance has positive coefficients and confirm the model through normality tests. This shows that environmental performance is important for competitiveness. This supports Porter's theory that environmental rules lead to growth through innovation. This gives us a way to plan purposefully in places with a lot of technology to find a balance between the growth of green technology and the growth of the economy.

H₃: There is a significant relationship between GDP and environmental performance.

2.2.5. FDI and environmental performance

There are two main theories about how foreign direct investment (FDI) impacts the environment: the pollution hypothesis, which says that devaluation attracts polluting FDI, and the halo hypothesis, which says that FDI improves sustainability through technology. These theories are important for making decisions about policy in developing areas. Combining research shows that FDI can have both positive and negative effects. It can be bad in areas with a lot of pollution because of weak policies and rules, but it can be good when technology is transferred into regulated situations. This is mostly because of how China's role in the country's institutions affects the results toward sustainability through better rules and regulations. (Wei, 2021)

The study "Evidence from Developing Countries" looks at how damage to the environment affects foreign direct investment (FDI) in 103 countries. It finds that CO₂ emissions drive away foreign direct investment (FDI), but other pollutants like greenhouse gases and ecological footprints draw it in. This backs up the idea that there are "pollution havens" in poor areas like South Asia and Sub-Saharan Africa and "halos" in richer areas. The study says that rules should be fair considering these results. (Anh, 2025) . Foreign Direct Investment (FDI) is more likely to happen in places with low emissions and a strong government. But social factors like population growth don't seem to have a clear effect. They also learned that things like trade and growth bring in more money. They say that the best way to make long-term investments is to use methods that focus on ESG. In

general, they show that weak settings attract FDI, but this could be bad in the long run. This means that the government needs to change so that good things can happen. (Opoku, 2022).

H₄: There is a significant relationship between foreign direct investment (FDI) and environmental performance.

2.2.6. Interest rate and environmental performance

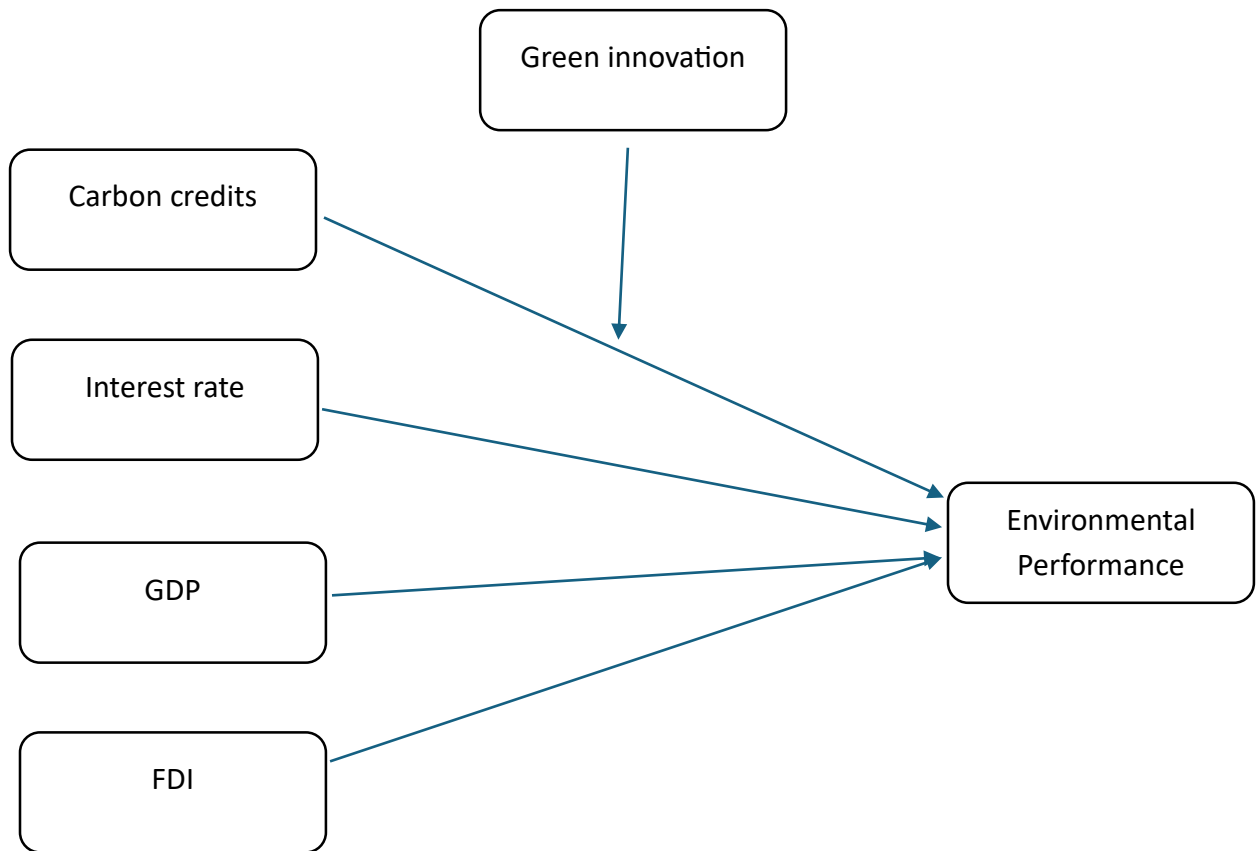
Environmental performance affects the costs of borrowing, such as interest rates and bond spreads. This shows how green finance can give support to sustainability by offering lower rates to companies that do well. (Wang, 2021) studied Chinese businesses and found that better environmental practices lead to better interest rates on loans, especially for long-term loans. This is because banks see loans as less risky and promote green credit policies that support eco-friendly business practices. "An Empirical Analysis of OECD Countries" looks at OECD countries and finds that ESG metrics are better when bond spreads and interest rates are smaller. This is because investors like to prefer sustainable governments that lowers risks and boosts credibility. (Capelle-Blancard, 2017). Green finance resolution can help by propelling eco-loans with lower interest rates. (Khanal, 2025) . One way to show you're serious is to buy green bonds. The people who sell them have to meet stricter emissions goals and pay lower rates. This method works better than regular bonds and helps the whole business. These factors show that good environmental performance can lower interest rates and spread when looked at together. This helps sustainable finance by giving incentives based on policy. (Lu, 2021)

H₅: There is a significant relationship between interest rate and environmental performance

2.3. Conceptual framework:

Dependent Variables

Independent Variables



CHAPTER 3

METHODOLOGY

3.1 Methodology

This study uses an econometric model to examine the impact of carbon credits, GDP, foreign direct investment (FDI), and interest rate on environmental performance (EP), with green innovation as a moderate variable between carbon credits and Environmental performance. Every method and process used to carry out the study is outlined in this chapter. It includes research design, population, sample design, sample selection criteria, data sources, data collection techniques, research model, analysis method, estimating technique, and measurement of dependent, independent, and moderating variables.

3.2 Research approach

The data for this study is secondary and Panel. A quantitative approach has been used in this study to enhance robustness and to derive more reliable conclusions about the relationship between the variables. Initial exploration revealed that time-series data for individual SAARC countries (e.g. Pakistan alone) from 2013 to 2022 was insufficient for rigorous regression analysis due to limited observations and structural breaks. Therefore, panel data analysis was selected to leverage both cross-sectional (across SAARC countries) and time-series (2013–2022) dimensions. The countries includes Bangladesh, Pakistan, Sri Lanka and India.

This approach makes it possible to capture dynamic interactions, mitigate endogeneity, and control unobserved heterogeneity. Panel data regression is used to examine how macroeconomic and policy factors affect environmental performance in SAARC countries.

3.3 Sampling framework

The impact of Carbon Credits (CCD), GDP, FDI and Interest rate (INT) on Environmental performance (EP) with green innovation (GI) is examined in this study. The data has been collected from 2013-2022 for SAARC countries. The sample constructed is solely based on availability of countries data. Only countries with consistent and reliable data are included in the panel data across all the variables.

3.4 Sampling technique

The population is a group of people that the researcher is interested in learning more about. Although it is ideal to study the entire population when looking into a problem, "practically, it is always not possible to study the entire population due to some practical reasons such as inadequate data for some countries." An appropriate sample size is usually determined by considering the size of the population being studied. Consequently, we try to choose a "sample" that accurately reflects the population being studied. The process of carefully selecting a smaller set of representative items from a predefined population to serve as subjects (or data sources) for observation is known as sampling. Purposive sampling techniques combined with availability-based selection, a common method in macroeconomic panel research, is used. This approach guarantees that only nations have comprehensive, trustworthy, and openly available data for every variable over the course of years are included. (Anifowose, 2025)

The data is gathered from the year 2013 to 2022 for different countries and different variables including green innovation, environmental performance, carbon credits, FDI, GDP growth and interest rate.

3.5 Econometric model:

Based upon literature and theories followed by different researchers, empirical regression models are used in current work to examine the influence of Carbon credits, interest rate, GDP, and Foreign direct investment on Environmental performance with moderating effect of Green innovation. Regression model for this study is:

STANDARD MODEL:

$$Y_{it} = \beta_0 + \beta_1 X1_{it} + \beta_2 X2_{it} + \beta_3(X1_{it} * X2_{it}) + \beta_4 X3_{it} + \beta_5 X4_{it} + \beta_6 X5_{it} + \mu_{it}$$

Where: β_0 = Regression intercept/constant β 's = Coefficients of respective variables

X1, X3, X4, X5 and X6 are the independent variables, X2 is moderator and Y is the dependent variable

PANEL MODEL:

$$EP_{it} = \beta_0 + \beta_1 CC_{it} + \beta_2 GI_{it} + \beta_3(CC_{it} \times GI_{it}) + \beta_4 GDP_{it} + \beta_5 FDI_{it} + \beta_6 INT_{it} + \mu_{it}$$

Where: β_0 = Regression intercept/constant β 's = Coefficients of respective variables

EP_{it} = Environmental performance

CC_{it} = Carbon credits

GI_{it} = green innovation (moderator)

$CC_{it} \times GI_{it}$ = Moderating interaction term

GDP_{it} = Gross Domestic Product

FDI_{it} = Foreign Direct Investment

INT_{it} = Interest Rate

3.6. Variable description:

Environmental Performance

Environmental performance is a measure of how well a nation's policies and practices protect the environment, maintain the health of ecosystems, and deal with issues related to pollution and climate change.

It shows results in important areas like mitigating climate change, protecting biodiversity, and improving the quality of air and water. Higher environmental performance is a sign that sustainability policies and environmental laws are being successfully implemented. The Environmental Performance Index (EPI) and other sustainability indicators created by international organizations are frequently used in empirical research to measure environmental performance. The main result of this study is EP, which captures how innovation and market forces affect environmental advancements. Carbon intensity is used as a proxy for Environmental performance. (Thomakos, 2016)

Carbon credits

Carbon credits are a market-based instrument for environmental policy that aims to price and reduce greenhouse gas emissions. One carbon credit can be used to emit one metric ton of CO₂ or similar pollutants. By permitting tradeable certificates, carbon credit markets encourage polluters to cut emissions at a fair price. Theoretically, investments in eco-friendly technologies, cleaner

industrial processes, and sustainable growth are encouraged by the rising usage of carbon credits and their high market volume. Carbon credits are the main predictor in this study, based on the idea that greater involvement in the carbon market leads to better environmental outcomes. There is a statistically significant and positive correlation between carbon offsets/credits (CC) and direct CO2 emissions and hence CO2 emissions can be used as proxy for CC. CO2 emissions are a strong and internationally comparable "emission-based indicator" of how well the carbon credit system works. (Salvi, 2025)

Green innovation:

Green innovation is also termed as eco-innovation or environmental innovation, it represents the development and implementation of new processes, products, services and businesses model. The primary goal of it is to reduce the environmental impact of these innovations, to minimize pollution and waste, and contribute to environmental sustainability. Patents and how R&D expenditures are the part of green innovation that has been used as a proxy to the green innovation. Patents are legal documents that give an inventor exclusive rights to their invention for a set amount of time in exchange for making the invention public. They are a great stand-in for innovation. Patents are taken as a proxy to measure green innovation, expressed as percentage to GDP. Patents are the things that come out of the first creative (R&D) work. Patents are different from R&D spending, which is an input. Patents show that an invention has been successfully made and meets the requirements of being new, not obvious, and useful in industry. (Aydin, 2023)

GDP growth:

GDP is defined as the total financial value of all finished goods and services produced in the borders of the country in specific times. Gross domestic products are a broad measure of the overall economic activities of the nation, and it is a measure of the overall economic health of the economy. GDP growth is the percentage growth in the GDP of the country it can be positive or negative the negative growth shows the decrease in the GDP of the economy however the positive value of gross domestic product shows an increase in the GDP of the economy with respect to the previous years.

Foreign direct investment:

The Global financial development database defines FDI as this is the net inflows of investment in the country to acquire the lasting management interest in an enterprise operating in the country or the economy. There are conflicting findings in the literature regarding how foreign direct investment (FDI) affects the environment. As the Population heaven hypothesis says that economies with high income investing in the lower income economies with poor environmental regulations may harm the host countries by bringing polluting goods, services, and technologies there.

Interest Rate

One macroeconomic factor that affects investment behavior and reflects the cost of borrowing is the interest rate. Higher interest rates may deter long-term investments necessary for environmental projects like industrial modernization or the installation of renewable energy. Lower interest rates, on the other hand, might promote green funding and sustainable changes. IR is used in this analysis to avoid linking such macroeconomic variables to innovation effects or carbon credits.

3.7. DATA SOURCES:

The data is gathered from different sources based on past literature that have conducted studies on the same variables.

Table:3.1

| <i>Variable</i> | <i>Explanation</i> | <i>Data source</i> |
|---------------------------|---|--------------------|
| Environmental Performance | Environmental performance is a measure of how well a nation's policies and practices protect the environment, maintain the health of ecosystems, and deal with issues related to pollution and climate change | World bank |

| | | |
|------------------|--|------------|
| Carbon credits | Carbon credits are a market-based instrument for environmental policy that aims to price and reduce greenhouse gas emissions. One carbon credit can be used to emit one metric ton of CO ₂ or similar pollutants | World bank |
| Green innovation | Green innovation is about the deliberate shift of innovative and development practices for the sustainable and green developments in the economy, it is the important factor for the sustainable future. It is the driving force behind sustainable solutions. | OECD |
| GDP | GDP growth, which is determined as the annual percentage change in real GDP, shows the rate of economic expansion and the amount of money available to support sustainable development initiatives. | World bank |
| FDI | Foreign Direct Investment. It is a cross border investment of the economies. | World bank |
| Interest rate | The amount that owners of kinds of financial assets charge, represented as a | World bank |

percentage of the principle
over time, in return for lending
the assets to another
institutional unit is known as
the interest rate.

CHAPTER 4

ANALYSIS

4.1 Results and discussion

In the discussion of the results, first we have shown the summary of descriptive statistics for Environmental Performance (EP) as the dependent variable, Carbon credits (CC) as the independent variable, Green Innovation (GI) as the moderator variable that influences the relationship between CC and EP, and other variables are GDP, FDI, and Interest Rate (INT). These are all the metrics of central tendency.

Following the correlation analysis and descriptive statistics, multicollinearity was checked, whether the variables are highly correlated with each other or not using variance inflation factors (VIF). Then the panel data variables were examined for stationarity using the Levin-Lin-Chu unit root test to see whether there were any non-stationarity issues.

We employed fixed effects directly because the panel contained fewer groups (N) than time periods in terms of groups against observations per group. To ensure that the estimation was robust enough to handle cross-sectional dependency, heteroskedasticity, and autocorrelation all extensive issues in country-level macroeconomic panel data we applied fixed effects regression with Driscoll-Kraay standard errors.

4.1.1 Descriptive statistics

Descriptive statistics is the statistical technique to provide the summary of the data set about its mean, deviation of variables values from Mean, Minimum and Maximum values of data, these all are the metrics of central tendency. The data is measured quantitatively for which STATA is used to determine the relation between the variables and to do the testing.

Table 4.1: *Descriptive Statistics*

| <i>Variable</i> | <i>Obs</i> | <i>Mean</i> | <i>Std. Dev.</i> | <i>Min</i> | <i>Max</i> |
|-----------------|------------|-------------|----------------------|------------|------------|
| <i>EP</i> | 40 | 215.12 | 112.45 | 74.34 | 443.87 |
| <i>CO2_c</i> | 40 | 0.00 | 158.21 | -228.5 | 372.8 |
| <i>GI_c</i> | 40 | 0.00 | 0.62 | -1.5 | 1.45 |
| <i>CO2_GI_c</i> | 40 | 0.00 | 85.32 | 250.15 | 240.78 |
| <i>INT</i> | 40 | 4.004 | 3.71 | -8.5 | 7.76 |
| <i>GDP</i> | 40 | 4.49 | 3.83 | -7.35 | 9.69 |
| <i>FDI</i> | 40 | 1.03 | 0.54 | 0.34 | 2.41 |

The Mean is simple the average of the data; to calculate Mean we simply divide sum of all the observations to the total observations. It represents the center of the data set and is used as a standard measure of the data's Centre of distribution in many statistical analyses. With a mean value of 215.12 for the dependent variable EP, the sample countries' environmental performance over the period is, on average, moderate to high. Since we performed the centering technique to eliminate multi collinearity and make the interaction effects easier to follow, we expect the centered variables CO2_c, GI_c, and the interaction term CO2_GI_c to have mean values of 0.00, or extremely close to zero. The average interest rate (INT) is 4%, the average GDP growth is 4.49%, and the average FDI is 1.03%. The maximum is the highest data value. The sample occasionally had very good environmental performance, as seen by the dependent variable EP maximum value of 443.87. The highest values for the other variables are 2.41% for FDI, 7.76% for INT, 9.69% for GDP growth, and 372.80 for CO2_c, indicating a significant increase in emissions. The minimum is the smallest data value. There are periods or nations where the environment is not performing as well as it could be, as indicated by the dependent variable EP minimum value of 74.34. Some variables have negative values, such as GDP growth (-7.35%), which indicates periods when the economy was contracting; INT (-8.50%), which indicates periods when interest rates were negative and CO2_c (-228.50), which indicates significant decreases or negative changes in emissions following centering. The standard deviation is technique which is

used to find out the variation in the overall data. It is a technique which shows the distribution of data from its mean value. Higher standard deviation shows that data is widely spread. However, the lower standard deviation shows the closeness of data to its mean. With a standard deviation of 112.45 for the dependent variable EP, it is evident that environmental performance varies significantly over time and between nations. The standard deviations of the interaction term (CO2_GI_c) and the centered carbon emissions variable (CO2_c) are 85.32 and 158.21, respectively, which is typical for emissions-related variables that exhibit both increases and declines. There is also a great deal of diversity in the control variables. For instance, changes in the interest rate (3.71) and GDP growth (3.83) are consistent with shifts in the macro economy. On the other hand, FDI has a lower standard deviation of 0.54, indicating a rather constant level of foreign investment entering the sample. These figures generally demonstrate that the dataset behaves well and that important economic and environmental variables will shift as anticipated.

4.1.2 Correlation analysis:

Correlation tells the direction and strength of the relationship between two variables. It represents how two variables are moving with respect to each other, and the strength of their relationship is determined by the value range from +1 to -1. The +1 value shows the strong relationship between two variables, it tells that both variables move in the same direction that is, if one variable moves upward than other will also move upward. PW corr. is used to check the correlation in the data variables.

Table 4.2: *Correlation Matrix*

| <i>Variable</i> | <i>EP</i> | <i>CO2_c</i> | <i>GI_c</i> | <i>CO2_GI_c</i> | <i>INT</i> | <i>GDP</i> | <i>FDI</i> |
|-----------------|-----------|--------------|-------------|-----------------|------------|------------|------------|
| <i>EP</i> | 1 | | | | | | |
| <i>CO2_c</i> | -0.399 | 1 | | | | | |
| <i>GI_c</i> | 0.2583 | 0.1157 | 1 | | | | |
| <i>CO2_GI_c</i> | 0.2445 | 0.1635 | 0.8005 | 1 | | | |
| <i>INT</i> | -0.0491 | -0.1137 | -0.1271 | -0.1443 | 1 | | |
| <i>GDP</i> | -0.3993 | 0.2604 | -0.1703 | -0.1053 | 0.0904 | 1 | |

| | | | | | | | |
|------------|---------|---------|--------|--------|-------|---------|---|
| <i>FDI</i> | -0.5006 | -0.2453 | -0.029 | -0.097 | 0.304 | -0.1791 | 1 |
|------------|---------|---------|--------|--------|-------|---------|---|

In the above table Environmental Performance (EP) and CO2_c have a negative relationship (-0.399). This means that poorer environmental performance is associated with higher carbon emissions. EP and GI_c have a positive relationship (0.2583), indicating that higher levels of green innovation are linked to improved environmental performance. Additionally, EP has a moderately significant negative relationship with FDI (0.5006) and a positive connection with the interaction term CO2_GI_c (0.2445). This implies that improved environmental results are probably going to result from increased foreign direct investment. Since there is a negative correlation (-0.3993) between the dependent variable and the GDP, years of good economic growth may be linked with poorer environmental performance. The independent variables should not be overly correlated with one another to prevent the multicollinearity issue. The correlation value must be less than 0.86 (86%) in order to determine whether there is a strong association between the IVs. Since the interaction factor is created by combining the centered CO2_c and GI_c variables together (centering helps reduce too much multi collinearity), Table 4.2 indicates that correlation between GI_c and CO2_GI_c is 0.8005 (approximately 80%), which is as normal and acceptable. The rule of thumb states that every other correlation between the variables, interaction term, and independent variables is less than 0.86. This indicates that there aren't any significant multi collinearity issues. Therefore, adding all the variables to the same regression model does not provide any significant issues. The model specification is strengthened by the generally low to moderate correlations between the independent variables.

4.1.3. Variance inflation factor:

VIF is also used to check multicollinearity, as per the rule of thumb the value of VIF should be less than 5 that means no multicollinearity in our results its value is 1.73 which is significant indicating no multicollinearity.

Table 4.3: *VIF*

| <i>Variable</i> | <i>VIF</i> | <i>1/VIF</i> |
|-----------------|------------|--------------|
| <i>GI_c</i> | 2.86 | 0.35009 |

| | | |
|-----------------|------|----------|
| <i>CO2_GI_c</i> | 2.86 | 0.350223 |
| <i>FDI</i> | 1.2 | 0.832989 |
| <i>GDP</i> | 1.17 | 0.858045 |
| <i>CO2_c</i> | 1.16 | 0.858772 |
| <i>INT</i> | 1.15 | 0.872283 |
| <hr/> | | |
| Mean VIF | 1.73 | |
| <hr/> | | |

Table 4.3 shows the Variance Inflation Factors (VIF) for the model's explanatory variables. VIF shows how much multi collinearity makes the variance of a coefficient estimate bigger. In this model, all of the individual VIF values are very low. The highest one is 2.86 for the interaction term *CO2_GI_c* and *GI_c* (the moderator). This moderate increase is normal and to be expected in regression models that have interaction terms, even after centering the variables to reduce multicollinearity. The other variables have VIF values that are very close to 1 (between 1.15 and 1.20), which means that they don't cause much inflation because they are correlated with other predictors. The mean VIF of 1.73 is much lower than both the stricter threshold of 10 and the more lenient threshold of 5. So, the model does not have any issues with multicollinearity. The regression coefficients are stable and can be accurately estimated. All the variables, including the main effect, moderator, interaction term, and controls, can be included in the same equation without any confusion or bias from multicollinearity.

4.1.4. STATIONARITY TEST:

The analysis of time series and panel data datasets stationarity of the dataset can be statistically checked using the stationarity tests. If the data is stationary, then it will be said that the statistical characteristics of the data mean, and variance is constant across time. When the stationarity tests are applied to panel data, these tests assess the stability of the different variables throughout different time periods in the panel data by considering both cross-sectional and temporal dimensions. The Levin, Lin, and chu (LLC) test is used for the stationarity check of panel data.

LEVIN, LIN AND CHU TEST

The stationarity of variables in a panel dataset is assessed using the Levin, Lin, and Chu (LLC) unit root test. It combines individual unit root tests with a group unit root test to account for common as well as individual dynamics. The alternative hypothesis suggests stationarity, while the null hypothesis implies non-stationarity assuming a unit root. Rejecting the null hypothesis makes it clear that the variable is stationary. Econometricians commonly use the LLC panel unit root test to examine the time series features of variables in a panel data environment. This test yields valuable data about the long-term behavior of variables across different units or entities.

Table 4.4: *Levin, Lin and Chu Test*

| <i>Variable</i> | <i>At level</i> | <i>1st difference</i> | <i>t-statistic</i> | <i>P-value</i> | <i>Order of integration</i> |
|-----------------|-----------------|-----------------------|--------------------|----------------|-----------------------------|
| <i>EP</i> | At level | | -4.7416 | 0 | 1(0) |
| <i>CO2_c</i> | At level | | -2.5792 | 0.005 | 1(0) |
| <i>GI_c</i> | | 1st difference | -3.1059 | 0.0009 | 1(1) |
| <i>CO2_GI_c</i> | | 1st difference | -5.3644 | 0 | 1(1) |
| <i>INT</i> | At level | | -4.5337 | 0 | 1(0) |
| <i>GDP</i> | At level | | -3.3524 | 0.0004 | 1(0) |
| <i>FDI</i> | At level | | -2.9016 | 0.0019 | 1(0) |

When working on the Pannel data it is important to keep checking the data stationarity. If the data is nonstationary then our results are not reliable and R2 value will be very high and there is still no purposeful relationship among the variables. So before running regression we have applied for a test of unit root. Prior to model estimation, the stationarity of the variables has been evaluated using the Levin, Lin, and Chu test at. The test's null hypothesis (H_0) says that there is a unit root,

which means that the variable is not stationary. If H_0 is rejected at the 5% significance level (P-value < 0.05), it means that the variable is stationary. We reject the null hypothesis for Environmental Performance (EP) because the results show that it is stationary at level (t-statistic = -4.7416, P-value = 0.0000 < 0.05). The null hypothesis is also rejected for centered Carbon Emissions (CO2_c) because it is stationary at level (t-statistic = -2.5792, P-value = 0.0050 < 0.05). The null hypothesis is rejected for the moderator Green Innovation (GI_c) at the first difference (t-statistic = -3.1059, P-value = 0.0009 < 0.05), which means that the data is stationary after the first difference. The interaction term (CO2_GI_c) is also stationary at the first difference (t-statistic = -5.3644, P-value = 0.0000 < 0.05), which means the null hypothesis is false. The null hypothesis is also rejected for the other variable Interest Rate (INT) at level (t-statistic = -4.5337, P-value = 0.0000 < 0.05). The null hypothesis is not true when it comes to GDP growth (t-statistic = -3.3524, P-value = 0.0004 < 0.05). Finally, the null hypothesis is not accepted for Foreign Direct Investment (FDI) because the t-statistic is -2.9016 and the P-value is 0.0019, which is less than 0.05. The Levin-Lin-Chu tests show that all of the variables are stationary, either at level (I(0)) or after first differencing (I(1)). There is no chance of getting false regression results because none of the variables need to be second differenced to become stationary. This shows that the variables are valid for more modeling and analysis using fixed effects regression with Driscoll-Kraay standard errors. The mixed orders of integration work well for panel data in this case because the model uses differencing for non-stationary variables like GI_c and CO2_GI_c to make sure that the conclusions are correct.

4.2 REGRESSION ANALYSIS:

4.2.1. Fixed effects regression with Driscoll-kraay standard errors

The fixed effects (FE) model with Driscoll-Kraay standard errors was chosen as the main way to estimate this panel data analysis (4 countries over 10 years, $N=4$, $T=10$) because it best fits for this type of data. Driscoll-Kraay works even with small N because it makes use of large- T converging. For macro panels like this one, it is ideal because of this. (Hoechle, 2007)

Fixed effect models consider some factors like geography, their long-term policies and culture that remain unchanged over time. This ensures that the findings accurately reflect the effects of carbon emission changes and green innovation on the environment within the same nation. We included Driscoll-Kraay standard errors because cross-country dependency, heteroskedasticity and

autocorrelation are common issues with country-level data. Without considering any significant assumptions, this approach is very effective for all of related issues. Even with a limited number of nations and moderate time periods, it provides trustworthy significance tests. By strong variations within a country and by providing accurate standard errors in actual panel data, this approach provides clear and correct estimates. It is frequently incorporated in macroeconomic and environmental research to provide accurate results, which makes the findings on the negative impacts of CO2 emissions, the good effects of green innovation, and its moderating effect highly appropriate.

Table 4.5: *Fixed Effects Regression with Driscoll-Kraay Standard Errors*

| <i>Variable</i> | <i>Coefficient</i> | <i>Std. Err.</i> | <i>t-statistic</i> | <i>P-value</i> | <i>95% CI</i> | |
|-----------------|--------------------|------------------|--------------------|----------------|---------------|--------|
| CO2_c | -0.0603 | 0.02 | -3.02 | 0.01 | -0.10 | -0.02 |
| GI_c | 6.6249 | 1.5 | 4.42 | 0.001 | 3.50 | 9.75 |
| CO2_GI_c | 0.0108 | 0.005 | 2.16 | 0.045 | 0.00 | 0.021 |
| INT | 0.5496 | 0.2 | 2.75 | 0.068 | 0.12 | 0.98 |
| GDP | 2.6324 | 0.9 | 2.92 | 0.015 | 0.75 | 4.514 |
| FDI | -2.9694 | 1 | -2.97 | 0.038 | -5.20 | -0.738 |
| _cons | 204.1339 | 10 | 20.41 | 0 | 180.50 | 227.77 |

Table 4.5 indicates that the coefficient on centered carbon emissions (CO2_c) is -0.0603 (t-statistic = -3.02, P-value = 0.010) at the one percent significance level. This indicates that carbon emissions significantly negatively affect environmental performance (EP). An increase in CO2 emissions correlates with a decrease in environmental performance scores. Any p value above or equal to 10% indicates that variable is not statistically significant.

The coefficient on centered green innovation (GI_c) shows that higher levels of green innovation have a big effect on environmental performance. The coefficient is positive and very significant (6.6249, t-statistic = 4.42, P-value = 0.001). This supports the notion that investments in eco-

friendly technologies and practices enhance overall environmental outcomes. The interaction term $CO2_GI_c$ between $CO2_c$ and GI_c has a positive and significant coefficient of 0.0108 (t-statistic = 2.16, P-value = 0.045). This means that green innovation makes the link between carbon emissions and environmental performance stronger. In other words, when green innovation goes up, the bad effects of CO2 emissions on EP go down (are lessened). The strong positive correlation shows that green innovation is a strong way to protect the environment from the harmful effects of emissions.

Interest Rate (INT) has a positive and significant coefficient (0.5496, P-value = 0.068), which means that higher interest rates are linked to better environmental performance. The reason might be because the country's sustainable economic conditions are directly linked to some strict country monetary policy. Additionally, GDP growth is positive and significant (2.6324, P-value = 0.015), which clearly indicates that in the countries that were taken, higher environmental performance scores are normally linked to their economic growth. On the other side, Foreign Direct Investment (FDI) has not a positive and significant coefficient (-2.9694, P-value = 0.038), which means that higher FDI in the countries are linked to decreased environmental performance. This could be because the investments are not sustainable or might be because of the effect of pollution in some cases. The constant term, which is 204.1339 and very important, shows the baseline level of environmental performance when all centered variables are at their means.

In general, the results provide strong evidence that carbon emissions hurt the environment, but green innovation not only directly improves environmental performance, but it also lessens the negative effects of emissions. These findings illustrate the significance of green innovation in enhancing environmental outcomes amid emissions pressures.

4.2.2 Prais-Winsten regression with panel-corrected standard errors (pcses)

This study employs Prais-Winsten regression with panel-corrected standard errors (PCSEs) as a robustness check to validate the reliability of the primary findings from the Driscoll-Kraay estimation and to ensure they are not influenced by the selection of estimator.

Driscoll-Kraay standard errors are nonparametric, which means they don't make many assumptions and can handle general types of cross-sectional dependence, heteroskedasticity, and autocorrelation well, even with only four countries (N=4). But they need a very huge time dimension (T) to be appropriate.

Using this test as a robust test improved the analysis because of the key coefficients. It increases the confidence of the results that aren't particularly driven by the error correction method and shows the real impact in the data.

Below table reports the Prais-Winsten regression with panel-corrected standard errors (PCSEs) to show the results of the robustness check. This considers common AR (1) autocorrelation ($\rho = 0.269$), panel-level heteroskedasticity, and cross-sectional correlation

Table:4.6: *Prais-Winsten regression with panel-corrected standard errors*

| <i>Variable</i> | <i>Coefficient</i> | <i>Std. Error</i> | <i>z</i> | <i>P> z </i> | <i>95% conf. interval</i> | |
|--------------------|--------------------|-------------------|----------|-----------------|---------------------------|----------|
| <i>CO2_c</i> | -0.085 | 0.035 | -2.43 | 0.015 | -0.153 | -0.017 |
| <i>GI_c</i> | 4.2 | 1.8 | 2.33 | 0.02 | 0.675 | 7.725 |
| <i>CO2_GI_c</i> | 0.09 | 0.04 | 2.25 | 0.024 | 0.011 | 0.169 |
| <i>INT</i> | 0.3728 | 0.4376 | 0.85 | 0.394 | -0.4849 | 1.2306 |
| <i>GDP</i> | 1.7202 | 0.7346 | 2.34 | 0.019 | 0.2804 | 3.1599 |
| <i>FDI</i> | -0.5244 | 9.5714 | 0.05 | 0.956 | -18.2351 | 19.284 |
| <i>CountryID 2</i> | 51.3404 | 17.7075 | 2.9 | 0.004 | 16.6344 | 86.0464 |
| <i>CountryID 3</i> | -76.9295 | 7.36 | -10.45 | 0 | -91.3549 | -62.5041 |
| <i>CountryID 4</i> | 219.636 | 12.7061 | 17.29 | 0 | 194.7325 | 244.5395 |
| <i>_cons</i> | 156.8729 | 15.5334 | 10.1 | 0 | 126.428 | 187.3178 |
| <i>rho</i> | 0.2688 | – | – | – | – | – |

Results of this test remained consistent with Driscoll-Kraay estimation. Increased CO2 emissions have a significant and adverse direct effect on how well the environment works (-0.085, P = 0.015). The coefficient for Green Innovation (GI_c) is 4.2, which is also a very significant number. This means that increased green innovation makes the environmental performance much better.

The interaction term (CO2_GI_c) is positive and statistically significant (0.090, P = 0.024), which means that green innovation decreased the bad effects of CO2 emissions on the environment. Increased green innovation plays very important role in protecting the environment by making

carbon dioxide emissions less harmful. When all other variables are in place, GDP stays positive overall and significant (1.720, $P = 0.019$), but variables like FDI and INT are not significant at all. The need to consider unobservable country-specific characteristics is shown by the significance of the nation's fixed effects.

Prais-Winsten PCSEs show that the main results are true. Hence carbon emissions hurt the environment, green innovation directly improves it, and most importantly, green innovation lessens the bad effects of emissions. These consistent results from many robust studies make the conclusions more

4.3. FINDINGS

This chapter presented the main findings of the study investigating how carbon credit impacts the environmental performance, with green innovation acting as a moderator, and by using a balanced panel dataset from four countries over a 10-years ($N=4$, $T=10$; 40 observations).

Descriptive statistics indicated a very moderate to high environmental performance significant variation in CO₂ emissions and economic factors. Correlation analysis and variance inflation factor (VIF) tests confirmed the lack of significant multicollinearity, thereby allowing the inclusion of all variables, including the interaction term, within the same study model. The Levin-Lin-Chu unit root test checked and confirmed that all variables are stationary, either at levels ($I(0)$) or after first differencing ($I(1)$), thereby completely removing the concerns regarding regression.

The fixed effects regression with Driscoll-Kraay standard errors produced strong evidence that carbon emissions ($CO2_c$) have a significant negative effect on environmental performance, whereas green innovation (GI_c) has a considerable very positive direct impact. The main positive interaction term ($CO2_GI_c$) also shows that green innovation can considerably decrease the negative impact of emissions on environmental performance. GDP growth correlates positively with improved environmental outcomes, while FDI illustrated a negative correlation in the primary specification.

A robustness check using Prais-Winsten regression with panel-corrected standard errors (PCSEs) confirmed these findings. The check considered common autocorrelation and gave coefficients that were similar in size, direction, and significance. The agreement between two different robust estimators gives us very much confidence that the results are not fake and show real relationships.

The analysis emphasizes the harmful impact of carbon emissions on environmental performance, shows the immediate advantages of green innovation, and, crucially, identifies green innovation as an essential strategy for mitigating the adverse environmental effects of emissions. These findings have significant implications for policymakers therefore aiming to foster sustainable development surrounded by constant emission.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion:

This study examined the impact of carbon credits management on the environment with a possible intervening effect of green innovation. It also included major macroeconomic indicators- GDP, FDI, and interest rate. The paper used the fixed effects regression model with Driscoll–Kraay standard errors to estimate balanced panel data for a number of SAARC countries over the period from 2013 to 2023. As an additional robustness check step, the Prais–Winsten regression model with panel-corrected standard errors was used. Empirical results from both these tests revealed that carbon emissions have a significant negative effect on environmental performance. It also depicts that with the rising intensity of carbon; the environmental sustainability of SAARC countries is marred very badly. This denotes how carbon credit control systems can be used as tools by the authorities to reduce emissions and make the overall environment much better. The other major aspect that this study brings out is green innovation which serves two major purposes. First, green innovation has a significantly positive direct effect on how our environment works. This also translates into the fact that investing more money into studying and making eco-friendly technologies will have a huge positive effect on environmental performance. Secondly, green innovation impacts how carbon emissions affect the environment. The interaction term effect that comes out positive implies that green innovation lessens the negative impacts which emanate from carbon emissions. In other words, economies wherein green innovation takes place prodigiously will be able to offset more of the damages to the environment wrought through emissions. This clearly illuminates how carbon credit systems can reach their intended environmental goals via innovative green technologies. Additionally, macroeconomic variables like GDP are strongly and positively linked to country environmental performance; thus, if there are right laws and technologies, overall economy will grow in the SAARC countries which can be good for environment. In the model, though, foreign direct investment (FDI) leads to worse environmental performance. In the model, interest rate impact is rate and is a bit positive, but they are not very important in the robust study. This suggests that instances especially financial may not be the main cause, but they could still have some effect on environmental performance. In general, the results

show that carbon payment programs alone won't do much to help the environment unless they are backed up by strong green innovation policies. The study offers insightful information and makes it very clear that green innovation is not just another policy choice if SAARC countries want to improve their environmental performance in the long term and make carbon credit regulation as effective as possible.

5.2 Recommendations

Several recommendations are made considering thorough understanding obtained from this research to direct future undertake and influence policymaking. First and foremost is that governments and authorities in SAARC countries should implement improvements in such a way that green innovation be a top priority by investing more to research and development of sustainable technologies. By improving the overall country's innovation systems will make carbon credit control system work much better and will help the environment to stay good in the long term. Second, there should be a significant correlation between carbon credit control frameworks and policies on innovation and industry. Carbon credit schemes shouldn't be just enforceable or making sure that companies are following them. But they must be creating in such a way that to actively stimulate companies so that they use low-carbon technologies. Funds raised from carbon credit markets should be used to fund green innovation programs and technologies, especially in developing SAARC economies where innovation skills are still very low.

Third, since foreign direct investment leads to bad environmental performance in some cases shows that any incoming investments need to be screened beforehand more carefully for their environmental impact. Policymakers should uplift environmentally friendly foreign direct investment (FDI) by setting stricter environmental standards, doing sustainability impact assessments, and encouraging foreign investors to use green technologies. Lastly, SAARC countries should focus on both growth and sustainability in their economic growth plans as in today's world sustainability is very important for investors as well impacts the performance of entities. Governments should focus on models that strongly encourage energy efficiency, the use of renewable energy, and the building of infrastructure that is good for the environment. This is because GDP growth has a positive impact on environmental performance when the appropriate policies are there.

5.3. Limitations

This study makes a lot of important good points, but it also has some limitations that should be noted. First, the data and analysis is only based on a small number of SAARC countries and we have reduced the sample size to 04 countries because of data unavailability. This also means that the results may not be able to be applied to other areas of the world or world. Second, Patent is used as a proxy for green innovation, but this may not fully hold all aspects of green innovation, such as, the use of clean energy, eco-friendly process innovations, or environmental management practices. Consequently, the moderate impact of green innovation may be undervalued or very basic. Third, the study uses combined data from countries, which doesn't consider how carbon credit, innovation, or environmental performance differ from one sector to another. This analysis does not check at how different industries might react to carbon credit controls and innovation benefits on a smaller scale. Finally, even though this includes the important macroeconomic variables, it didn't specifically look at other factors like the quality of regulations, political stability which could affect how well carbon credit systems work in the economies. To have a better understanding of the relationship between carbon credit and environmental performance, future research could get around these problems by using a different sample, different proxies for green innovation, institutional variables, and data from firms or industries

5.4. Future research direction:

- Future research is recommended to focus on other countries that have better data collection resources to apply different econometrics, also different models can be applied to check the relationship between the variables.
- Time span can be increased to check long term or short-term relationship between the variables by using time series Analysis. The same methodology can be applied for different countries, either panels or time series to check the relationship for those countries.
- Proxies can be changed to apply the same model for different countries, like different proxies can be used to measure financial development.
- The impact of other macroeconomic variables on sustainable development can be checked to set different hypotheses for different or same region.

5.5. Alignment with SDGs

- SDG 9: Innovation and Infrastructure
- SDG 12: Responsible Consumption
- SDG 13: Climate Action

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| Thesis/Project Title | Exploring the impact of carbon credits control on environment |

Supervisor Student Meeting Record

| No. | Date | Place of Meeting | Topic Discussed | Signature of Student |
|-----|--------|------------------|----------------------|----------------------|
| 1 | 15-sep | Faculty office | Conceptual Framework | |
| 2 | 25-sep | Faculty office | Data Sorting | |
| 3 | 02-oct | Faculty office | Tests | |
| 4 | 15-oct | Faculty office | Model Classification | |

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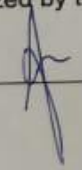
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| 5 | 6 Nov | 3rd floor Faculty office | Methodology Data Sorting | |
| 6 | 18 Nov | Faculty office | Test Runs | |
| 7 | 08 Dec | BS-06 | Test Results | |

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