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DEPARTMENT OF BANKING AND FINANCE

FOUR ESSAY THESIS ON GREEN FINANCE, ENVIRONMENTAL SUSTAINABILITY, AND DEVELOPMENT

PhD THESIS

MUMTAZ ALI

Nicosia
January, 2024

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APPROVAL

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DECLARATION

I hereby declare that the thesis entitled “Four essay thesis on green finance, environmental sustainability, and development” submitted for the Doctor of Philosophy (PhD) in Banking and Finance at the Institute of Graduate Studies, Near East University, is entirely my own work. I also declare that all information, documents, figures, analysis, and empirical results in this thesis have been collected and presented according to the academic rules and ethical guidelines of the Institute of Graduate Studies, Near East University. As required by these rules and conduct, I have fully cited and referenced information and data not original to this study.

I declare that this thesis has not been submitted in whole or in part for the award of any other degree or qualification in any other educational institution. The work presented in this thesis results from my original research efforts, conducted under the proper guidance and kind supervision of my supervisor, Prof. Dr. Turgut Tursoy, and co-supervisor, Assoc. Prof. Dr. Mehdi Seraj.

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DEDICATION

I would like to dedicate this thesis to my father **Allah Rakhio (late)**, and to my **Nana Haji Suhrab (Late)**. Moreover, I would like to dedicate this thesis to my mother **Qaim Khatoon**, brother **Ali Mohammad,** and all my family members for their endless support throughout my entire education.

ABSTRACT

Four essay thesis on green finance, environmental sustainability, and development

Ali, Mumtaz

PhD, Department of Banking and Finance

Prof. Dr. Turgut Tursoy (Supervisor)

Prof. Dr. Mehdi Seraj (Co-Supervisor)

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The role of green finance is to develop green industry mechanisms in areas including transportation, building, water preservation, clean energy production, storage, and distribution, which ultimately results in emissions and waste reduction, biodiversity habitat protection, and pollution control. Therefore, recognizing the significance of green finance, case study 1, investigates the asymmetric role of green finance and clean energy in the reduction of carbon emissions along with economic growth, foreign direct investment, and urbanization as control antecedents using the econometric model of "Nonlinear Autoregressive Distributed Lag (NARDL)" for the period 2000-2020 in ASEAN nations. According to the NARDL outcomes, green finance, and clean energy positive shock enhances the ecological quality and negative shocks harm environmental quality. In addition, economic growth, and urbanization contribute to harmful pollutants. Therefore, the results recommend ASEAN nations' governments, environmentalists, and policymakers, devise strong financial mechanisms and develop long-term green investment strategies to attract green finance and investment opportunities to bridge the gap in clean energy.

Moreover, Concern about climate change is spreading around the globe. The urge to comprehend the environmental effects and take action is sharply rising. Regarding this,

the banking industry has a great chance to offer a solution in terms of green financial solutions and can meet the needs of carbon-conscious organizations to combat and defend our planet. Therefore, in light of this, case study 2, investigate the role of banking sector development, economic growth, and clean energy consumption in scaling up green finance investment in South Asian nations, taking carbon emissions, foreign direct investment, remittances, inflation, and trade openness as control variables. This study uses a novel Residual Augmented Least Squares-Engle and Granger (RALS-EG) co-integration to test the long-term link and the Quantile Autoregressive Distributed Lag (QARDL) econometric approach to extract the association across the quantiles (q0.05-q0.95) for the period 2000-2020. The outcomes of QARDL show that banking sector development, economic growth, clean energy, carbon emissions, foreign direct investment, remittances, and trade openness play a positive role in attracting green finance in the long term. However, only inflation has a negative influence on scaling up finance in South Asian nations. Therefore, the concerned authorities (government, Central Banks, Environmentalists, and policymakers) are urged to implement green finance policies and strategies as suggested and recommended by the results of this study.

Additionally, green finance is an organized financial activity that has been developed to assure a better result for the environment. Green funding is an essential component in the achievement of a number of the “United Nations' Sustainable Development Goals.” Despite its importance in combating climate change, green finance has a significant investment gap. Green financing is a feasible way to close the gap in green investment. Despite the potential benefits of green finance in green renewable energy technologies, this study topic has received little attention. Investment in green energy projects draws attention since it eliminates the negative consequences of fossil fuels

while also conserving the environment. Case study 3 looks into the nexus between investments in green finance, renewable energy consumption, carbon dioxide, foreign direct investment, remittances, inflation, gross fixed capital formation, trade openness, and human capital for the "Organization for Economic Co-operation and Development (OECD)-15 European" countries, utilizing newly developed "Residual Augmented Least Squares (RALS) cointegration technique and the Quantile Autoregressive-Distributed Lag (QARDL)" model for the period spanning from 1990-2020. In empirical results, the RALS cointegration test confirms the cointegration link between the studied antecedents. Additionally, QARDL empirical estimates show that the lag of renewable energy consumption, foreign direct investment, gross capital creation, trade openness, and human capital all have a positive and statistically significant influence on green finance investment. Carbon dioxide emissions and inflation, on the other hand, are proven to be adversely related. However, remittances, have a negligible relationship with green finance investment. The study's findings give insight into the current state and future requirements of green finance investment, which will aid researchers, policymakers, and practitioners in improving and promoting the implementation of green finance investment programs and projects to address climate change.

Finally, a relative lack of empirical research exists in assessing the relationship between the green finance and green productivity despite many antecedents in literature. Case study 4 examines the role of green finance, environmental technology innovation, environmental policy stringency, renewable energy, and industrial structure on green total factor productivity in G5 and GL5 economies. We employed the Super SBM model to calculate green total factor productivity index. The estimations from Panel Autoregressive distributed Lag (PARDL) model using period

2000-2020 reveal that the green finance, renewable energy, and technological innovations uplift the level of green productivity and protect environment. We find that current policy stringency and industry has inverted U shaped association with green productivity. We conclude that by implementing green finance projects, renewable energy initiatives, and technological innovation policies will further augment the green economy and environment quality. Finally, the predicted association between green production and its antecedents allows us to conclude with policy recommendations unique to the G5 and GL5.

Keywords: *Green Finance; Banking Sector Development; Total Factor Productivity; Foreign direct investment; Clean Energy; Environmental Sustainability; Economic Growth; NARDL, ARDL, RALS Cointegration; QARDL Approach; SEAN, Asian, OECD, GL5 and G5 Economies*

ÖZ

Yeşil finans, çevresel sürdürülebilirlik ve kalkınma üzerine dört makalelik tez

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Ocak, 2024, 274 (sayfa)

Yeşil finansın rolü, ulaşım, bina, su koruma, temiz enerji üretimi, depolanması ve dağıtımı gibi alanlarda yeşil endüstri mekanizmaları geliştirmektir; bu da sonuçta emisyon ve atık azaltımı, biyoçeşitlilik habitatının korunması ve kirlilik kontrolü ile sonuçlanır. Bu nedenle, yeşil finansın öneminin farkında olan vaka çalışması 1, ASEAN ülkelerinde 2000-2020 dönemi için "Doğrusal Olmayan Otoregresif Dağıtılmış Gecikme (NARDL)" ekonometrik modelini kullanarak ekonomik büyüme, doğrudan yabancı yatırım ve kontrol öncülleri olarak kentleşme ile birlikte karbon emisyonlarının azaltılmasında yeşil finans ve temiz enerjinin asimetrik rolünü araştırmaktadır. NARDL sonuçlarına göre, yeşil finans ve temiz enerji pozitif şokları ekolojik kaliteyi artırırken, negatif şoklar çevresel kaliteye zarar vermektedir. Ayrıca, ekonomik büyüme ve kentleşme zararlı kirleticilere katkıda bulunmaktadır. Bu nedenle sonuçlar, ASEAN ülkelerinin hükümetlerine, çevrecilere ve politika yapıcılara, güçlü finansal mekanizmalar geliştirmelerini ve temiz enerji açığını kapatmak için yeşil finans ve yatırım fırsatlarını çekmek üzere uzun vadeli yeşil yatırım stratejileri geliştirmelerini tavsiye etmektedir.

Dahası, iklim değişikliği konusundaki endişe tüm dünyaya yayılıyor. Çevresel etkileri anlama ve harekete geçme dürtüsü hızla artıyor. Bu bağlamda, bankacılık sektörü yeşil

finansal çözümler açısından bir çözüm sunma konusunda büyük bir şansa sahiptir ve gezegenimizle mücadele etmek ve onu savunmak için karbon bilincine sahip kuruluşların ihtiyaçlarını karşılayabilir. Bu nedenle, bunun ışığında, vaka çalışması 2, karbon emisyonları, doğrudan yabancı yatırım, işçi dövizleri, enflasyon ve ticari açıklığı kontrol değişkenleri olarak alarak, Güney Asya ülkelerinde yeşil finans yatırımının ölçeklendirilmesinde bankacılık sektörünün gelişimi, ekonomik büyüme ve temiz enerji tüketiminin rolünü araştırmaktadır. Bu çalışmada, uzun vadeli bağlantıyı test etmek için yeni bir Artık Artırılmış En Küçük Kareler-Engle ve Granger (RALS-EG) koentegrasyonu ve 2000-2020 dönemi için kuantiller (q0.05-q0.95) arasındaki ilişkiyi çıkarmak için Kuantil Otoregresif Dağıtılmış Gecikme (QARDL) ekonometrik yaklaşımı kullanılmaktadır. QARDL sonuçları, bankacılık sektörü gelişimi, ekonomik büyüme, temiz enerji, karbon emisyonları, doğrudan yabancı yatırım, işçi dövizleri ve ticari açıklığın uzun vadede yeşil finansmanı çekmede olumlu bir rol oynadığını göstermektedir. Ancak, sadece enflasyonun Güney Asya ülkelerinde finansmanın artırılması üzerinde olumsuz bir etkisi vardır. Bu nedenle, ilgili makamlar (hükümet, Merkez Bankaları, Çevreciler ve politika yapıcılar) bu çalışmanın sonuçlarının önerdiği ve tavsiye ettiği şekilde yeşil finans politikalarını ve stratejilerini uygulamaya çağırılmaktadır.

Ayrıca yeşil finansman, çevre için daha iyi bir sonuç sağlamak üzere geliştirilmiş organize finansal faaliyetlerdir. Yeşil finansman, "Birleşmiş Milletler Sürdürülebilir Kalkınma Hedefleri "nin bir kısmının gerçekleştirilmesinde önemli bir bileşendir. İklim değişikliğiyle mücadeledeki önemine rağmen, yeşil finansman önemli bir yatırım açığına sahiptir. Yeşil finansman, yeşil yatırım açığını kapatmak için uygulanabilir bir yoldur. Yeşil finansmanın yeşil yenilenebilir enerji teknolojilerindeki potansiyel faydalarına rağmen, bu çalışma konusu çok az ilgi görmüştür. Yeşil enerji

projelerine yatırım, fosil yakıtların olumsuz sonuçlarını ortadan kaldırırken çevreyi de koruduğu için dikkat çekmektedir. Vaka çalışması 3, 1990-2020 yılları arasındaki dönem için yeni geliştirilen "Residual Augmented Least Squares (RALS) eşbütünleşme tekniği ve Quantile Autoregressive-Distributed Lag (QARDL)" modelini kullanarak "Ekonomik İşbirliği ve Kalkınma Örgütü (OECD)-15 Avrupa" ülkesi için yeşil finans yatırımları, yenilenebilir enerji tüketimi, karbondioksit, doğrudan yabancı yatırım, işçi dövizleri, enflasyon, gayri safi sabit sermaye oluşumu, ticari açıklık ve beşeri sermaye arasındaki bağlantıyı incelemektedir. Ampirik sonuçlarda, RALS eşbütünleşme testi, incelenen öncüller arasındaki eşbütünleşme bağlantısını doğrulamaktadır. Ayrıca, QARDL ampirik tahminleri, yenilenebilir enerji tüketimi, doğrudan yabancı yatırım, brüt sermaye yaratımı, ticari açıklık ve beşeri sermayenin gecikmesinin yeşil finans yatırımı üzerinde pozitif ve istatistiksel olarak anlamlı bir etkiye sahip olduğunu göstermektedir. Öte yandan, karbondioksit emisyonları ve enflasyonun olumsuz yönde ilişkili olduğu kanıtlanmıştır. Bununla birlikte, işçi dövizlerinin yeşil finans yatırımları ile ihmal edilebilir bir ilişkisi vardır. Çalışmanın bulguları, yeşil finans yatırımının mevcut durumu ve gelecekteki gereksinimleri hakkında fikir vermekte olup, araştırmacılara, politika yapıcılara ve uygulayıcılara iklim değişikliğini ele almak için yeşil finans yatırım programlarının ve projelerinin uygulanmasını iyileştirme ve teşvik etme konusunda yardımcı olacaktır.

Son olarak, literatürdeki pek çok öncüle rağmen yeşil finans ve yeşil üretkenlik arasındaki ilişkiyi değerlendiren ampirik araştırmalar nispeten eksiktir. Vaka çalışması 4, G5 ve GL5 ekonomilerinde yeşil finans, çevresel teknoloji yeniliği, çevre politikası sıkılığı, yenilenebilir enerji ve endüstriyel yapının yeşil toplam faktör verimliliği üzerindeki rolünü incelemektedir. Yeşil toplam faktör verimliliği endeksini hesaplamak için Super SBM modelini kullandık. Panel Otoregresif Dağıtılmış

Gecikme (PARDL) modelinden 2000-2020 dönemi kullanılarak yapılan tahminler, yeşil finans, yenilenebilir enerji ve teknolojik yeniliklerin yeşil verimlilik seviyesini yükselttiğini ve çevreyi koruduğunu ortaya koymaktadır. Mevcut politika sıkılığının ve endüstrinin yeşil verimlilik ile ters U şeklinde bir ilişkiye sahip olduğunu buluyoruz. Yeşil finans projeleri, yenilenebilir enerji girişimleri ve teknolojik yenilik politikalarının uygulanmasının yeşil ekonomi ve çevre kalitesini daha da artıracağı sonucuna varıyoruz. Son olarak, yeşil üretim ve öncülleri arasında öngörülen ilişki, G5 ve GL5'e özgü politika önerileriyle sonuca varmamızı sağlamaktadır.

Anahtar Kelimeler: Yeşil Finans; Bankacılık Sektörünün Gelişimi; Toplam Faktör Verimliliği; Doğrudan Yabancı Yatırım; Temiz Enerji; Çevresel Sürdürülebilirlik; Ekonomik Büyüme; NARDL, ARDL, RALS Eşbütünleşme; QARDL Yaklaşımı; SEAN, Asya, OECD, GL5 ve G5 Ekonomileri

TABLE OF CONTENTS

APPROVAL i

DECLARATION ii

ACKNOWLEDGEMENTS iii

ABSTRACT vi

ÖZ x

LIST OF TABLES xix

LIST OF FIGURES xxi

LIST OF ABBREVIATIONS xxii

CHAPTER 1 1

INTRODUCTION 1

1.1 Research background 1

1.2 Historical Background of Green Finance 3

1.3 Concept Definition 4

1.3.1 Green Finance 4

1.3.2 Environmental Quality 7

1.3.2 Total Green productivity 8

1.4. Green Finance types/Products 9

1.5 Problem statement 13

Research objectives 15

1.5.2 Research Method 16

1.6 Research questions 19

1.8 Significance of Study 19

1.9 Research Framework 21

1.10 Organization of Study 25

CHAPTER 2 28

LITERATURE REVIEW 28
2.1 Theoretical Review 28
2.1.1 Theory of Financial Social Entrepreneurship 28
2.1.2 Environmental Kuznets Curve (EKC) 30
2.1.3 Green Economy Theory 32
2.2 Empirical Review 34
2.2.1 Green Finance and Environmental quality 34
2.2.2 Economic growth, Green Finance, & Environmental Quality 38
2.2.3 Banking Sector development, Green Finance, and Environmental quality 41
2.2.4 Clean energy, Green Finance, and environmental quality 43
2.2.5 Foreign Direct Investment, Green Finance, and environmental quality 47
2.2.6 Urbanization and Environmental Quality 48
2.2.7 Green Finance and Green total factor productivity 50
2.2.8 Environmental Technological Innovation and Green total factor productivity 51
2.2.9 Environmental Policy Stringency and Green total factor productivity 52
2.2.10 Industry and Green total factor productivity 54
2.2.11 Renewable energy and Green total factor productivity 55
2.3 Research Gap 55
CHAPTER 3 60
“GOING AWAY OR GOING GREEN IN ASEAN COUNTRIES: TESTING THE IMPACT OF GREEN FINANCING AND ENERGY ON ENVIRONMENTAL SUSTAINABILITY” 60
3.1 Introduction 60

3.2 Research Methods 65
3.2.1 Data 65
3.2.2 Estimation Procedures 67
3.3 Empirical results 73
3.3.1 Cross-sectional dependence and unit root test results 73
3.3.2 Westerlund Cointegration Results 75
3.3.3 Panel Nonlinear ARDL Results 75
3.3.4 CS-ARDL Results 81
3.3.5 Dumitrescu Hurlin Panel Causality Tests 82
3.4 Conclusions and implications of the policy 83
CHAPTER 4 87
"DO BANKING SECTOR DEVELOPMENT, ECONOMIC GROWTH, AND CLEAN ENERGY CONSUMPTION SCALE UP GREEN FINANCE INVESTMENT FOR A SUSTAINABLE ENVIRONMENT IN SOUTH ASIA? EVIDENCE FOR NEWLY DEVELOPED RALS CO-INTEGRATION" 87
4.1 Introduction 87
4.2 Methodology 91
4.2.1 Data 91
4.2.2 Estimation procedure 92
4.2.3 Quantile Autoregressive Distributed Lag (QARDL) Model 94
4.3 Empirical Results and discussion 97
4.4 Conclusion and policy recommendations 109
4.4.1 Theoretical contribution 110
4.4.2 Practical implications 111

CHAPTER 5 113

"GREEN FINANCE INVESTMENT AND CLIMATE CHANGE MITIGATION IN OECD-15 EUROPEAN COUNTRIES: RALS AND QARDL EVIDENCE"..... 113

5.1 Introduction 113

5.2 Empirical Methodology and Data 118

5.2.1 Data 118

5.2.2 Estimations Procedure 119

5.3 Results and Discussion 124

5.3.1 QARDL long term results..... 128

5.4 Conclusion and policy implications 135

CHAPTER 6 139

HOW CAN G5 COUNTRIES LEARN FROM GL5 GREEN LEADER COUNTRIES TO DECREASE ENVIRONMENTAL DEGRADATION WHILE HAVING GREEN PRODUCTIVITY? 139

6.1 Introduction 139

6.2 Methodology 147

6.2.1 Data 147

6.2.2 Econometric Model 152

6.3 Results and discussion 153

6.3.1 Descriptive, Unit root and cointegration estimations 153

6.3.2 Main Panel ARDL (PARDL) estimations..... 156

6.3.3 Robustness estimation..... 164

6.4 Conclusion and policy remarks 165

CHAPTER 7 168

CONCLUSION AND POLICY RECOMMENDATIONS 168

7.1 Conclusion 168

7.1.1 Theoretical contribution 173

7.1.2 Methodological contributions 174

7.1.3 Practical implications 174

7.2 Policy recommendations 175

7.3 Limitation and future direction 182

REFERENCES 184

LIST OF TABLES

Table 1 ASEAN Green Finance Opportunities (Sectorial and Sub-Sectorial) 62

Table 2 Data disruption and source 66

Table 3 CD and CIPS and CADF Test Outcomes 74

Table 4 Slope Heterogeneity Test 74

Table 5 Westerlund Cointegration Outcomes 75

Table 6 Results of the Nonlinear ARDL 80

Table 7 Results of the CS-ARDL 82

Table 8 Dumitrescu Hurlin Panel Causality Tests 83

Table 9 Variables information 92

Table 10 ADF and RALS-ADF Unit root test results 98

Table 11 Shapiro-Wilk normality test 98

Table 12 RALS co-integration test results 101

Table 13 Quantile Autoregressive Distributed Lag (QARDL) results 105

Table 14 Variable's description, measurement and data sources 118

Table 15 Cross-Sectional Dependence Test 125

Table 16 Variance Inflation Test 125

Table 17 ADF and RALS-ADF Unit Root test 126

Table 18 Shapiro-Wilk normality test 126

Table 19 RALS Cointegration 128

Table 20 Correlation Test 128

Table 21 QARDL long term estimations 134

Table 22 Variable's description, measurement, and data sources 148

Table 23 Input-Output variables 151

Table 24 Descriptive Statistics 155

Table 25 Unit Root Test 155

Table 26 Pedroni Residual Cointegration Test 156

Table 27 Panel ARDL Results 159

Table 28 ARDL robustness test results 163

LIST OF FIGURES

Figure 1 Case 1 “Going Away or Going Green in ASEAN countries: Testing the impact of green financing and energy on environmental sustainability.” 21

Figure 2 Case 2. “Do Banking Sector development, economic growth, and clean energy consumption scale up green finance investment for a sustainable environment in South Asia? Evidence for newly developed RALS Co-integration.” 22

Figure 3 Case 3 “Green finance investment and climate change mitigation in OECD-15 European countries: RALS and QARDL evidence.” 23

Figure 4 Case 4 How can G5 countries learn from GL5 green leader countries to decrease environmental degradation while having green productivity? 24

Figure 5 ASEAN Sector wise green finance Opportunities 62

Figure 6 QQ Plot results 66

Figure 7 Methodological structure of the current study 73

Figure 8 Graphical presentation of the long-term results 80

Figure 9 Green Finance investment in selected Asian Countries 88

Figure 10 Research Methodology structure 97

Figure 11 Graphs of normality 99

Figure 12 Graphical representation of QARDL results 106

Figure 13 Graphs of normality 127

Figure 14 Carbon emissions in study economies 143

Figure 15 Comparison of green total factor productivity 163

LIST OF ABBREVIATIONS

ASEAN:	Association of Southeast Asian Nations
OECD:	Organization for Economic Cooperation and Development
G5:	Great Five
GL5:	Green Leaders Five
CIPS:	Cross-sectionally Augmented Im, Pesaran, and Shin
CADF:	Cross-sectionally Augmented Dickey Fuller test
ECM:	Error Correction Model
NARDL:	Non-linear Autoregressive Distributed Lag Model
ARDL:	Autoregressive Distributed Lag Model
RALS:	Residual Augmented Least Square
RALS-EG:	Residual Augmented Least Square-Engle and Granger
QARDL:	Quantile Autoregressive Distributive Lag
SBM:	Slacks-Based Measure
LLC:	Liven, Lin, & Chin unit root test
ADF:	Augmented Dicky Fuller unit root test
PP:	Philips Peron (PP) unit root test
PARDL:	Panel Autoregressive Distributed Lag model
GTFP:	Green Total Factor Productivity

SH:	Slope Heterogeneity
CSD:	Cross Sectional Dependence test
VIF:	Variance Inflation Factor
CO_2:	Carbon Dioxide
GDP:	Gross Domestic Product
EKC:	Environmental Kuznets Curve
EG:	Economic Growth
FD:	Financial Development
FDI:	Foreign Direct Investment
URB:	Urbanization
CE:	Carbon Emissions
GF:	Green Finance
WDI:	World Bank Development Indicators
CEC:	Clean Energy Consumption
CS-ARDL:	Cross Sectional Autoregressive Distributed Lag Model
GDP^2:	Gross Domestic Product Square
BSD:	Banking Sector Development
REM:	Remittances
INF:	Inflation
TR:	Trade Openness

GFCF:	Gross Fixed Capital Formation
LE:	Life Expectancy
ETI:	Environmental Technological Innovation
EPS:	Environmental Policy Stringency
REN:	Renewable Energy
INDS:	Industrial Structure
GFI:	Green Future Index Report
DEA:	Data Envelopment Analysis
IRENA:	International Renewable Energy Agency
WB:	World Bank
UNFCCC COP:	United Nations Climate Change Conference
SDG:	Sustainable Development Goals
UNEP FI:	United Nations Environment Program Finance Initiative
EES:	Economic, Environmental, and Social dimensions
ICMA:	International Capital Market Association
ESG:	Environmental, Social, and Governance
GHG:	Greenhouse Gas
ICMA:	International Capital Market Association
GBA:	Green Bond Principles

SRI:	Socially Responsible Investment
REDD:	Reducing Emissions from Deforestation and forest Degradation
DID:	Difference-in-Differences
N-11:	Next Eleven Economies
BRICS:	Brazil, Russia, India, China, and South Africa
GMM:	Generalized Moment Method
R&D:	Research and Development
CCE-PMG:	Pooled Mean Group Estimator
NAFTA:	North American Free Trade Agreement
MINT:	Mexico, Indonesia, Nigeria, and Turkey
FMOLS:	Fully Modified Ordinary Least Square:
EU:	European Union
G7:	Great Seven Nations
G8:	Great Eight Nations
G-20:	Great Twenty Nations
E-7:	Emerging Seven Nations
DCC-MIDAS:	Dynamic Conditional Correlation with Mixed Data Sampling model
CCEMG:	Common Correlated Effect Mean Group

IEA:	International Energy Agency
MENA:	Middle East and North Africa
TFP:	Total Factor Productivity
ER:	Environmental Regulations
EPS:	Environmental policy stringency
IS:	Industry Structure
REN:	Renewable Energy
POLS:	Pooled Ordinary Least Squares
RE:	Random Effect
FE:	Fixed Effect
ADB:	Asian Development Bank
CNN:	Cable News Network
QQ:	Quantile & Quantile
OLS:	Ordinary Least Square
ACFF:	ASEAN Catalytic Finance Facility
ADPC:	Asian Disaster Preparedness Centre
ESRMS:	Environmental and Social Risk Management Standards
CST:	Climate Stress Testing

CHAPTER 1

INTRODUCTION

1.1 Research background

Climate change is a significant and urgent problem that humanity is now facing (Samour et al., 2023). Global temperatures are seeing a notable yearly increase due to the gradual "emission of greenhouse gases" (Ali & Seraj, 2022). Particularly, carbon dioxide (CO_2) emissions have a detrimental impact on the Earth's climate, resulting in climate change and ecological damage (Adebayo et al., 2021) and great threat to the world (Joof et al., 2023). This leads to a range of environmental problems, including air and water pollution, risks to the ozone layer, and the presence of persistent organic pollutants. These issues have severe consequences for the ecosystem and contribute to high mortality rates in affected regions (M. U. Ali et al., 2021). The increase in atmospheric CO_2 emissions has resulted in a rise in world temperatures of around 1°. It is projected that the global temperature will surpass 1.5° between 2030 and 2050 due to the ongoing increase in global emissions (Global Sustainable Development Report 2023)[1]. And according to "United Nations Climate Change Conference (UNFCCC COP 28)[2]" "the world must not cross is the line that takes our planet over the 1.5-degree temperature limit and the world must not to relent in the fight for climate justice and climate ambition."

However, every country aspires to achieve economic development. Without a question, the industrial revolution expedited global economic advancement and enhanced human well-being. Nevertheless, endeavors aimed at attaining economic expansion

[1] "https://sdgs.un.org/gsdr/gsdr2023"
[2] https://www.un.org/en/climatechange/cop27

have resulted in the deterioration and eradication of green lands, forests, and other crucial elements of ecosystems, posing a threat to human well-being (Z. Wang et al., 2023). Since the beginning of the industrial revolution, there has been a substantial modification of bio-productive land, with over 85% of wetlands disappearing and seas experiencing extensive pollution. Energy is a crucial determinant of a nation's economic and social progress, serving as a key factor in enhancing a country's economy (Baz et al., 2021). Undoubtedly, energy being vital force for economic growth, the need for electricity has grown dramatically in all sectors of both rich and emerging countries since the industrial revolution.

During the last three decades, researchers from all around the world have conducted a variety of studies to investigate the connection that exists between national economic growth and energy use. Multiple studies such as (Gokmenoglu & Sadeghieh, 2019; Wei et al., 2020; Rehman et al., 2019; Rehman et al., 2019; Kossele et al., 2020; A. Rehman et al., 2021; Gyimah et al., 2022; Jiang et al., 2022; Bui Minh & Bui Van, 2023; Farhidi, 2023), have shown a strong correlation between "energy consumption and economic development," with greater levels of economic expansion necessitating more energy demands. The use of polluting energy systems is seeing a fast rise throughout several sectors of the economy (Xue et al., 2022) a significant increase in the use of resources, leading to a corresponding rise in environmental footprints (Global Footprint Network, 2021)[3] which further exacerbate global climate change and environmental issues (Z. Wang et al., 2023).

[3] https://data.footprintnetwork.org/

1.2 Historical Background of Green Finance

Indeed, the origins of green financing may be traced back to the 1970s (Florea & Morales, 2021)[4]. The inception of green finance started in 2010 by the founding of the "Green Climate Fund," which was formed by 194 nations. This fund was created to provide financial assistance to poor nations for the purpose of addressing and adapting to climate change (D. Zhang et al., 2019). Subsequent to the acceptance of the "Paris Agreement, Sustainable Development Goals (SDGs), and Sendai Framework for Disaster Risk Reduction in 2015[5]", The importance of green money in funding climate change initiatives has been recognized (International Financial Corporation, 2016)[6]. Moreover, the "United Nations Environment Program Finance Initiative (UNEP FI)" was established in 1992 via a collaboration between UNEP and a consortium of commercial banks. Its primary objective was to foster awareness and integration of environmental initiatives within the banking sector (Mohd & Kaushal, 2018). The UNEP Finance Initiative is a distinctive entity within the "United Nations Environment Program (UNEP)" and the business sector. The concept might be noticed as the foundational notion of Green Finance. Subsequently, the effort continues to foster active participation from a wider range of "financial institutions, including investment and commercial banks, insurers, and fund managers," in meaningful discussions on the integration of environmental preservation with the pursuit of sustainable economic growth. The objective is to incorporate environmental factors into existing financial services and procedures. Presently, a total of over 190 financial institutions have embarked on the process of signing the declaration of the UNEP FI. These institutions hail from over 40 different nations. The institutions who have signed the UNEP FI

[4] "Green Financing: A Look at the History | Bechtel"
[5] "What is the Sendai Framework for Disaster Risk Reduction? | UNDRR"
[6] International Finance Corporation (IFC)

statement are afforded the opportunity to acquire knowledge from the network on current trends and practices to capitalize on environmentally friendly prospects for expansion. Additionally, they are able to contribute to the formulation of a sustainable finance agenda that aligns with their own developmental objectives.

1.3 Concept Definition

1.3.1 Green Finance

Green finance has been outlined in several academic works. Ryszawska (2016), stated that green finance encompasses the provision of financial resources that contribute to sustainable development across three interconnected aspects: “the economic, environmental, and social dimensions” (EES). Similarly, “International Capital Market Association (ICMA 2020),” “green finance considers issues related to the environment, the economy, and society while also taking into account the role and stability of the larger financial system in which the organizations receiving funding operate.” In the view of Gerster (2011), the concept of sustainable finance encompasses the importance of “environmental, social, and governance (ESG)” aspects within financial practices. Moreover, the “United Nations Environment Program” (UNEP, 2017), green finance denotes the financial activities that effectively address the long-term requirements of a sustainable and inclusive economy, including several factors crucial for attaining these objectives, such as “economic, social, and environmental considerations.” The definitions of green finance may be classified into two overarching groups when considered together. The first group perceives green finance as a kind of finance that incorporates economic, social, and governance factors (ESG). Conversely, the second category of financing effectively addresses the long-term requirements of the economy. Ozili (2021), affirmed that the concept of green

finance encompasses the integration of ESG factors into the decision-making process of financial investments.

Moreover, as stated by Migliorelli (2021), green finance pertains to financial assistance targeted towards industries or activities with fundamental sustainable characteristics. Sommer (2020), the concept of sustainable finance encompasses the “process of mobilizing and allocating resources with the aim of facilitating the transition towards an economy” that is more sustainable in nature.

Green finance is the integration of commercial practices with a focus on ecological concerns (Al-Sheryani & Nobanee, 2020). The idea is determined by the conduct of all entities engaged in the supply chain of goods and services, including the suppliers of monetary assets, the manufacturers of products and offerings, and the users of these products and offerings. Significantly, green financing might be seen distinctly depending on the party involved. For example, the financial aspect is responsive to the use of the assigned money for environmental protection via detailed strategies and proposals for investment returns. Green finance distinguishes itself from conventional banking by focusing on the advantages derived from ecological conservation. It takes into account climate risk management strategies and the long-term viability of these strategies. In addition, green finance seeks to advance the greener economy by financing sectors that are predicted to achieve substantial reductions in carbon emissions. Consequently, the green economy offers triple advantages. First, the customers' quality of life is improved, resulting in more potential for corporate development compared to conventional operations. Secondly, the green economy fosters ecological consciousness and guarantees that both producers and consumers preserve the environment by adopting green energy and using biodegradable and low-carbon goods. Thirdly, the communities living near the industrial areas have a social

impact in which they get the advantages of corporate social obligations that are facilitated by the green financing fund. The advantages include the supply of uncontaminated water and air.

The concept of green funding lacks a universally accepted definition. Green financing refers to financial support provided for the purpose of promoting environmentally sustainable development, specifically "aimed at reducing greenhouse gas (GHG) emissions and air pollution." Green development is characterized by the harmonious integration of economic growth with environmental sustainability. The term green finance refers to the breakthroughs and innovations in the world of finance that are related to the decrease of emissions of greenhouse gases and other environmental pollutants in modern civilization. Green development is proposed as a viable solution to address three pressing challenges facing the global economy, namely "climate change, energy constraints, and financial crises." The idea of green finance poses a substantial challenge to the conventional legal structures that govern financial transactions in each and every nation. During the 1990s, there was a noticeable increase in the significance of environmental considerations within the realm of venture capital. This trend had a substantial impact on shaping and influencing the decision-making processes of organizations involved in lending activities. The green fund addresses the transformation of natural ecosystems, such as air and water pollution, depletion of water resources, "encroachment on rivers, improper disposal of industrial, medical, and household waste, deforestation, and the reduction of open spaces and biodiversity loss." The product or solution should exhibit ecologically sustainable attributes and have the capacity to assist in the reduction of unemployment. Integrating the economic aspect into the "transition process towards low-carbon and resource-efficient economies is a crucial approach, particularly in the context of

climate change adaptation" (Chaudhary & Bhattacharya, 2006). Green finance refers to financial investments that are specifically aimed at supporting green economic initiatives, ecologically acceptable goods, and initiatives that contribute to the advancement of a greener economic system. The notion of green finance encompasses the incorporation of climate-focused funding, yet its breadth goes beyond this specific dimension. Additionally, it encompasses a wider array of ecological goals, such as the control of environmental contamination, the purifying of water, and the conservation of wildlife. The concept of moderation and adjustment is closely associated with activities related to climate change. Mitigation encompasses the allocation of resources towards endeavors and endeavors that actively contribute to the diminishment or prevention of GHGs. Adaptation, on the other hand, refers to monetary expenditures that aim to lessen the vulnerability of commodities and people to the effects of climate change (Höhne et al. 2012).

1.3.2 Environmental Quality

The preservation of environmental quality is of utmost significance to all individuals. The level of environmental consciousness increased over the latter part of the twentieth century. The public's recognition of this issue led to a heightened desire for government intervention in order to implement environmental protections and solutions. Prior to the 1960s, many regulations were in existence, including first iterations of federal statutes aimed at tackling certain forms of water and air pollution, as well as some concerns related to solid waste, such as the eradication of open dumping. Substantial expansion, however, ensued after the turbulent decade of the 1960s. The environment has emerged as a societal concern, comparable to the "civil rights and antiwar movements." Several causes have adverse impacts on environmental quality, and climate change is among them. Climate change denotes enduring changes in

temperatures and weather patterns. Human activities, namely the combustion of fossil fuels, are the primary drivers of climate change. This process leads to an “increase in the concentration of greenhouse gases in the Earth's atmosphere,” resulting in a rise in the average surface temperature of the planet. Human actions have had a significant impact on climate change, but it is important to note that natural processes may also play a role in contributing to this phenomenon. Climate data records offer empirical evidence of crucial indicators of climate change, including the escalation of global land and ocean temperatures, the elevation of sea levels, the depletion of ice in Earth's polar regions and mountain glaciers, alterations in the frequency and intensity of extreme weather events such as hurricanes, heatwaves, wildfires, droughts, floods, and precipitation, as well as modifications in cloud and vegetation coverage. Consequently, it is important to reduce climate change to enhance the environmental quality.

1.3.2 Total Green productivity

Green productivity is a strategic approach that seeks to improve both productivity and environmental performance to achieve sustainable growth. It entails enhancing industrial processes and goods to diminish their environmental footprints and enhance their quality and effectiveness. Green productivity may provide advantages to organizations and society via cost savings, value creation, and environmental protection.

Green productivity centers around enhancing productivity and safeguarding the environment. The core principle of the green production approach involves scrutinizing and reassessing production processes and products to minimize their ecological footprints and identify opportunities for enhancing productivity and product quality. The use of these alternatives initiates a further cycle of evaluation, so fostering continual development.

Furthermore, green development has been acknowledged as a viable approach to impede the transmission of unidentified infectious illnesses to the environment. This has also fostered people's conviction in transitioning the economic growth paradigm and embracing an environmentally sustainable economy. Since the 1970s, the pressing issue of resource depletion, global warming, environmental deterioration, and land desertification has emerged as a significant challenge that several cities must address. The global community is increasingly focused on addressing the degradation of the environment and climate change and is actively pursuing a green economy to achieve sustainable and high-quality development. This involves encouraging the integrated enhancement of the natural environment, resources, and economy.

1.4. Green Finance types/Products

Green finance has "a broader scope, covering both climate finance, and all other financial products and services aimed at other, wider range of environmental objectives as well, including industrial pollution control, and natural resources and biodiversity conservation" (ICMA, 2023[7]; GPB, 2023[8]). It involves various "financial institutions, both public and private, and such asset classes as green bonds, green loans, green funds, green banks, green credits, climate finance, climate bonds, environmental finance, carbon finance, sustainable finance, sustainability bonds, socially responsible investment (SRI), and responsible or environmental, social and governance (ESG) finance" (Berrou et al., 2019).

Carbon finance: Carbon finance is related to "trading and investment activities relating to financial policies for reducing GHG emissions, including the trading and investment of carbon emission rights and their derivates, investments and financing

[7] https://www.icmagroup.org/sustainable-finance/icma-publications/
[8] https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/green-bond-principles-gbp/

for the development of low-carbon projects, and other financial intermediary activities." Its application is "Low carbon projects, such as the reducing emissions from deforestation and forest degradation (REDD+) projects" (Peskett et al., 2011; L. Liu et al., 2015; K. Zhou & Li, 2019).

Climate finance: It is "financing that supports the transition to a climate-resilient economy by enabling mitigation actions, especially the reduction of GHG emissions, and adaptation initiatives towards promoting the climate resilience of infrastructure as well as social and economic assets in general." The objective of climate finance is "climate change mitigation, including GHG emissions reduction projects, such as clean energy and energy efficiency projects; and climate change adaptation projects, such as building flood defenses to warming waters" (ICMA, 2018[9]; Berrou et al., 2019).

Climate bonds: These are "fixed-income financial instruments that are linked with climate change solutions. They are issued to raise finance for climate change solutions for mitigation- or adaptation-related projects." Climate bonds have the same application as climate finance (Berrou et al., 2019).

Green Bonds: Green bonds are "any type of bond instrument where the proceeds are exclusively applied to the finance or re-finance of projects with clear environmental benefits." These bonds have application such as "Green projects, such as renewable energy, energy efficiency, pollution prevention and control, terrestrial and aquatic biodiversity conservation, clean transportation, sustainable water and wastewater

[9] "https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/green-bond-principles-gbp/ (2018), Accessed May 2021"

management, climate change adaptation, eco-efficient and/or circular economy, and green building projects" (Debrah et al., 2022).

Green loans: These are "any type of loan instrument made available exclusively to finance or re-finance, in whole or in part, new and/or existing eligible green projects." The applications of green loans are same as that of green bonds (Debrah et al., 2022).

Green funds: These are "funds (equity or debt financing) that provide clients with platforms through which environmentally friendly businesses and organizations are supported with long-term funding." These funds are applicable to "Climate change and environmentally friendly projects, such as energy efficiency, agriculture and waste management projects" (Berrou et al., 2019; Debrah et al., 2022).

Green credits: The green credits refer to "the green deposit and loan industry, mortgage and project loans." These credits are application to "Green industries, constrain investment in pollution and overcapacity industries, and withdraw financing from prohibited industries that have been primarily targeted for their negative environmental impact" (Ren et al., 2020).

Green/sustainable banking: The "Green banking facilitates private investments in domestic low-carbon, climate-resilient infrastructure and other green sectors such as water and waste management." The green/sustainable banking "meet ambitious emissions targets, creating jobs, supporting local community development, mobilizing private capital, energy-efficient street lighting, lowering the cost of capital, rooftop solar photovoltaic systems, developing green technology markets, and commercial and residential energy retrofits" (Debrah et al., 2022).

Environmental finance: It is "finance and investment targeting the ecological environment (air, soil, water, etc.) or to deliver quality environment while mitigating

environmental risks." The application of this is "Renewable energy, energy efficiency, green buildings, sustainable transport, waste and wastewater, agriculture and land use, forestry, ecological resources, infrastructure, energy and built environment, and environmental technologies, solar technologies, and solar home systems" (Lee et al., 2013).

Responsible or ESG finance: "Strategies and practices that incorporate environmental, social, and governance factors in investment decisions and active ownership with a view to minimize risks and maximize returns." "Pollution prevention and control; natural resources and biodiversity conservation; climate transition; climate change mitigation and adaptation; social issues and outcomes; and governance" (Debrah et al., 2022)

Socially responsible investment (SRI): "Investing with the aim to achieve financial returns while respecting specific ethical, environmental, and/or social criteria." SRI projects, "including community investing, alternative/clean energy technologies, affordable housing and loans, human rights, political and social activism, and religious value" (Berry & Junkus, 2013).

Sustainable finance: It "incorporates climate, green, and social finance while also adding wider considerations concerning the longer-term economic sustainability of the organizations that are being funded, as well as the role and stability of the overall financial system in which they operate." It is applicable to "all projects financed under climate, green, and social projects" (Debrah et al., 2022).

Sustainability bonds: These are "any type of bond instrument where the proceeds or an equivalent amount will be exclusively applied to finance or re-finance a

combination of both green and social projects." The applications of these bonds are the same as that of sustainable finance (Debrah et al., 2022).

1.5 Problem statement

The Association of Southeast Asian Nations (ASEAN) has been experiencing rapid economic growth, industrialization, population growth, and carbon emissions leading to significant environmental challenges. According to ADB (2017) report climate shocks in ASEAN nations could decline economic growth by 11% by 2023. About 28% of the population is living in unhygienic environment which could result that 70,000 people could die annually by 2030, due to extensive air pollution, resulting primarily from the burning of coal in power plants. Moreover, South Asia, encompassing countries like Pakistan, India, Bangladesh, and Sri Lanka, is at a critical juncture where economic development is increasingly intersecting with environmental challenges. Climate challenges such as sea intrusion, ice melting, deforestation, heavy rainfall, flooding, rising temperature, water salinity, and greenhouse gas emissions remain major concerns of the region. Additionally, OECD countries best kwon for their advanced economies and high standards of living, face climate change problems. It is fact that OECD countries account for 25.04% of world GDP, and 7.73% of carbon emissions resulting from burning dirty energy sources to meet energy demands. Therefore, OECD nations has started European Green Deal program to reduce carbon emissions by 2030, by investing in renewable energy, renewable in buildings, and transportation electrification, aims to make Europe climate neutral continent by 2050. Finally, great 5 economies such as France, Germany, Japan, UK, and USA are racing in terms of economic growth ignoring its worst consequences on the environment as these nations accounts for 27% of global GDP, and 14% of global GDP growth. Like only USA is contributing 14% of global carbon emissions. On the other hand, green

five leaders such as Denmark, Norway, France, Ireland, and Netherlands are epi center for the green finance investment. According to GFI (2023) report these nations are top five in terms of their progress and commitment towards building a low carbon future as these countries heavy invest in clean energy, industry, agriculture, and actively developing activities in carbon pricing, policy structures, and investment programs to attain green economy and decarbonization.

Therefore, keeping in view the above discussion, climate change stands as one of the gravest challenges facing humanity today, with its widespread impacts evident across various environmental, social, and economic spheres. The phenomenon, primarily driven by anthropogenic activities, has led to alarming changes in weather patterns, increased frequency of extreme weather events, and rising global temperatures, posing a significant threat to ecosystems, human health, and livelihoods. Despite increasing awareness and global efforts to mitigate climate change, there is a critical gap in understanding and effectively addressing its multifaceted impacts. Moreover, this research aims to delve into the complexities of climate change, examining its causes, consequences, and the effectiveness of current mitigation and adaptation strategies. It seeks to assess the environmental impacts, such as shifts in biodiversity and ecosystems, alongside socio-economic repercussions, including effects on economic stability.

Moreover, the concept of GTFP has emerged as a critical metric in assessing the efficiency of economic production while considering environmental sustainability. GTFP extends beyond traditional productivity measures by incorporating environmental factors such as resource utilization, emission reduction, and ecological impact. Despite its growing relevance, especially in the context of global climate change and resource depletion, there is a significant gap in understanding how GTFP

can be effectively measured, enhanced, and integrated into various economic sectors. This research seeks to explore the intricacies of GTFP, examining how it is impacted by environmental policies, technological innovation, and sustainable practices across different regions.

Research objectives

Based on the problem statement, this research thesis setts precise and well-defined research objectives in case of ASEAN, South Asian, OECD, G5, and GL5 nations as under:

1. **To Investigate Green Finance's Contribution to Environmental Sustainability**: It involves analyzing the ways in which green finance efforts support environmentally sound activities in ASEAN nations.
2. **To investigate key factors affecting green finance investment**: It includes the determining the potential factors influencing the green finance investment in case of South Asian and OECD nations.
3. **To Assess the Influence of Green Finance on Green Total Factor Productivity (GTFP):** Assessing the impact of green finance investments and policies on GTFP across various G5 and GL5 countries is the objective of this study. This will include tracking how the GTFP evolves in response to green funding and figuring out how financial inputs and environmental efficiency relate to one another.
4. **To Identify and analyze key factors affecting GTFP:** This objective aims to determine the variables that significantly impact GTFP across G5 and GL5 nations. It includes exploring technological innovation, environmental policy stringency, industrial structure, and renewable energy.

5. To propose policy recommendations to maximize green finance's use for sustainable development and green economy:
6. **To Propose Policy Recommendations to Optimize the Use of Green Finance for Sustainable Development:** The study will endeavor to provide practical suggestions, grounded on the research results, to enable policymakers, financial institutions, and enterprises to optimize their use of green financing in the pursuit of sustainable environmental and development objectives.

By focusing on these objectives, this research will provide comprehensive insights into the synergies and dynamics regarding green finance, environmental sustainability, and GTFP, offering valuable contributions to both academic research and practical applications in these fields.

1.5.2 Research Method

To achieve the objectives of this study as mentioned above we adopted the following research method.

Extensive literature review has been done on the factors such as green finance, green economic productivity, environmental quality, and other related facets to have brother understating of the concept. Based on the thorough literature review, this study developed the research questions. Later the data from the different sources have been collected, scrutinized, analyzed, and interpreted. To do the empirical analysis this study employed:

In case 1, the “cross sectional Dependency test to estimate the cross sectional dependency among the studied countries, slope homogeneity test as proposed by Pesaran and Yamagata (2008) to check the data's similarities,” the second generation

stationary CIPS and CADF to address the issue of estimating inefficiencies, Westerlund panel co-integration test to test the cointegration and “Non Linear Autoregressive Distributed Lag model” to check the linear and nonlinear long and short term links among the facets of study. The fact that tradiational time series regression models use constant parameters and make the unsuitable assumption that changes in explanatory variables have the same impact throughout time. It seems unjust to estimate a connection that could have asymmetry using symmetric methodologies and might result in some really wrong policy findings (Enders, 2008). The traditional econometric models could not assess the non-linearities in macroeconomic facets, hence multiple econometric techniques have been developed such as “Threshold ECM, Smooth transition regression ECM. Markov-switching ECM etc.” but “recent Non-linear Autoregressive Distributed Lag (NARDL) econometric Model” developed by Shin et al. (2014b)incorporates the asymmetries in short and long run along with capturing dynamic adjustment. Therefore, the NARDL model is used to ascertain the asymmetric correlation between the variables under investigation.

In case 2 and 3, RALS cointegration approach based on flowing facts and advantages over conventional cointegration test such that (1) it is more powerful and strong as it utilized the information in non-normal errors (H. Lee et al., 2015). (2) The RALS process avoids the usage of nonlinear estimating techniques by using “nonlinear moment conditions associated with non-normal errors.” In nonlinear cointegration tests, misidentifying the functional form leads to power loss, which is avoided by RALS cointegration approach. (3) When there is no knowledge about nonmorality, the power of RALS-based tests is comparable to other “single equation-based cointegration tests” (H. Lee et al., 2015; Oh et al., 2020). Moreover, to accessed the long-term results across the quantiles by employing the newly developed “Quantile

Autoregressive Distributive Lag (QARDL) econometric model" (Cho et al., 2015). The QARDL model leaves behind traditional linear models due to three major reasons. First, it considers locational asymmetry. The outcomes depend on the outcome variable; green finance, as in our study, may diverge within the parameters of its conditional distribution, as indicated by (Yan et al., 2022). Secondly, it contemplates the long-term's association among regressed and regressor variables like green finance, "banking sector development, economic growth, clean energy consumption, carbon emissions, foreign direct investment, remittances, inflation, and trade openness." Third, it outclasses the traditional linear ARDL model by allowing local asymmetry and assessing short and long-term outcomes throughout the quartiles of the conditional distribution. Moreover, it is lofty compared to non-linear models such as NARDL econometric model as it describes the asymmetry exogenously while setting a threshold to zero as compared to depending on a data-driven process. Therefore, based on the above competitive advantages, we have employed the QARDL model.

In case 4, this study applied the "super-efficiency slacks-based measure" model known as super-SBM model to calculate the total green factor productivity index. Supper SBM takes into account energy consumption in addition to Labor and capital as inputs, carbon emissions and gross domestic product as undesirable and desirable outcomes. Therefore, The Super SBM model effectively addresses the issue of potentially neglecting energy and environmental limitations. Moreover, "the Liven, Lin, & Chin (LLC), Augmented Dicky Fuller (ADF), and Philips Peron (PP) unit root tests" to investigate stationary of the data. to reveal the cointegration among the facets of study we used Padroni residual cointegration test. Additionally, "Panel Autoregressive Distributed Lag (PARDL) model to explain the long and short run" influence of factors

of interest on GTFP. The PARDL model helps to overcome the problem of spurious regression and provide robust and consistent inferences.

1.6 Research questions

Given the current environmental and green economy challenges in all around the world, this research study is designed to answer the following four main questions:

(1) What drives the environmental sustainability in case of ASEAN economies?

(2) Do Banking Sector development, economic growth, and clean energy consumption scale up green finance investment for a sustainable environment in South Asia?

(3) Does green finance investment climate change mitigation in OECD-15 European countries? Role of foreign direct investment and remittances.

(4) How can the great five economies learn from the green five leading economies to decrease environmental degradation while having green productivity?

1.8 Significance of Study

This research holds significant importance as it delves into the critical and timely intersection of green finance, environmental quality, and green total factor productivity, offering valuable insights into sustainable economic growth. In an era where environmental degradation poses a major threat to both ecosystems and economies, understanding the role of green finance in enhancing environmental quality is pivotal. By exploring how investments and policies focused on sustainability can influence GTFP, the study will contribute to the evolving discourse on balancing economic development with ecological preservation. The findings are expected to provide a robust framework for policymakers and businesses, guiding them towards more sustainable practices and investments. This research is not only vital for

advancing academic knowledge in the field of sustainable finance and environmental economics but also crucial for informing practical, actionable strategies. By highlighting the effectiveness of green finance initiatives, the study will aid in directing future investments towards more environmentally friendly and productive practices. Furthermore, the insights gleaned will help tailor environmental policies, ensuring they are more aligned with the goal of sustainable development, thus resonating with global efforts to combat climate change. Additionally, by providing a comprehensive analysis of green finance, environmental and green productivity, the research intends to contribute to the formulation of more robust and informed strategies to tackle the ever-evolving challenge of climate change, ultimately aiding in steering global efforts towards a sustainable and resilient future. Moreover, the study aspires to contribute to the broader discourse on sustainable economic practices and to guide policymakers and industry leaders in adopting strategies that enhance green total factor productivity. In essence, this research is poised to offer a comprehensive understanding that bridges the gap among green finance, economic growth, and environmental stewardship, providing a pathway for future studies and actions in the realm of sustainable development.

1.9 Research Framework

The research framework of this study is as under:

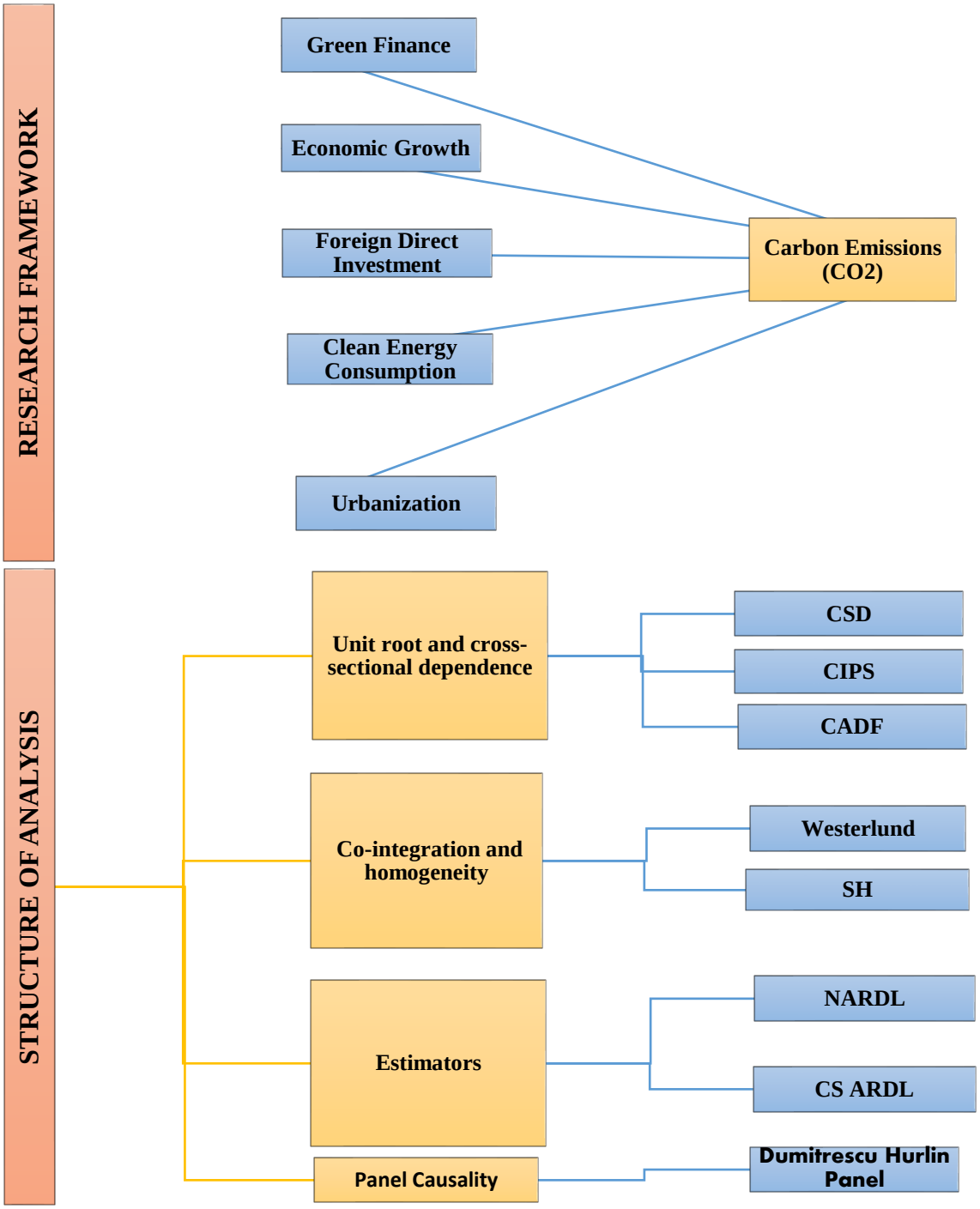


Figure 1 Case 1 "Going Away or Going Green in ASEAN countries: Testing the impact of green financing and energy on environmental sustainability."

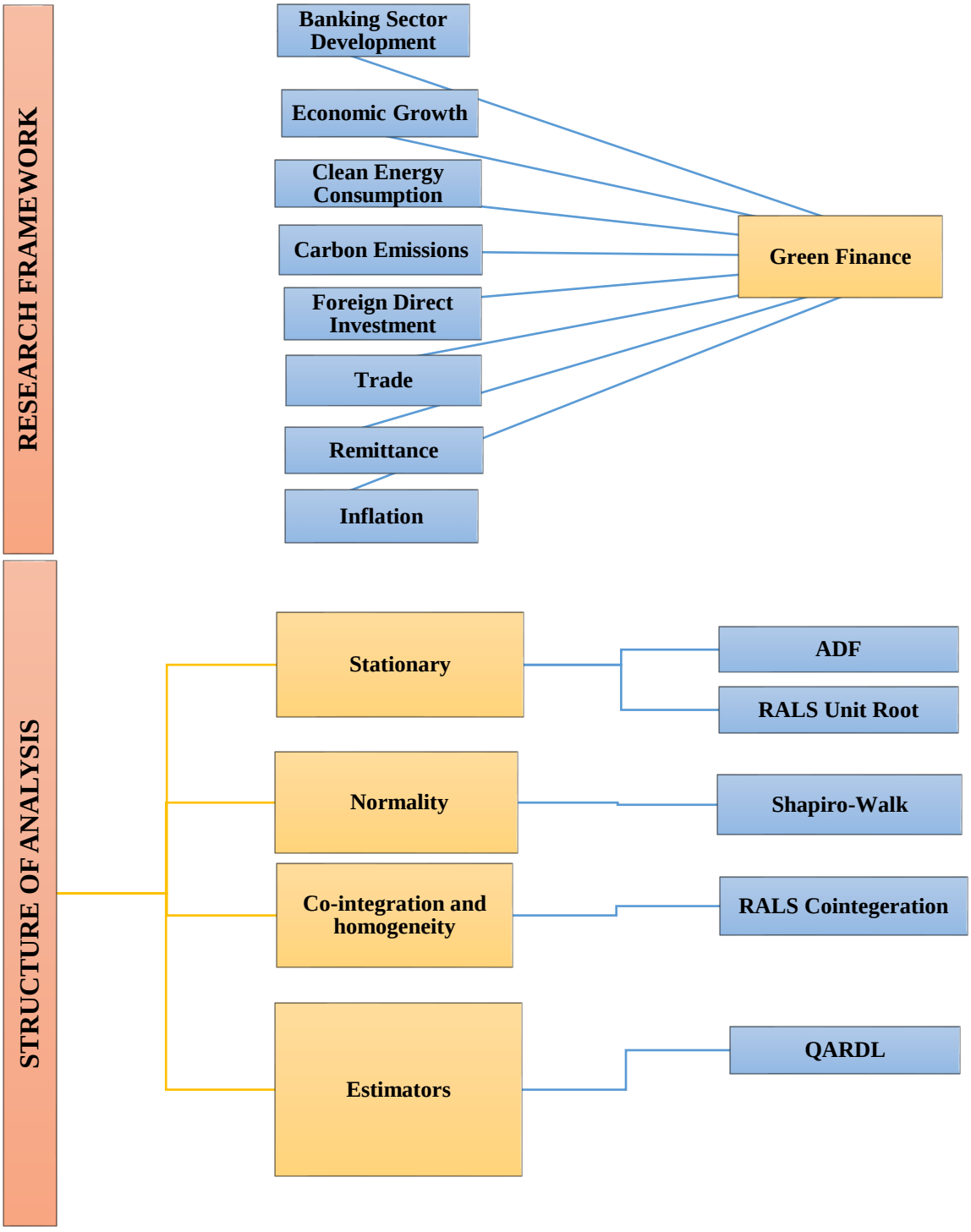


Figure 2 Case 2. "Do Banking Sector development, economic growth, and clean energy consumption scale up green finance investment for a sustainable environment in South Asia? Evidence for newly developed RALS Co-integration."

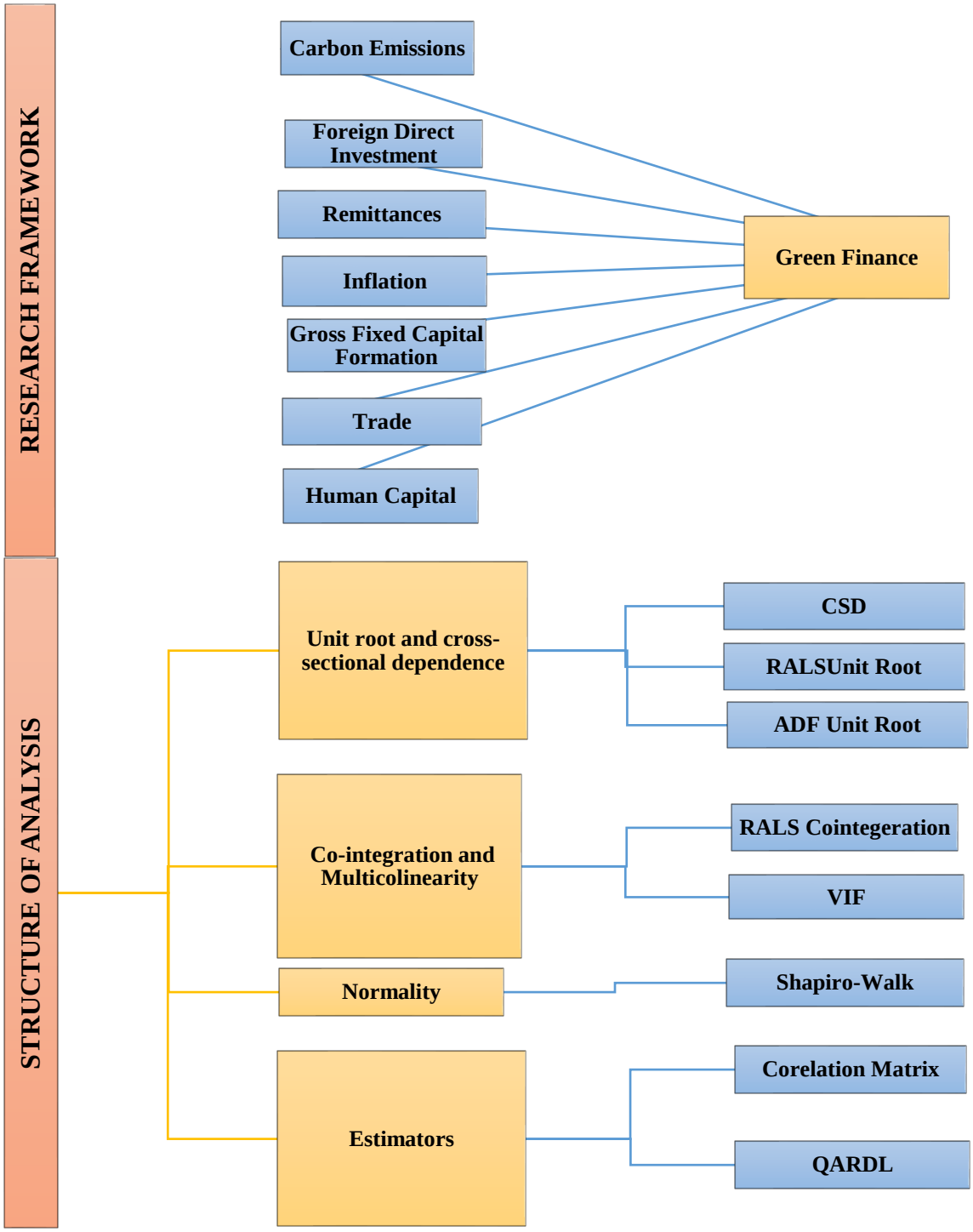


Figure 3 Case 3 "Green finance investment and climate change mitigation in OECD-15 European countries: RALS and QARDL evidence."

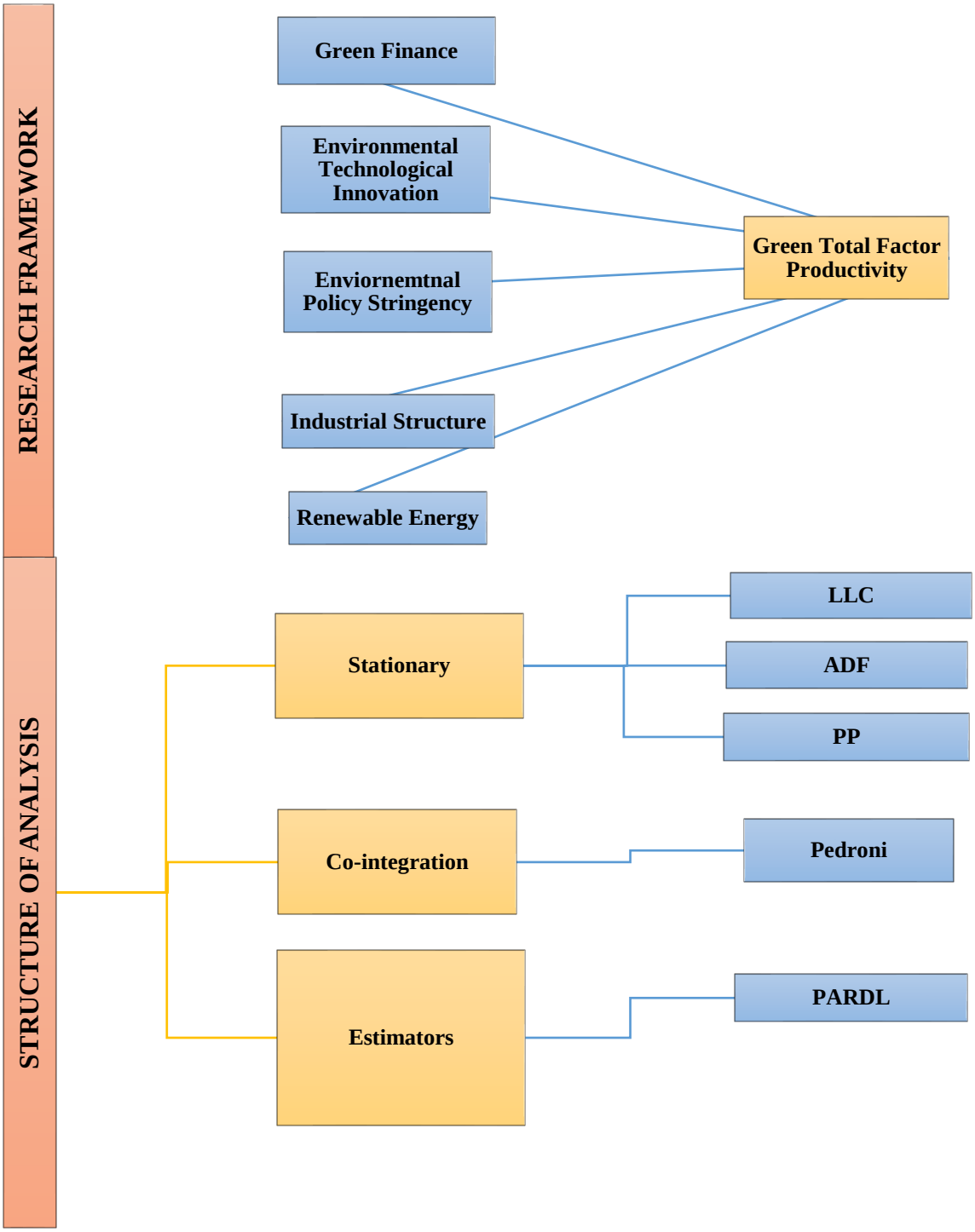


Figure 4 Case 4 How can G5 countries learn from GL5 green leader countries to decrease environmental degradation while having green productivity?

1.10 Organization of Study

This study is structured in a case studies form, examining the dynamics of green finance on sustainable environment and green economic development in ASEAN, Asian, OCED and G5 & GL5 economies.

The study is organized into 7 chapters. Chapter II presents two broad perspectives such as theoretical and empirical literature review examining the link among green finance, environmental, and economic sustainability. In first perspective, this study presents the number of green finance theories developed, sustainable environment theories, and green economy theories. In second perspective, this study explains the existing body of literature on the antecedents effecting the environmental quality, green finance investment, and green economic growth.

Chapter III provides the provides the detailed study of case 1. It includes the detailed introduction of green finance in terms of ASEAN economies including the objective, contribution, and uniqueness of the study in case of ASEAN economies. Secondly, this chapter elaborates the data obtained to explore the link between green finance and environment, econometric approaches used to estimate the link. Third, it presents the outcomes obtained from ARDL and NARDL econometric approaches, and its discussion of the results. Finally, it presents the conclusion, policy implications and recommendation to the ASEAN economies based on the outcomes retrieved from econometric models.

Chapter IV provides the provides the detailed study of case 2. This chapter presents the detailed introduction of green finance investment and its consequences in case of South Asian economies. Secondly, this chapter explains in detail the empirical literature and conceptual framework used in case study 2. Third, it summarized the variables, data sources, and econometric procedures and techniques used to explain

the link amount facets such as green finance, banking sector development, clean energy consumption, carbon emissions, foreign direct investment, remittances, inflation, economic growth, and trade openness. Fourth, it presents the explanation, analysis, and discusses of the outcomes obtained from econometric models such as RALS unit root, RALS cointegration, and QARDL model. Finally, this chapter presents the conclusion inclusion policy recommendations, limitations, and future direction.

Chapter V depicts details of case study 3, which investigates the role of green finance investment and its antecedents in the case of European nations. It includes the introduction to green finance and climate change in the case of OECD-15 European economies. Secondly, it presents the existing literature review on the existing facets of the study. Thirdly, it explains the data and methodology employed in case 3. Thirdly, it elaborates the results obtained and discusses the results obtained from econometric models used. Finally, this chapter presents the conclusion, policy recommendations, suggestions, limitations, and future direction to the potential researchers.

Chapter VI reports case study 4 which explores the link between green finance and green total factor productivity in the case of G5 and GL5 economies. In this chapter, the first introduction to green finance and total green factor productivity is discussed in detail. Secondly, data sources and estimators used in case 4 are thoroughly discussed. Third, it presents the outcomes obtained from the econometric estimators and discussion on them. Lasty, conclusion section is reported with policy recommendations, limitations, and future gape.

Chapter VII provides a concise recapitulation and finalization of all 4 case studies. This chapter presents the significant empirical discoveries and examines the policy

implications that arise from those discoveries. In addition, this chapter recognizes the constraints of the study and proposes possible avenues for further research in this field.

CHAPTER 2

LITERATURE REVIEW

2.1 Theoretical Review

The subject of sustainable finance continues to expand as an area of academic inquiry, and the exploration of these ideas may contribute to the progression of continuous discourse around sustainable finance. The theories developed in the field of sustainable finance have significant significance for establishing a robust framework to comprehend the behaviour and decisions of economic actors in relation to sustainable finance. The forthcoming advancements in sustainable finance have the potential to introduce novel prospects and complexities for the advancement of theoretical frameworks.

2.1.1 Theory of Financial Social Entrepreneurship

Impact investing has become more popular as investors strive to link their financial objectives with social and environmental outcomes. When it comes to impact investing, one of the most basic issues is accurately evaluating and quantifying the social and environmental impacts of investments. On the subject of impact measurement, several academics and practitioners have investigated a wide range of frameworks and measurements. As an example, Krueger and Pradhan (2017) highlight the significance of standardized impact measurements, but Schreiner and Woller (2019) suggest that context-specific metrics are required in order to capture the distinctive qualities that are associated with various investments. Furthermore, Godeke and Wu (2020) examine the role that technology and data analytics play in enhancing the accuracy of impact assessment. These studies, taken as a whole, provide insight on

the ever-changing environment of impact assessment, recognizing the need of both uniformity and flexibility.

As an additional point of interest, the connection between financial returns and effect in the context of impact investing has been the topic of discussion. Early research (Schwienbacher & Larralde, 2012) revealed that impact investments could provide lower financial returns than standard investments. This suggests that impact investments may be more profitable. On the other hand, more recent evidence casts doubt on this generalization. As an example, Emerson and Botsman (2018) contend that impact investment may be financially competitive, and that investors do not have to settle for lower returns in order to achieve the desired effect. Furthermore, Clark et al. (2020) conducted a thorough meta-analysis, and their findings indicate that there is no substantial difference in the financial returns provided by impact investments and non-impact investments. The results of this study indicate that impact investing has the potential to provide financial returns that are equivalent to or even surpass those of standard investments.

In addition, impact investing has the potential to play a significant part in tackling urgent global issues such as the reduction of poverty, the mitigation of climate change, and the elimination of social injustice. Bhagavatula and Ehrlich (2019) analyze the effect of investing in sustainable agriculture, highlighting its capacity to improve food security and mitigate environmental deterioration. In addition, van der Rhee and de Lange-Ros (2018) explore the ways in which impact investing might aid in the attainment of the United Nations Sustainable Development Goals (SDGs).

Ultimately, impact investing has emerged as a prominent influence in the realm of finance, providing investors with the chance to produce favourable social and

environmental results while possibly attaining competitive financial gains. The area is still evolving, with continuous arguments over effect measuring methodology and the financial success of impact investments. Furthermore, impact investment shows potential in tackling some of the most urgent global issues, such as reducing poverty and promoting environmental sustainability. As this field progresses, further research is required to investigate the intricacies and intricacies of impact investing across various asset classes and geographies. This study will provide significant insights for investors, regulators, and stakeholders who want to maximize both financial and impact returns.

2.1.2 Environmental Kuznets Curve (EKC)

The Environmental Kuznets Curve (EKC) is a contentious idea that seeks to elucidate the correlation between economic progress and the deterioration of the environment. EKC proposed by Grossman and Krueger (1991), suggests that when economic expansion occurs, environmental pollution first rises but ultimately declines, following a curve that is shaped like an inverted U. They contended that during the early phases of economic advancement, nations tend to emphasize economic expansion at the expense of environmental preservation, resulting in a rise in pollution levels.

Moreover, as economic levels increase, societies develop a greater awareness of environmental issues, prompting the use of cleaner technology and more stringent laws, eventually leading to a reduction in pollution. The EKC therefore proposes a possible situation in which economic progress and environmental preservation might live together. Many researchers have examined the accuracy of the EKC hypothesis since it was first proposed. Stern (2004) conducted a thorough analysis and discovered varying levels of empirical evidence supporting the EKC in relation to various pollutants and nations. Although sulfur dioxide emissions exhibited signs of an EKC

pattern, other pollutants did not. In addition, scholars such as Carson and Jeon (2018) emphasize the significance of considering other aspects, including the quality of institutions, level of trade openness, and rate of population increase, when examining the EKC. These factors may have a substantial impact on the form and presence of the EKC.

A criticism is that the EKC may not be generally applicable because to its dependence on assumptions on the efficiency of policies, technological advancements, and wealth distribution (Cole, Rayner, & Bates, 1997). Moreover, it is proposed that the EKC may not be an absolute correlation, but instead dependent on particular policy decisions and circumstances (Dinda, 2004). In addition, several scholars contend that the EKC might be attributed to a transfer of pollution from industrialized nations to emerging economies as a result of globalization and the practice of outsourcing (Grossman & Krueger, 1995).

Although the EKC has some constraints, it has substantial policy ramifications. It implies that economic expansion has the potential to contribute to environmental enhancements, however it is not an absolute assurance. To expedite the shift towards the declining phase of the EKC, policymakers should prioritize the implementation of efficient environmental legislation, encourage technology advancements, and advocate for sustainable consumption habits. In addition, international collaboration is essential for tackling global environmental issues, since pollution may transfer across nations as they progress along the curve (Dasgupta et al., 2002).

Ultimately, the Environmental Kuznets Curve continues to be a relevant and powerful notion within the realms of environmental economics and sustainable development. Although it offers a theoretical framework proposing a possible method to separate

economic development from environmental harm, the actual data is inconclusive, and its relevance differs depending on the kind of pollutants and geographical areas. Additional study is required to get a deeper understanding of the circumstances in which the EKC applies, and to provide valuable insights for implementing successful policy measures that promote both economic growth and environmental sustainability.

2.1.3 Green Economy Theory

The concept of the green economy has become a major paradigm for tackling environmental concerns while promoting economic growth. This theory asserts that economic progress may coexist with the preservation of the environment and the achievement of social fairness, based on principles of sustainability and environmental stewardship. Recently, it has garnered considerable focus as a reaction to the urgent worldwide concerns of climate change, resource exhaustion, and inequality.

The notion of the green economy is based on many philosophical underpinnings. Daly and Cobb (1994) established the foundation for ecological economics by highlighting the need of attaining economic expansion while safeguarding the limited capacity of the Earth's ecosystems. In addition, the study "Our Common Future" (1987) by the Brundtland Commission developed the notion of sustainable development, emphasizing the incorporation of environmental, social, and economic aspects. The green economy, as defined by the United Nations Environment Programme (UNEP) in 2011, refers to an economic system that improves the quality of life for humans and promotes fairness, all while minimizing environmental hazards and resource shortages. The key ideas include the separation of economic progress from environmental harm, the optimization of resource use, the promotion of environmentally friendly innovation, and the promotion of inclusion.

The green economic discourse revolves around a key dispute about the compatibility of green development with sustainability. Advocates contend that the attainment of green development is feasible by means of technical advancement and the optimization of resources (Sachs, 2015). On the other hand, the de-growth movement argues that ongoing economic development is fundamentally unsustainable and advocates for decreasing general levels of consumption and output (Kallis et al., 2012). This argument underscores the intricate compromises between economic expansion and environmental durability, underscoring the need for meticulous scrutiny.

Several empirical studies have investigated the practical consequences of the green economy hypothesis. Barbier (2012) performed a comprehensive review of 86 research, revealing that investments in natural capital may provide favorable economic outcomes. The Global Green Economy Index (GGEI) offers a thorough evaluation of nations' endeavors in advancing green economic development, providing valuable insights into national initiatives (Global Green Economy Index, 2020). These empirical experiments highlight the possible advantages of adopting green economic models.

The green economy hypothesis has been acknowledged by governments and international organizations as being crucial in tackling global concerns. The Sustainable Development Goals (SDGs) of the United Nations include several dimensions of the green economy, with a focus on fostering equitable and sustainable economic expansion (UN, 2015). Several nations have developed green growth plans and policies to advance the adoption of renewable energy, sustainable agriculture, and circular economies (OECD, 2017). These policies often strive to promote environmentally friendly innovation, provide employment opportunities in the green sector, and decrease the release of greenhouse gases.

To summarize, the green economy idea signifies a fundamental change in economics, promoting a holistic approach that harmonizes economic expansion, environmental preservation, and societal welfare. It incorporates a range of fundamental ideas and has ignited discussions over the practicality of environmentally sustainable economic development and the need for reducing economic growth. Empirical data indicates that sustainable economic models may provide favorable results, despite the presence of ongoing obstacles. In the face of worsening environmental issues, the idea of the green economy continues to be an essential paradigm for governments, corporations, and scholars who are working towards a future that is both sustainable and fair.

2.2 Empirical Review

2.2.1 Green Finance and Environmental quality

Green finance encompasses a diverse range of environmental objectives, including the reduction of industrial pollution, the mitigation of CO2 emissions, the improvement of water sanitation, and the preservation of biodiversity (Nawaz et al., 2021). Mitigation Finance pertains to investments in initiatives and endeavors aimed at mitigating or eradicating “greenhouse gas emissions (GHGs).” Financial flows for adaptation, on the other hand, are related to investments made to lessen the vulnerability of people and products to the effects of climate change. Green finance has provided the potential opportunity for many businesses to grow and expand, which was restricted before due to environmental control (Tran, 2021). Consequently, green finance has emerged as a potential breakthrough and backbone to inject green funds into potential growth opportunities for businesses to expand while keeping in view the environmental effects and harms (Naderipour et al., 2020).

In light of the growing critical importance of green finance, researchers and academics have diverted their research direction to it. For example, Muganyi et al. (2021)

examined how green finance-related policies affect protection in 290 Chinese cities. Using the econometric approach “Difference-in-Differences (DID)” and their research revealed that green finance policies play a substantial positive role in mitigation of environmental hazards. Moreover, Nawaz et al. (2021) employed “difference in difference” estimator to explore the relationship between “green finance and climate change mitigation in N-11 and BRICS” economies using Panel data ranging from 2005-2019. They evidenced that “economic growth, population, technical cooperation grants, foreign direct investment, human development index, carbon dioxide, inflation, local credit to the private sector and domestic investment private participation in the energy sector” are significantly associated with green finance.

Additionally, Chen and Chen (2021) and Huang and Chen (2022) used a green finance index system composed of four components, including “green credit, green insurance, green investment, and green securities”. The results of these studies approved that injecting green finance investment into the economy of 30 provinces of China boosts environmental performance. Moreover, Zhou and Xu (2022) investigated the role of green finance on the ecological development of China. They used the system “Generalized moment method (GMM)” as an econometric model to estimate the association. It was discovered that, when considering the whole country, the coefficient representing the impact of green financing on ecological development is negative, whereas the coefficient representing the impact of the quadratic term on ecological development is positive. The link between green finance and ecological development exhibits a U-shaped pattern of effect. In their study, Wang et al. (2021) examined the impact of various green financial assets on the reduction of CO_2 emissions. The investigation was conducted within the context of varied levels of environmental regulation intensity, focusing specifically on “126 resource-based prefecture-level

cities in China." The findings of the study indicate that the implementation of green finance instruments has a noteworthy and detrimental impact on the level of CO_2 emissions.

Additionally, it is observed that green finance has the ability to conform to varying degrees of environmental standards, hence facilitating the reduction of carbon emissions. Furthermore, while comparing the two, it can be seen that the debt-based green finance instrument had a more pronounced impact in contrast to the equity-based green finance instrument. Furthermore, there was no evidence of a coupling connection between the two instruments. Hence, there is a need for an administrative adjustment in the realm of "green finance and environmental regulation" in order to effectively mitigate environmental emissions and enhance sustainable development. In their research, Zakari and Khan (2022) conducted an investigation of the impact of green financing on the attainment of environmental sustainability across 11 leading nations, as determined by their investments in environmental preservation between 2006 and 2017. Through the use of "panel-corrected standard errors and the feasible generalized least squares model," the researchers discovered a positive correlation between green financing and enhanced environmental sustainability. Mngumi et al. (2022) used panel quantile regression analysis to examine the relationship between green financing, among other determinants, and carbon dioxide (CO_2) emissions in the economies of the BRICS countries. It has been projected that the progress made in the establishment of the green finance development index has had a significant role in the mitigation of carbon dioxide emissions. The efficacy of green finance initiatives in achieving sustained outcomes has been continuously lacking. Therefore, the research proposes that enhancing the use of renewable energy and establishing a carbon trading

market are integral components of the suggested measures to enhance green financing policies.

In their study, Khan et al. (2022) examined the dynamic nature of green finance and its significance. The researchers operationalized green finance as “climate mitigation finance” and conducted an analysis to assess its influence on the ecological footprint within twenty-six economies situated in the Asian area. In order to do this, the researchers used a “conventional ordinary least squares baseline model,” which was then complemented by fixed-effects estimation. The empirical evidence presented in this study demonstrates that the implementation of green financing has led to a reduction in ecological footprints, indicating its ecologically beneficial nature. From an Asian standpoint, specifically, green financing performs as expected. Furthermore, researchers have used various proxy for green finance, such as Tran (2021) and Ngo et al. (2021) used “green bonds, green credit, green security, and green investment” to investigate the possible effect of green finance on environmental degradation, and outcomes affirmed that green finance is a prospective solution to mitigate ecological hazards.

Furthermore, the study conducted by Li et al. (2021) examined the factors that contribute to carbon emissions, specifically focusing on the impact of green investment in 30 provinces of China over a period spanning from 1985 to 2017. The study's empirical findings suggest that green investment plays a significant role in mitigating carbon emissions. In contrast, the findings of the study demonstrate a noteworthy positive correlation between natural resources rent, financial development, and energy investment with carbon dioxide emissions, thereby resulting in a deterioration of environmental quality.

2.2.2 Economic growth, Green Finance, & Environmental Quality

The goal of global economies is to accelerate the nation's economic growth. The GDP, which measures economic growth, is a key indicator of a country's overall national income and is seen as a tool for gauging a society's and a country's overall health. Therefore, policymakers, economists, and environmentalists have close insight into economic statistics. But one of the unfavourable effects of economic growth is carbon emissions, because it has been shown to be strongly associated with air pollution and climate change, both of which have substantially harmed our environment and way of life (Ali & Seraj, 2022; Nguyen et al., 2021). Moreover, Zhang et al. (2022) stated that emissions of CO_2 are usually high all through times of strong economic boom but low all through times when economic boom.

Grossman and Krueger (1991) initially discovered "Environmental Kuznets Curve (EKC)" stating that "there is an inverted U-shaped" association between per capita GDP and environmental degradation. The outcomes reveal that "at the initial level; EG harms the environment (scale effect); after that, EG leads to less polluting activities (composition effect), and the final level of economic growth leads to technical progress, more spending in R&D, replacing dirty, eco-unfriendly, and obsolete technology, installing new and clean innovative, friendly technology (technique effects)." Similarly, Xiaoguang Zhou et al. (2020) tested the connection between economic growth and environmental pollution and discovered that the concentration of dust and Sulphur dioxide in the air increased as per capita income increased until it reached a tipping point, at which time it started to fall. Various studies have tested the above relationship, including (Jiang et al., 2021; Tran, 2021).

The literature evidenced mixed results with respect to validation of the EKC U-shaped Curve. For instance, Tenaw & Beyene, (2021) in case of "Sub Saharan Economies"

validated the EKC hypothesis by utilizing “Pooled Mean Group Estimator (CCE-PMG) in the context of error-correction based panel Autoregressive Distributed Lag (ARDL) model augmented with cross-sectional averages”. Similarly, Isik et al., (2021) in 4 OECD economies, Mahmood et al., (2023) and Pata & Caglar, (2021) in China, Dogan & Inglesi-Lotz, (2020) in European economies, Işık et al., (2019) “Florida, Illinois, Michigan, New York, and Ohio”, Pata, (2021) and Işık et al., (2022) in USA, Jahanger et al., (2022) “North American Free Trade Agreement (NAFTA)” Pata & Kartal, (2023) in South Korea, and Pata et al., (2023) in Germany.

On the other hand, Pata & Samour, (2022) in case of France evidenced that there is no U shaped EKC curve. Jahanger et al., (2023) studied the nexus between CO2 and economic activities in case of “top 10 nuclear producing economies.” They found an N-shaped Curve rather than u shaped. According to Wang et al. (2023), their research demonstrates that income inequality has altered the correlation between “economic growth and carbon emissions.” Specifically, the relationship has shifted from an inverted U-shaped curve to an N-shaped curve. This implies that income inequality has redefined the EKC and has made the decoupling of economic growth and carbon emissions more intricate. The study conducted by Hossain et al. in 2023 did not provide evidence to support the existence of an N-shaped EKC when examining the ecological footprint.

Moreover, it has been demonstrated that GDP is closely correlated with the greenhouse effect, which have adversely affected our ecosystem and daily lives (Abaidoo & Agyapong, 2022b; Alola et al., 2019; K. Li et al., 2020; Nathaniel & Adeleye, 2021a; Sheraz et al., 2021). Ramzan et al., (2022) estimated the “role of economic growth, trade openness, and fossil fuel energy for the rising level of ecological footprints in Pakistan”. The researchers discovered that the process of “financial development, trade

liberalization, and economic growth" leads to the depletion of resources and contributes to the rise of the environmental footprint. Additionally, they revealed that fossil fuel energy consumption hampers the environment by emitting high levels of CO_2. Similar outcomes have been obtained by Quito et al., (2023) in the case of 43 European economies. Bashir et al., (2023) concluded that economic growth enhances the carbon emissions in OECD nations, hence, these nations must utilize the green energy for the economic development to keep the environment clean. Tran (2021) the findings show that economic expansion is significantly positively correlated with CO_2 emissions. The study concluded that green finance is best alternative to improvise environmental quality with sustainable economic growth under SDG7 in Vietnam.

However, various researchers have shown the potential negative influence of economic development on carbon emissions in the long run, for instance (Muganyi et al., 2021), in China, (Joof and Isiksal, 2021) in MINT countries and (Nawaz et al., 2021) in BRICS and OCED member nations. Similarly, Fatai Adedoyin et al., (2021) in 26 European economies estimated that "economic growth and energy consumption" enhances carbon emissions. This implies that the rise in, intricacy of the economy, and financial downturn does not expedite environmental crises in these economies.

In addition, that, Alam and Murad (2020) looked into the repercussion of the "economic growth, trade openness, and technological progress on the renewable energy in 25 OECD countries," utilizing ARDL and FMOLS econometric approaches for the robustness of the results. They found that on panel data spanning from 1970-2012, "economic growth, trade openness and technological progress" are significant indicators of renewable energy in 25 OECD countries. These countries must ponder over the investment in renewable energy to mitigate the worst impact of CO_2 on

environmental quality by promoting technological advancement, trade liberalization and economic growth.

Green finance is an emerging financial tool designed to address environmental issues, representing a manifestation of financial innovation within the realm of environmental conservation and economic growth (Zhou et al., 2020). According to research by He et al. (2019), environmentally friendly investment in sustainable energies has a threshold impact on the growth of the green economy. Over the long term, greener investment in renewable energy may successfully foster this growth.

In addition, green banks provide both public and private capital towards enhancing energy efficiency, hence stimulating economic growth (Ning et al., 2023). The potential for using green bonds to fund ecologically advantageous initiatives or enterprises is boundless. Allowing the evaluation of energy efficiency investment proposals with low payback hurdle rates might result in significant missed opportunities. Green bonds may facilitate the elimination of financial obstacles for green finance and sustainability initiative. Nawaz et al., (2021) stated that green finance boosts the green economy by reducing the carbon footprint and boosting sustainable environment. Green finance may have a crucial impact in expediting this transition in order to provide the circumstances that ensure equal opportunities for both the conventional and green economy (Falcone, 2020).

2.2.3 Banking Sector development, Green Finance, and Environmental quality

Climate change is becoming a growing worldwide worry. The desire to understand the environmental impact and to take action is significantly increasing. In this regard, the banking sector has a real opportunity to provide a solution in terms of green financial products and can serve the demands of carbon-conscious units to fight and protect our planet. In line with this Xu and Li (2020) debt instruments such as green credit issued

by the banking sector are the most essential and indispensable financial instruments in Asian economies. Similarly, Zhou et al. (2020) stated that green credit is an essential and indispensable financial tool that the government has set up to incentivize banking firms to distribute monetary capacity and direct capital flow to clean-producing sectors. Banking firms are reducing their lending to pollution problems. Majeed et al. (2020) used NARDL on times series data from 1972-2018 in Pakistan to test the impact of financial development on carbon emissions. They found that negative shocks are responsible for mitigating CO_2 emissions. However, Park et al. (2018) estimated the effects of FD on CO_2 in European Union countries. The studied outcome showed mixed results for the EU countries such as "Austria, Germany, Hungary, and Slovenia" FD increases CO_2 emissions; however, "Croatia, Czech Republic, Finland, Greece, and Portugal" FD reduces it. Moreover, Rafique et al. (2020), Raheem et al. (2020), Abid et al. (2022), Susanti et al. (2020), and Z. Xu et al. (2018) in BRICS, G7, G8, ASEAN, and Saudi Arabia, respectively empirically analyzed the association the influence of financial development on carbon emissions.

Additionally, Paramati et al., (2018) in 23 industrialized and 20 developing nations utilized the panel data from 1991 to 2011 to discover the association between "stock market development on carbon emissions." The finding of the study claimed reduction of carbon emissions in industrialized nations because of strong emission control systems; however, in emerging countries, whereby emission decrease has not been accomplished, the converse is true. This ground-breaking finding encourages developing countries to greener existing investment portfolios by mandating companies listed adopt eco-friendly strategies and increase the share of renewable energy sources in their energy use. Therefore, we hypothesized banking sector development might lead to attracting green finance investment by issuing green and

eco-friendly products to carbon-intensive business units to mitigate environmental hazards.

Additionally, Mukhtarov et al. (2018) examined the impact of financial development along with real domestic credit and economic growth on renewable energy consumption in Azerbaijan from 1980-2011, deploying "Vector Error Correction Model." They presented that the variables are key drivers to boost investment in renewable energy and policymakers of Azerbaijan must attract real domestic credit and develop strong financial system to invest in green energy resources to promote quality environment along with sustainable economic development. Green banking seeks to diminish the release of carbon emissions and enhance society's ability to withstand the effects of climate change, all while considering other sustainability objectives, including economic growth (Park & Kim, 2020).

2.2.4 Clean energy, Green Finance, and environmental quality

The increasing energy use has created substantial demand for green finance (Espejo et al., 2020). As a result, using renewable energy below the specified threshold has a detrimental impression on green, clean, and eco-friendly finance and economic development (Chen et al., 2020; Deka & Dube, 2021). Rendering to Chen et al. (2020) use of renewable energy has been demonstrated to have a favourable impact on macroeconomic indices in countries that are members of the Organization for Economic Cooperation and Development (OECD). Li et al. (2021) discovered the beneficial effects of green finance on increasing renewables initiatives, mostly limited energy initiatives. Rasoulinezhad & Taghizadeh-Hesary (2022) studied green finance can assist countries in improving long-term renewable energy growth by engaging venture capitalists and generating harmony between the government and industry. Azhgaliyeva et al. (2019) recommended that financial market operations and green

financial regulatory frameworks are necessary for green finance to have a rapid and positive impact on the development of renewable energy. Sachs et al. (2019) investigated many elements of renewables financing in India and discovered that its expansion of the renewables financing market enhances green initiatives, resulting in a greater commitment to renewables to Asia's overall energy portfolio. Ali et al. (2022) revealed that renewable energy must be bused in a larger proportion than fossil fuel to diminish the climate effects in South Africa. As per Tu et al. (2021), economic conditions, as well as the green finance market process, are two important aspects in establishing a favourable association involving green finance and renewable energy. Therefore, we propose that the increasing use of clean energy in South Asian countries scale up the investment in green finance.

Moreover, antecedent playing a critical role in carbon emissions is energy use. The association between energy and CO_2 has been a controversial research topic in environmental research for the last few decades. Concerning climate change, clean energy consumption is projected to significantly impact environmental sustainability by reducing atmospheric CO_2 emissions. Consequently, many policymakers, environmentalists, and the ministry of the environment significantly recognized the increasing importance of clean energy in meeting energy demand and supply while reducing carbon emissions (Ali & Seraj, 2022; Samour et al., 2022). Chien-Chiang Lee et al. (2022) tested how clean energy interacts with CO_2 in the global economy. The results of the “Dynamic Conditional Correlation with Mixed Data Sampling (DCC-MIDAS) model” showed a very significant inverse relationship between renewable energy and CO_2. Their research recommended consuming more clean energy to enhance environmental performance. Abbas et al. (2021) conducted a study in Pakistan to examine the impact of traditional energy and renewable energy on CO_2.

The researchers utilized data spanning from 1970 to 2018 and employed statistical models such as the “autoregressive distributed lag model” (ARDL), fully modified ordinary least squares, and dynamic ordinary least squares. The findings of this study align with previous research in this field. They found that in short run traditional energy and renewable energy insignificantly affect environmental quality, however, traditional energy has negative effect and renewable energy effects positively on the environment quality. This study suggests the need for the formulation of suitable policies pertaining to the energy sector, such as the discouragement of conventional energy consumption by the government and the promotion of renewable energy consumption within the industrial sector. Nawaz et al. (2021) in BRICS and OECD nations, employed “quantile autoregressive distributed lag (QARDL)” to estimate the link between “nonrenewable energy, renewable energy and carbon emissions” on the panel data. They revealed that the renewable energy effect is negative and nonrenewable energy effect on the carbon emission is positive and significant. Hence, they concluded that it is advisable to adopt a renewable energy centric strategy for energy production in the designated area for forthcoming initiatives. Doğan et al. (2020) in European countries, estimated the nexus of energy efficiency on the carbon emissions. The energy efficiency by implementing new and latest technologies in the industrial sector can improve the environmental quality in the studied countries.

On the other hand, it is evidence that the use of fossil fuel energy hampers the environment. Numerous researchers have affirmed this association, such as Ali et al. (2020) in case of Pakistan quantified the link between fossil energy consumption and carbon emissions by using ARDL econometric estimator. The outcome of their study signifies that the fossil fuel energy consumption is the cause of the hazarded environment in Pakistan. The outcomes of their study are in line with Martins et al.

(2021), and Bekun et al. (2019). Who tested the effect of non-cleaner sources (Fossil fuels) while applying various econometric approaches. The results of their analysis showed that increasing reliance on unclean energy sources causes CO_2 emissions to increase, which is hazardous to the environment.

Moreover, Hussain and Rehman (2021) explored dynamic influence of CO_2 on renewable energy in Pakistan, employing ARDL estimation and concluded that renewable energy is negatively influenced by CO_2 and Pakistan needs to develop mechanism to reduce CO_2 by stimulating investment in renewable energy projects. Their results have been supported by Rehman et al. (2021) in Pakistan, Vural (2021) in Latin American economies, Sadorsky (2009) in Japan and da Silva et al. (2018) in Sub-Saharan African Countries. However, on the contrary, Sadorsky (2009) evidenced positive association of CO_2 to renewable energy consumption in "Canada, France, Germany, Italy, UK, and USA" and concluded that the policymakers of G7 countries except Japan must keep in mind the heighten importance of CO_2 explaining renewable energy. Similar results have been obtained by Omri et al. (2015) in 64 countries, Rasoulinezhad and Saboori (2018) in commonwealth independent states, Apergis and Payne (2014) in Central America, Omri and Nguyen (2014) in lower, middle- and higher-income countries, and Salim and Rafiq (2012) in Brazil, Canada, India, Indonesia, Philippines and Turkey.

Furthermore, other scholars Qamruzzaman & Jianguo (2020) employed "Non-Linear Autoregressive Distributed Lag" technique to provide fresh evidence on renewable energy consumption in lower income countries from 1990-2017. They evidenced that all studied antecedents are significantly positive with renewable energy at 1% significant level in long run. Further concluded that renewable energy initiatives can be uplifted while developing financial institutions network, attracting capital inflows,

nurturing trade openness. Hence, policymakers must take into account these vital outcomes to formulate energy policy, focusing green energy expansion in particular.

In India, Bekun (2022) showed that renewable energy and energy sector investment cut CO_2 emissions while non-renewable economic development increases them. Moreover, Bekun et al., (2021) in E7 blocs found that fossil fuel consumption enhances, and renewable energy reduces the emissions in the studied bloc. In their study, Bekun et al. (2023) made a significant finding regarding the emissions associated with cement production, specifically those linked to carbon. The researchers proposed that a more assertive strategy towards energy transition, enhanced regional trade openness, and the adoption of a sustainable natural resource rent policy could effectively mitigate these emissions. Tran (2021) investigated the association of "green investment, green credit, economic growth, renewable energy, and energy import on carbon emission" in the context of Vietnam, using time series data from 1986 to 2018. The researcher employed a vector autoregressive model to examine the relationship between various factors and their impact on CO_2 emissions. The results show that renewable energy, green investment, and green credit all significantly lower CO_2 emissions.

2.2.5 Foreign Direct Investment, Green Finance, and environmental quality

The foreign direct investment measured as net inflows (% of GDP) and urbanization measured in terms of % of the total population are studied in the existing literature in terms of their effect on CO_2 (Bekun et al., 2022; Li et al., 2020; Musah et al., 2021; Nathaniel et al., 2021). The results of the mentioned studies are mixed in terms of FDI and URB on CO_2. Such as K. Li et al. (2020) employed the CCEMG econometric model in the G-20 economies for the time period 1992-2014. The findings of their analysis showed that FDI might have a favorable impact on CO_2 in G-20 countries.

These outcomes are supported by Musah et al. (2021) in Northern Africa. On the contrary, Nguyen et al. (2021) examined how FDI affected G6 CO_2 emissions, utilizing the "GMM model." They revealed that FDI is an important component in reducing CO_2 and enhancing environmental quality in G6 nations. Similar results are evidenced by Yüksel et al. (2020) in the E-7 and G7 states. Furthermore, urbanization has a positive impact on carbon emissions, however the square of urbanization has a negative impact, according to a U-shaped inverted curve discovered by Faisal et al. (2021) in Turkey.

Additionally, Alshubiri and Elheddad (2019) in 32 OECD economies evidenced that foreign direct investment, and remittances are significantly negatively associated with CO_2 indicating inverted U-shaped association. It implies that although they initially contribute considerably to CO_2, the investments become more ecologically beneficial after they reach a certain degree. EG, on the other hand, degrades environmental quality while stimulating and boosting 32 nations' economies.

2.2.6 Urbanization and Environmental Quality

The ARDL results presented that, at the initial stage, the URB is harmful to the environment, but then passing the threshold level becomes friendly to the environment because of awareness of the harmful effects it has. However, in the context of Africa, it was determined that URB had a substantial environmental impact, like Solomon Prince Nathaniel et al. (2021) in "BRICS," F. V. Bekun et al. (2022) and Abaidoo and Agyapong (2022a) in 'Sub-Saharan Countries', and S. P. Nathaniel et al. (2021) in "Latin American and Caribbean countries". Yang & Khan, (2022) Nevertheless, the process of urbanization and the increase in population have a detrimental effect on long-term ecological stability in nations that are members of the International Energy Agency (IEA). Rahman & Alam, (2021) investigated the role of urbanization along

with other factors on the carbon emissions by employing the ARDL Model and found that population intensity and urbanization hampers the environment in Bangladesh. In the case of China, Liu et al. (2020) used the dynamic Spatial Durbin Model and discovered that increasing local urbanization levels would degrade local environmental quality.

Moreover, the economies of the “Middle East and North Africa (MENA)” are characterized by their high levels of urbanization and their abundance of natural resources. Nevertheless, these economies are facing significant challenges as a result of climate change. In light of this, Sun et al., (2022) investigated the links between "renewable energy consumption, urbanization, economic growth, and carbon emissions (CE)" from 1991 to 2019. This research makes use of “constantly updated completely modified and continuously updated bias-corrected methodologies,” and it demonstrates that fast urbanization and economic expansion lead to greater CE levels. These findings show that the MENA area is significantly dependent on fossil fuel usage; hence, a shift to alternative and environmentally friendly energy sources is necessary in order to mitigate the negative effects on the ecosystem. Musah et al., (2021) found that urbanization had a large and positively impactful effect on CO_2 emissions in all the three panels of west Africa.

Despite this, Wang et al. (2021) conducted research on the connection between the two characteristics and discovered that urbanization does, in fact, lower carbon emissions; however, the impact is negligible in countries that are members of the OECD. Zhang et al. (2017) investigated the inverted U-shaped connection that exists between “urbanization and carbon emissions” in countries that are members of the OECD. According to Sun and Huang's (2020) analysis of data from 30 of China's provinces,

the link between urbanization and emission efficiency resembles an upside-down version of a U shape.

2.2.7 Green Finance and Green total factor productivity

According to theory and research, financial deepening may boost economic growth by encouraging savings, capital accumulation, better capital allocation, and trade and risk management. As a new financial invention, green finance's functions and features are similar to conventional finance, but its environmental objective seems to be the main difference (Lee & Lee, 2022a). He et al. (2019) revealed that green infrastructure growth and development leads bolster the macroenvironment's financial framework and direct small business units to participate in economic and environmental advantages for the growth of the green economy. Thus, green finance changes conventional "financing-investment" industry to influence firms' environmentally friendly investments and create a green financial system for sustainable growth. Ali & Seraj (2022) suggested that investment in renewable energy as part of green finance investment reduces the environmental degradation resulting in strengthening the green economy. Similarly, Zhou et al. (2020) found how green financing affects economic growth and environmental quality. According to their findings, green finance may maximize economic development and optimize environmental performance.

Over the last several years, academia has increasingly studied green finance concept as new financial model, environmental finance, financial innovation, financial farmwork. GF boosts effectiveness and ecological excellence by shifting investment from high-polluting enterprises to environmentally conscientious sectors. Semenda and Semenda (2018), stresses the need of investing in green economic hub and ecological management to reduce environmental damage (Gusheva & de Gooyert, 2021), and supports industrial reform, provides loan opportunities, and protects the

environment (Werikhe, 2022). Besides, the GF leverage environmental quality in many ways, such as investment assistance (S. Liu et al., 2021), allocation of capital (Liu et al., 2021), and high-tech novelty (Ponta et al., 2022). Technological effect reveals that GF provides the opportunities to invest funds in green projects, clean energy initiatives, and energy efficiency tracks to boost green industry, which results less production of pollutants to harm the ecology (Lee & Lee, 2022a). Due to the GTFP's emphasis on inputs and outputs, GF acts as an input in the present movement to promote eco-friendly behaviors and restore the natural environment by lowering CO2 emissions (Tong et al., 2022). Based on this, we postulate that the GF may promote the GTFP by enhancing the energy efficiency and decreasing the environmental deterioration. Therefore, we postulate the hypothesis is as under: Green Finance (GF) boosts the green total factor productivity (GFTP) in the G5 and GL5 economies.

2.2.8 Environmental Technological Innovation and Green total factor productivity

Any nation's industrial growth depends on manufacturing industry technology. Green and sustainable development relies on green technology to decrease pollution, preserve energy, and coordinate environmental protection with company competitiveness. Green technology advancement is slow, expensive, and risky and green innovation depends on environmental assessments (Song et al., 2022). Scientists have shown that environmental quality may be restored via green innovation when economic expansion is associated with rising pollution levels due to climate change (Wu et al., 2022). Green technology helps combat climate change by improving the environment (Yu et al., 2019). Du et al. (2019), Shang et al. (2022), and Razzaq et al. (2023) produced that green technology enhance the quality of environment in high income economies, China, and top ten GDP economies, respectively. Several research has shown that

green innovation might support company TFP and have a positive impact on the environment at the micro level (Ren et al., 2022; Song et al., 2022; Wu et al., 2022; Zhang et al., 2021).

Green innovation may influence the TFP of an organization largely via three processes. The first, adjusting for stringent environmental regulation, and enhancing green production technology, and unit labor productivity (Du & Li, 2019; Wu et al., 2022). The second method is to enhance TFP while lowering production costs via innovations in renewable energy sources (Lee & Lee, 2022; Wu et al., 2022). The third machine works by using additional elements like technical distances or aptitude for absorbing and understanding new technologies (Fang et al., 2021; Wu et al., 2022). Based on the three plausible pathways, this research postulates the hypothesis that environmental technological innovation increases GTFP. The environmental technological innovation enhances the GTFP in the G5 and GL5 economies.

2.2.9 Environmental Policy Stringency and Green total factor productivity

Sustainable development gained recognition on a global scale since 1990 (Tong et al., 2022). The three pillars of development—economy, environment, and society—are receiving more attention (Petković et al., 2022). In-depth academic study has been done on how to achieve a condition where economic development and environmental conservation are mutually beneficial (Aboud & Yang, 2022). In this case, environmental regulations stringency is one of the most crucial strategies for creating a "win-win" scenario in this case. To encourage environmentally friendly growth and environmental balance, nations establish environmental restrictions. In this regard, Ahmed et al. (2021) found that G7 environmental policies reduced ecological footprint and improved ecological sustainability.

Moreover, Porter (1991) postulated the hypothesis that “strict environmental regulation can induce efficiency and encourage innovations that help improve commercial competitiveness” and stimulate the technology transmission process. This will benefit the productivity of the country and environmental quality. The exiting literature (Cheng & Jin, 2022; Tong et al., 2022; Wang et al., 2021) is built on various cities of China at nation and provincial level only to investigate the influence of environmental regulations on total green factor productivity. Wang et al. (2021) investigated the association between environmental regulation with green total factor productivity at the provincial level in China. They revealed that environmental regulations have significantly positive link with green total factor productivity in provinces of China. Similar results have been obtained by (Cheng & Jin, 2022; Qiu et al., 2021; Tong et al., 2022; Wu et al., 2020) in the context of China.

The second perspective is restriction hypothesis. This hypothesis claims that ER raises production costs, reduces investment, and lowers social GTFP. Gray (1987) discovered that ER may reduce TFP for US manufacturers. Similarly, (Barbera & McConnell, 1990; Boyd & McClelland, 1999) proved that stringent environmental regulations are harmful for output (TFP) from industry and firms, as it enhances restriction on capital investments, similar to the results obtained by Lanoie et al. (2011), Tang et al. (2020), and Hou et al. (2020). Finally, the uncertainty hypothesis provides the situational effect of ER on TFP. For instance, Becker (2011) proves the insignificant association of ER to TFP; Wang and Shen (2016) U-shaped Curve between ER and TFP; and Shuai and Fan (2020), and Cao et al. (2020) found U-Shaped Curve and He et al. (2021) found insignificant association between ER and GTFP. Based on the above discussion we postulate the following hypothesis: Environmental

policy stringency (EPS) promotes the green total factor productivity in the G5 and GL5 economies.

2.2.10 Industry and Green total factor productivity

The structure of industry is a significant aspect that can have an effect on the ecological environment of an economy (Yan et al., 2020). It is widely held that the "waste gas, wastewater, and solid emissions" that are produced as a byproduct of industrial and agricultural operations will result in a significant amount of pollution to the surrounding environment (Wang et al., 2021; Ze-Lei et al., 2017). The continuous development and enhancement of manufacturing technology has the potential to completely reorganize the structure of the industrial sector (Drucker, 2011), leading to a reduction in environmental toxins and will help encourage ecological sustainability (Ahmed et al., 2016), and boosts economic output (Norcliffe & Mitchell, 1977). Hence, the industrial structure has influence on the green total factor productivity (Zhu et al., 2018). A few studies have determined the link between industrial structures and green total factor productivity such as, Lee and Lee (2022) examined the association in China and found negative link. Yan et al. (2020) revealed that INDS is positively and insignificantly association with green total factor productivity in China. However, Zhao & Chen (2022) and Wang et al. (2021) found positive and significant nexus between two facets. Hence, it can be viewed that existing literature produces mixed set of results, therefore, to validate it we have add industrial structure variable in this research to help macroeconomic policies. We postulated the hypothesis as: Industry structure (IS) can produce the green total factor productivity in the G5 and GL5 economies.

2.2.11 Renewable energy and Green total factor productivity

Energy usage, mostly fossil fuels, is the main engine of economic development. Yet, repetitive use of fossil fuel input causes sustainability challenges, such as dwindling natural resources and rising CO_2 over time (Sinha et al., 2018). Therefore, identifying the causality between energy use and green economic development is essential to energy policy planning. Many researchers have investigated the linkage between economic growth and renewable energy. See For instance, Payne (2009) in context of US, Menegaki, (2011) in 27 EU economies, Apergis et al, (2010) in developed and developed countries, Sadorsky, (2009) in emerging countries, Apergis & Payne, (2011) in central America, Aperies and Payne (2012) in 80 economies, Tugcu et al. (2012) in G7 economies, and Ozcan and Ozturk's (2019) in 17 emerging nations. All the above research works have affirmed that renewable energy boosts economic growth. Some studies have investigated the link between REN and green economic growth. Such as, Taşkın et al. (2020) discovered the positive and significant link between REN and green economic growth in case of OECD economies. However, according to best of our knowledge, none of these studies have considered effect of REN on the green total factor productivity. Therefore, keeping REN as driving force to reduce the environmental hazards, we postulate the following hypothesis: Renewable energy (REN) can produce the green total factor productivity in the G5 and GL5 economies.

2.3 Research Gap

From the above literature review we are "unable to find a study to investigate how carbon dioxide emissions are affected by green financing, economic development, foreign direct investment, clean energy consumption, and urbanization in ASEAN economies." This is due to the fact that mainly ASEAN nations are industrialized and largely populated, and carbon emissions have a detrimental effect on human activities

along with sustainable economic growth. This creates a pressing need to identify strategies for reducing environmental harms caused by activities to accelerate sustainable economic and environmental development in ASEAN member states. Thus, the first case study offers “clear direction to ASEAN environmentalists, government authorities, organizations, regulators, legislators, environmental ministries, and policymakers to curb CO_2 emissions by properly dealing with green finance, economic growth, foreign direct investment, clean energy consumption and urbanization.”

Moreover, countries all across the world are putting measures into place to lessen the hazards brought on by climate change and its effects on the environment. To elevate the necessary investment in green finance initiatives for battling the escalating consequences of global warming, a number of mechanisms, processes, and products are required, such as the issuance of climate bonds. Therefore, the world has come to understand that investing in green finance initiatives is the best course of action for reducing the planet's rising temperature caused by climate change. Literature on green finance is becoming more and more significant. The literature discussed above has investigated the role of green finance (Dai et al., 2022; Zheng Guang-Wen & Siddik, 2022), Renewable energy (Ahmed et al., 2022; Huang et al., 2023; Jahanger et al., 2022; Siddik et al., 2023; Sun et al., 2023), foreign direct investment (Anwar et al., 2021; Rafique et al., 2020; Zhou et al., 2023), economic growth (Akadiri et al., 2019; M. Ali et al., 2022; C. Chen et al., 2020; Foday Joof et al., 2023; F. Joof et al., 2023), and trade (Belloumi & Alshehry, 2020; Nathaniel et al., 2021; Padhan & Bhat, 2023) on the environmental degradation. However, there are a few studies (Guang-Wen & Siddik, 2023; Nawaz et al., 2021) that focused on determining the antecedents of green finance. Therefore, the second case study, investigates the “effect of banking sector

development, economic growth, and renewable energy consumption on investment in green finance while keeping carbon dioxide, foreign direct investment, remittances, inflation, and trade as control variables in South Asian nations."

Additionally, the prevailing body of research has focused on examining the causal relationships between the utilization of renewable energy and its underlying factors. These studies employed a range of econometric methodologies and focused on various nations, time periods, and variables. However, a handful of them have looked at green finance investment specifically in the OECD-15 European countries. However, the actual outcomes of these studies point in opposite ways and contradict each other. For the study's stated goal, the OECD-15 European nations, in particular, remained understudied in the literature. Furthermore, we were unable to locate any research that explored this link using the recently adopted Quantile Autoregressive-Distributed Lag (QARDL) econometric approach and RALS cointegration technique. Following the identification of these research gaps, the third case study aims to assess the antecedents of green finance investment in OECD-15 European countries. In order to invest in clean, green, and efficient energy projects that may assist these countries achieve long-term economic development while maintaining environmental integrity, they have a lot of green finance potential. Our study may thus significantly advance the little body of knowledge on green financing in the OECD-15 European countries.

Finally, it is evidenced from the literature that majority of research on green finance, environmental technology innovation, and green total factor productivity has been conducted in context of China (Cao et al., 2021; Ren et al., 2022; Song et al., 2022; Wu et al., 2022; Yan et al., 2020). Therefore, fourth case study is first to fill the gap and to explore the antecedents of green total factor productivity in G5 and GL5 economies. Second, unlike previous works on traditional productivity that mainly

considers good output, this case study applies the "super-efficiency slacks-based measure" model known as super-SBM model. Supper SBM takes into account energy consumption in addition to labor and capital as inputs, carbon emissions and gross domestic product as undesirable and desirable outcomes. Therefore, Super SBM model solves the potential omission problem of energy and environmental constraints. Third, in contrast to previous studied (Lee & Lee, 2022; Cheng & Jin, 2022; Tong et al., 2022) who applied traditional models such as, "pooled ordinary least squares (POLS), the random effect (RE), the fixed effect (FE), the two-way fixed effect (Two-way FE), and the generalized method of moments (GMM) models," we employ Panel Autoregressive Distributed Lag (PARDL) model to explain the long and short-run influence of factors of interest on GTFP. The PARDL model helps to overcome the problem of spurious regression and provide robust and consistent inferences. Finally, we extend research models of Lee & Lee, (2022) and Tong et al., (2022)[10] by adding more antecedents in the model such as environmental technological innovation, environmental policy stringency, renewable energy, and industry structure in the model in the context of G5 and GL5 group economies. Addition of antecedents provides additional insights considering the importance of the connection between green finance and green productivity and by doing so, detailed information about the causes of green productivity is achieved. In addition, we draw answer to the central question based on the expansion of new framework. Moreover, the findings of our study will shed light on the mechanisms by which environmentally responsible investments, technological policy, renewable energy, and industrial structure may bring benefit to the economy and the environment via the promotion of green economic growth and green productivity. The outcomes of addressing this gap may provide guidance to the

[10] Lee & Lee, (2022) conducted the study in context of China and Tong et al., (2022) explored this relationship in context of Asian Region.

governments, policymakers, environmentalists, stakeholders, and economic units in G5 and GL5 economies. The findings may aid in policymaking to improve green economic growth, reduce energy cost, enhance living standards, preserve ecological balance, and to meet “sustainable development goals (SDGs) 7 (affordable and clean energy), SDGs 8 (decent work and economic growth), SDGs 9 (industry, innovations, and infrastructure), and SDGs 13 (climate action).”

CHAPTER 3

"GOING AWAY OR GOING GREEN IN ASEAN COUNTRIES: TESTING THE IMPACT OF GREEN FINANCING AND ENERGY ON ENVIRONMENTAL SUSTAINABILITY"

3.1 Introduction

Green finance deals with methods of funding various initiatives to enhance the quality of the environment, ecosystem, natural resources, and health of living beings by addressing the harmful effects of pollutants (Dayong Zhang et al., 2019) and promoting social activities (Ngo et al., 2021). In addition, green finance stimulates economic growth by providing a healthy workforce, ensuring high-quality natural resources, and boosting green economic productivity. Consequently, financial institutes such as banks act as a driving force to offer green finance grants and credit to the social, commercial, and industrial sectors to accelerate and sustain substantial economic development and a sustainable environment (Streimikiene & Kaftan, 2021). Green finance entails a number of components such as "green bonds, green grants, green insurance, climate initiative bonds, and green investment" to strengthen economies of the associated economies while reducing environmental shocks (Ngo et al., 2021).

Ecological catastrophes brought about in terms of environmental degradation, resource scarcity, and soil devastation have become a global challenge that requires an immediate solution (Chiu & Lee, 2020). To combat global climate shocks, mounting environmental repercussions, and striving to attain eco-friendly inclusive development of sustainable development growth, global economies have started to establish green economies, which speaks to the coordinated growth of the economy, the environment, and the natural resources (Chi-Chuan Lee & Lee, 2022). In this connection, green financing has emerged as a crucial indicator to gauge the green of how well a nation

mitigates ecological problems, enhances environmental quality, and assures sustained economic growth. In light of this, policymakers, researchers, and academics are paying increasingly close attention to the question of how green financing is widely regarded a key topic of importance in preventing environmental degradation due to the transition to a green economy.

Furthermore, green financing is thought to be capable of boosting economic growth, clean energy consumption, attracting opportunities for foreign direct investment, and innovative technologies benefiting transition to the green economy, therefore improving the quality of the environment by lowering carbon emissions. Therefore, this research study investigates the effect of green finance, economic growth, foreign direct investment, clean energy consumption, and urbanization on carbon emissions in ASEAN countries. The world economy, as well as the vast number of industrial sectors and institutions, is supporting green finance primarily because of its primary advantage of combating climate change; ASEAN nations are not apart, as they are giving additional consideration to this concept, especially creating and using energy resources (Taghizadeh-Hesary et al., 2021). According to BDS and the UN environment report (2017), the estimated green financing opportunities in sectors and sub-sectors of the ASEAN are depicted in figure 1 and table 1 respectively.

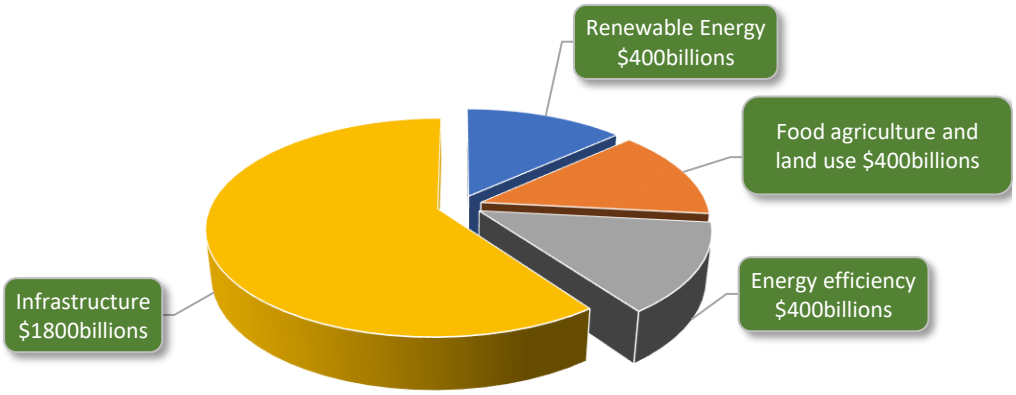


Figure 5 ASEAN Sector wise green finance Opportunities

Table 1 ASEAN Green Finance Opportunities (Sectorial and Sub-Sectorial)

Sectors	Sub-Sectors	Opportunities (In USD billions)	%
Renewable Energy	Solar	140	35%
	Hydropower	90	22.5%
	Wind	35	8.75%
	Bioenergy and others	135	33.75%
Food Agriculture and Land Use	Agriculture and food production	170	42.50%
	Distribution and management of food	180	45%
	Forestry and land management	50	12.50%
Energy efficiency	Buildings	152	38%
	Industry and production	57	14.25%
	Transport	191	47.75%
Infrastructure	Rail	60	3.33%
	Transmission and distribution of energy	700	38.89%
	water.	380	21.11%
	Telecommunications	260	14.44%
	Climate adaptation and mitigation	400	22.22%

Source: Author compilation; Data source: https://wedocs.unep.org/handle/20.500.11822/22284

The effect of climate shocks in ASEAN nations could cause regional economic development to decline by up to 11% in 2023 (ADB, 2017), and 70,000 could die annually by 2030 as 20,000 people die every year in the region of air pollution caused by extensive use of coal in power plants (CNN, 2017), and the health cost in the region is calculated at 280 billion dollars and could increase in the future (OECD, 2014). The ASEAN economies are susceptible to environmental shocks due to high dependency

on climate-sensitive industries like agriculture and fisheries (OECD, 2003), the fast-growing rate of urbanization, and population growth (smart cities, 2017). Around 28% of the total ASEAN population lives in unhygienic conditions, exposed to direct environmental shocks. The ASEAN nations are at a crossroads now to make the right decision in the right direction to adopt a green financing model to boost the economy by addressing environmental shocks. As stated by OECD (2014), "ASEAN economies have golden opportunities to leapfrog over the low performing, polluting, resource inefficient technologies and practices of more developed countries". This research primarily aims to investigate how green finance affects carbon emissions in ASEAN nations from 2000-2020. In addition, it guarantees that clean energy use and urbanization will contribute to improved environmental quality.

Previous studies have discussed the importance of green financing in establishing a sustainable ecosystem, such as , Chen and Chen (2021), Zhou and Xu (2022) in China, Zakari and Khan (2022) 11 OECD countries, and Mngumi et al. (2022), BRICS countries. But in the literature above, the ASEAN region has been ignored by researchers. For instance, Ngo et al. (2021), instead of focusing on environmental shocks, explored the function of green financing in economic growth. In addition, earlier research has focused on green financing using proxies such as "green credit, green bonds, green insurance, and renewable energy". Such studies have not considered the climate development finance used in terms of financial instruments such as grants, debt instruments, equity shares, and debt relief provided to the ASEAN economic sectors, including energy, transportation, industry, mining, construction, and environmental protection to finance green projects such as sustainable forest utilization, national resource management, environmental rehabilitation, industry detoxing cleaner environment, energy education, policy and system analysis, sea level

and climate monitoring projects, constructing biomass plants and environmental research.

This research examines environmental sustainability in the ASEAN nations while focusing on green finance, specifically climate development financing. This makes a noticeable contribution to the current body of literature. Also, to theoretical contributions, the present work presents practical values for ASEAN nations. This is due to the fact that mainly ASEAN nations are industrialized and largely populated, and carbon emissions have a detrimental effect on human activities along with sustainable economic growth. This creates a pressing need to identify strategies for reducing environmental harms caused by activities to accelerate sustainable economic and environmental development in ASEAN member states. Furthermore, the results of this study will assist the ASEAN industries in becoming green, encourage technological advancement, provide the financial sector with new green business prospects such as developing green products and services, facilitate access to the new market and, above all, help mitigate environmental shocks. Furthermore, methodologically, our study is pioneering in investigating the non-linear (Asymmetric) effects of green finance and clean energy utilizing the "Non-linear Autoregressive Distributed Lag (NARDL) Model". Thus, the current study hopes to "offer clear direction to ASEAN environmentalists, government authorities, organizations, regulators, legislators, environmental ministries and policymakers to curb CO_2 emissions by properly dealing with green finance, economic growth, foreign direct investment, clean energy consumption and urbanization."

The structure of paper is follows as: Section 2, includes extensive literature on previous studies, section 3 presents information on data and methodology, section 4 depicts

results and discussion. Finally, section 5, presents conclusion and policy recommendations based in study findings.

3.2 Research Methods

3.2.1 Data

The goal of this investigation is to assess how the ASEAN countries' "carbon dioxide emissions are affected by green financing, economic development, foreign direct investment, clean energy consumption, and urbanization." The data on green finance was extracted from the "Organization of Economic Co-operation and Development (OECD)" and the rest of the study variables from the "World Bank Development Indicators (WDI)" from 2000 to 2020. The generic model in Equation 1 below is created based on the literature review for this study.

$$lnCO_{2_{it}} = \tau_0 + \tau_1 lnGF_{it} + \tau_2 lnEG_{it} + \tau_3 lnFDI_{it} + \tau_4 lnCEC_{it} + \tau_5 lnURB_{it} + \mu_{it} \quad (1)$$

Where CO_2, EG, FDI, CEC, and URB refer to carbon dioxide, economic growth, foreign direct investment, clean energy consumption, and urbanization, respectively. However, *t* refers to the time period from 2000 to 2020, τ_0 refers to constant, $\tau_1, \tau_2, \tau_3, \tau_4,$ and τ_5 refers to coefficients of variables, respectively, and *i* denotes ASEAN countries ("Cambodia, Indonesia, Lao people's democratic republic, Malaysia, Myanmar, Philippine, Thailand, and Vietnam"). However, due to a lack of data, Singapore and Brunei were omitted from the research. The information on the variables of the study is summarized in Table 2.

Table 2 Data disruption and source

Variable	Abbreviations	Measurement	Source
Carbon dioxide	CO_2	"CO_2 emissions (metric tons per capita)"	WDI
Green Finance	GF	Climate-related development finance - commitment - current USD thousand	OECD
Economic Growth	EG	"GDP per capita (constant 2015 US$)"	WDI
Foreign Direct Investment	FDI	"Foreign direct investment, net inflows (% of GDP)"	WDI
Clean Energy Consumption	CEC	"Renewable energy consumption (% of total final energy consumption)"	WDI
Urbanization	URB	"Urban population (% of the total population)"	WDI

Sources: Authors compilation

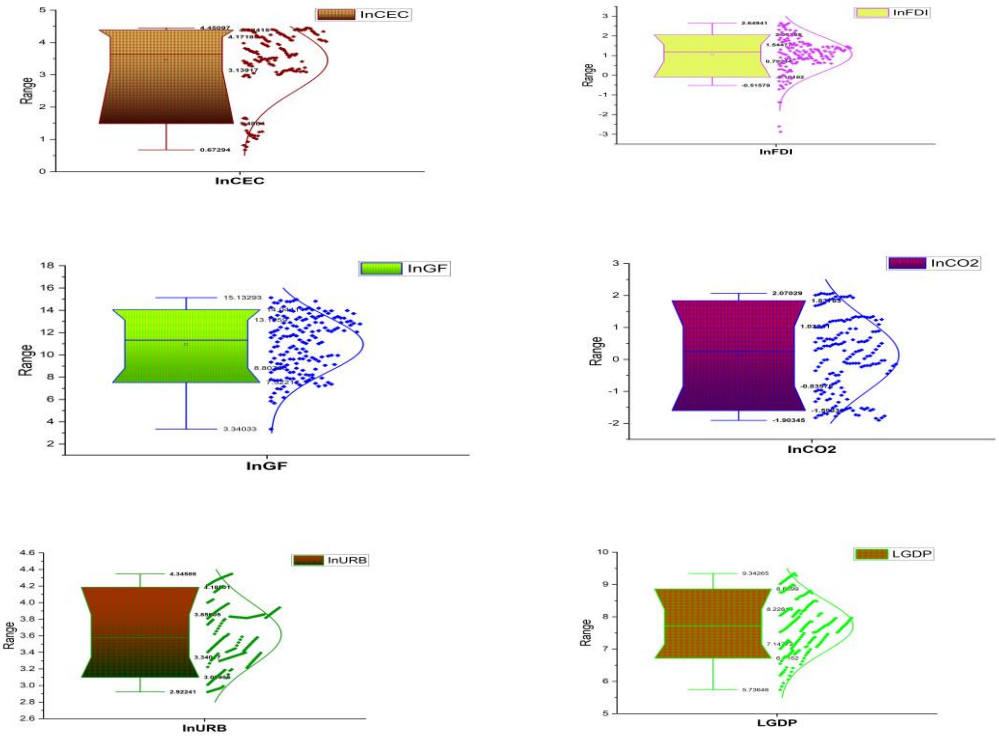


Figure 6 QQ Plot results

3.2.2 Estimation Procedures

3.3.2.1 Cross-Section Dependency (CD) Test

This research study is on panel data, so it utilizes CD test developed by Pesaran (2015) as it provides direction for applying first or second-generation panel econometric approaches as proposed by (F. V. Bekun et al., 2022). The CD equation is as follows:

$$CD = \sqrt{(2T/N(N-1)}\ (\sum_{i=1}^{n-1}.\sum_{j=i+1}^{n}\delta_{ij}^{t}) \quad (2)$$

Where T and N refer to cross sections and time, respectively, however, δ_{ij}^{t} refers to correlation residual estimate.

3.3.2.2 Slope homogeneity (SH) test

This work also conducts a slope homogeneity test as proposed by Pesaran and Yamagata (2008) to check the data's similarities. The SH test equation is as follows:

$$\Delta_{SH}^{\sim} = N^{\frac{1}{2}}2K^{\frac{1}{2}}\left(\frac{1}{N}\ S^{\sim} - K^{\cdot}\right) \quad (3)$$

$$\Delta_{ASH}^{\sim} = N^{\frac{1}{2}}\left(\frac{2K(T-k-1).^{-1/2}}{T+1}\left(\frac{1}{N}\ S^{\sim} - K^{\cdot}\right)\right) \quad (4)$$

Where $\Delta_{SH}^{\sim}$ refers to delta tilde and $\Delta_{ASH}^{\sim}$ denotes adjusted delta tilde.

3.3.2.3 Panel Stationery and Normality Approach

The first-generation stationary is inefficient, as shown by the estimated CD evidence Im et al. (2003). Hence, we used the second generation stationary CIPS and CADF to address the issue of estimating inefficiencies. Equation 6 presenting unit root is as under:

$$\Delta \mathrm{Y}_{it} = \Delta\theta_{it} + \beta_i \mathrm{X}_{it} + \vartheta_{iT} + \sum_{j=1}^{n}\delta_{ij}\Delta X_{i,t-j} + \epsilon_{it} \quad (5)$$

Where $\Delta\theta_{it}$, X_{it}, Δ, T, and ϵ_{it} refer to intercept, factor analysis, variance operator, time period, and white noise. To evaluate the long-term consequences of the variables being considered, a second-generation test is done close to the first differences of stationary variables. In addition to that the normality of data is checked by quantile-Quantile (QQ) Plots as shown in figure 2.

3.3.2.3 Panel Cointegration Approach

This research used the "Westerlund panel co-integration test" to verify that the study parameters are co-integrated after the unit root test. The "estimation error rectification technique (ECM)" is present in equation 5.

$$\Delta y_{it} = \propto_i \partial_t + \delta_i y_{it} + \sum_{j=1}^{pi} \theta_{ij} \Delta y_{it-1} + \sum_{j=0}^{pi} \tau_{ij} \Delta x_{it-j} + \in_{it} \quad (6)$$

Where $\propto_i = (\propto_i 1, \propto_i 2)'$, $\partial_t = (1, t)'$, and θ_{ij} denote vectors of parameters, determining procedure, and error correction, respectively. Based on the "Ordinary Least Square (OLS)" approach of θ_i, four statistical tests are developed in equation (6) to identify the presence of long-term association (Cointegration) as shown under:

$$G_\tau = \frac{1}{N} \sum_{i=1}^{N}. = \frac{\hat{}\propto i}{SE(\hat{}\propto i)} \quad (7)$$

$$G_\alpha = \frac{1}{N} \sum_{i=1}^{N}. \frac{T\hat{}\propto i}{\hat{}\propto i(1)} \quad (8)$$

$$P_\tau = \frac{\hat{}\propto i}{SE(\propto i)} \quad (9)$$

$$P_\alpha = T1\alpha\hat{} \quad (10)$$

where Pa and Pt are the panel statistics and Ga and Gt are the group statistics. The null hypothesis of no cointegration is set up against cointegration.

3.3.2.4 Panel Non-Linear ARDL

Traditional time series regression models use constant parameters and make the unsuitable assumption that changes in explanatory variables have the same impact throughout time. It seems unjust to estimate a connection that could have asymmetry using symmetric methodologies and might result in some really wrong policy findings (Enders, 2008). The traditional econometric models could not assess the non-linearities in macroeconomic facets, hence multiple econometric techniques have been developed such as "Threshold ECM, Smooth transition regression ECM. Markov-switching ECM etc." but "recent Non-linear Autoregressive Distributed Lag (ARDL) econometric Model" developed by Shin et al. (2014b)incorporates the asymmetries in short and long run along with capturing dynamic adjustment. Therefore, the NARDL model has been applied to determine the asymmetric association between the variables of the study. Because NARDL is derived from ADRL as an extended model, therefore following the work of Pesaran et al. (2001), we have re-structured equation (1) into ARDL error correction terms to capture long- and short-term dynamics as presented in the equation below:

$$\Delta CO_{2_t} = \partial_0 + \sum_{k=0}^{\rho} \partial_1 \Delta CO_{2_{t-k}} + \sum_{k=1}^{\rho} \partial_2 \Delta GF_{t-k} + \sum_{k=1}^{\rho} \partial_3 \Delta EG_{t-k} + \sum_{k=1}^{\rho} \partial_4 \Delta FDI_{t-k} + \sum_{k=1}^{\rho} \partial_5 \Delta CEC_{t-k} + \sum_{k=1}^{\rho} \partial_6 \Delta URB_{t-k} + \gamma_0 CO_{2_{t-1}} + \gamma_1 GF_{t-1} + \gamma_2 EG_{t-1} + \gamma_3 FDI_{t-1} + \gamma_4 CEC_{t-1} + \gamma_5 URB_{t-1} + \theta_t \quad (11)$$

$$\Delta CO_{2_t} = \vartheta_0 + \sum_{k=0}^{\rho} \vartheta_1 \Delta CO_{2_{t-k}} + \sum_{k=1}^{\rho} \vartheta_2 \Delta GF_{t-k} + \sum_{k=1}^{\rho} \vartheta_3 \Delta EG_{t-k} + \sum_{k=1}^{\rho} \vartheta_4 \Delta FDI_{t-k} + \sum_{k=1}^{\rho} \vartheta_5 \Delta CEC_{t-k} + \sum_{k=1}^{\rho} \vartheta_6 \Delta URB_{t-k} + \lambda_0 ECT_{t-1} + \theta_t \quad (12)$$

where, and k indicate the first difference and lagged values, respectively. However, ∂_1 to ∂_6 and ϑ_1 to ϑ_6 denote short-term coefficients, and γ_1 to γ_5 indicate long-term coefficients of parameters. Additionally, θ_t represents the white noise term. Our study chose the NARDL approach presented by Shin et al. (2014a) because it enables us to capture asymmetries resulting from both positive and negative shocks of macroeconomic antecedents ((Rahman & Ahmad, 2019). It is an exhaustive version of a linear ARDL model. Additionally, this co-integration approach makes it possible to combine asymmetric non-linearity and model co-integration into a single equation and is better suited for small sample sizes. This method is also better than previous ones since it may be applied regardless of whether the order of integration is I(0), I(1), or a combination of both. Consequently, NARDL is superior to other methodologies; therefore, we have applied NARDL in line with Ayad et al. (2022). Therefore, based on Eq. (1) The NARDL model has been derived as follows:

$$lnCO_{2_{it}} = \tau_0 + \tau_1 lnGF_{it}^{+} + \tau_2 lnGF_{it}^{-} + +\tau_3 lnEG_{it} + \tau_4 lnFDI_{it} + \tau_5 lnCEC_{it}^{+} + \tau_6 lnCEC_{it}^{+} + \tau_7 lnURB_{it} + \mu_{it} \quad (13)$$

Furthermore, the above-mentioned equations are based on the assumption that green finance (GF) and clean energy consumption (CEC) have a linear association with CO_2 emissions. Our main goal is to determine whether GF and CEC have an asymmetric

or symmetric impact on CO_2 emissions. GF and CEC are split into two parts; First, (GF_t^+ and CEC_t^+) capture positive shocks in green finance and clean energy consumption, and second, (GF_t^- and CEC_t^-) capture negative shocks in green finance and clean energy consumption as presented in following equations (14-17):

$$GF_t^+ = \sum_{j=1}^{t} \Delta GF_J^+ = \sum_{j=1}^{t} maximum\left(\Delta GF_j^+, 0\right) \tag{14}$$

$$GF_t^- = \sum_{j=1}^{t} \Delta GF_J^- = \sum_{j=1}^{t} minimum\left(\Delta GF_j^-, 0\right) \tag{15}$$

$$CEC_t^+ = \sum_{j=1}^{t} \Delta CEC_J^+ = \sum_{j=1}^{t} maximum\left(\Delta CEC_j^+, 0\right) \tag{16}$$

$$CEC_t^- = \sum_{j=1}^{t} \Delta CEC_J^- = \sum_{j=1}^{t} minimum\left(\Delta CEC_j^-, 0\right) \tag{17}$$

We have derived the NARDL equations by substituting equations (14), (15), (16) and (17) into equations (11) and (12), as presented below:

$$\begin{aligned}\Delta CO_{2_t} = \partial_0 &+ \sum_{k=0}^{\rho} \partial_1 \Delta CO_{2_{t-k}} + \sum_{k=1}^{\rho} \partial_2 \Delta GF_t^+ + \sum_{k=1}^{\rho} \partial_3 \Delta GF_t^- + \sum_{k=1}^{\rho} \partial_4 \Delta EG_{t-k} \\ &+ \sum_{k=1}^{\rho} \partial_5 \Delta FDI_{t-k} + \sum_{k=1}^{\rho} \partial_6 \Delta CEC_t^+ + \sum_{k=1}^{\rho} \partial_7 \Delta CEC_t^+ \\ &+ \sum_{k=1}^{\rho} \partial_8 \Delta URB_{t-k} + \gamma_0 CO_{2_{t-1}} + \gamma_1 \Delta GF_{t-1}^+ + \gamma_2 \Delta GF_{t-1}^- + \gamma_3 EG_{t-1} \\ &+ \gamma_4 FDI_{t-1} + \gamma_5 \Delta CEC_{t-1}^+ + \gamma_6 \Delta CEC_{t-1}^- + \gamma_7 URB_{t-1} + \theta_t\end{aligned}$$

(18)

$$\Delta CO_{2_t} = \vartheta_0 + \sum_{k=0}^{\rho} \vartheta_1 \, \Delta CO_{2_{t-k}} + \sum_{k=1}^{\rho} \vartheta_2 \, \Delta GF_t^+ + \sum_{k=1}^{\rho} \vartheta_3 \, \Delta GF_t^- + \sum_{k=1}^{\rho} \vartheta_4 \, \Delta EG_{t-k} + \sum_{k=1}^{\rho} \vartheta_5 \, \Delta FDI_{t-k} + \sum_{k=1}^{\rho} \vartheta_6 \, \Delta CEC_t^+ + \sum_{k=1}^{\rho} \vartheta_7 \, \Delta CEC_t^- + \sum_{k=1}^{\rho} \vartheta_8 \, \Delta URB_{t-k} + \lambda_0 ECT_{t-1} + \theta_t$$

(19)

3.3.2.4 Cross -sectional Autoregressive Distributed Lag

Additionally, the econometric Autoregressive Distributed Lag (ARDL) model is used for robustness checks developed by Chudik et al. (2016). It addresses "endogeneity, unobserved shared variables, cross-section dependence, heterogeneous slop coefficients, and non-stationarity." CS-ARDL method is presented in equation (20):

$$\mathrm{Y}_{it} = \sum_{i=1}^{qy} \partial_{it} \, \bar{Y}_(i,t) + \sum_{i=0}^{qz} \sigma'_{i1} \, \bar{\mathrm{Z}}_{i,t-1} + \sum_{i=0}^{qT} \theta'_{i1} \, \bar{\mathrm{Z}}_{i,t-1} + \in_{it}$$

(20)

Where the average cross-sections $X^-_{t-1} = (\mathrm{Y}^-_{t-1}, \mathrm{Z}^-_{t-1})l,$ are denoted by $\bar{\mathrm{Y}}_t$ and $\bar{\mathbf{Z}}_t$. Furthermore, X^-_{t-1} denotes the averages of explanatory and explained variables. However, the 'Dumitrescu Hurlin Panel Causality Test' statistic is used to examine the bidirectional relationship between the variables tested on a short-term level. Figure 3 presents the structure of the methodology.

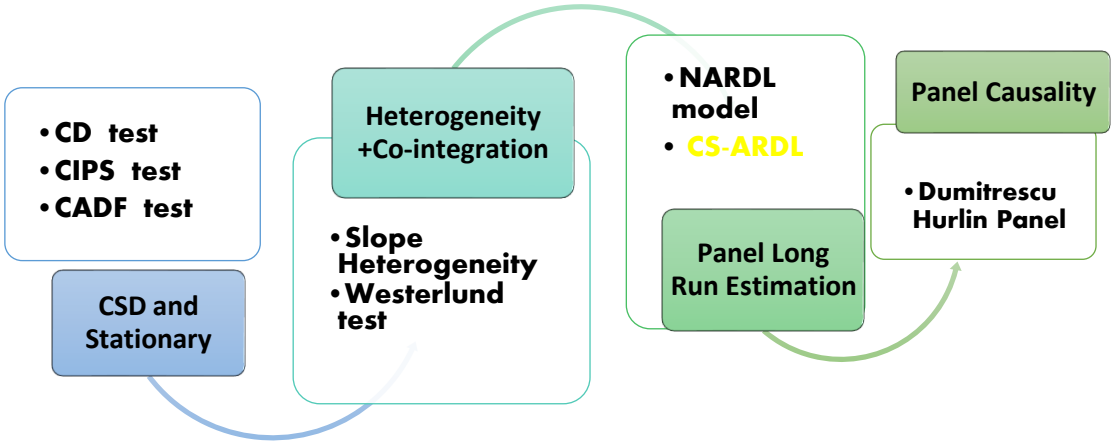


Figure 7 Methodological structure of the current study

3.3 Empirical results

The following analysis is done on the empirical findings of the research: The report first summarizes the findings from the CSD and unit root evaluations. The paper then offers the non-linear integration evaluations. Lastly, the NARDL testing model's empirical results and their robustness.

3.3.1 Cross-sectional dependence and unit root test results

The study utilized cross-sectional dependency (CSD) to evaluate how closely the variables under study are related. Table 4 displays the findings of the cross-sectional dependency measurement. The results of this test demonstrated the significance of the p-values for CO_2, GF, EG, FDI, CEC, and URB. The outcomes suggest that the null hypothesis of "no CSD" is not rejected. However, the CSD data offer impressive scientific evidence of CSD in GF, EG, FDI, CEC and URB emissions, as well as CO_2 emissions, although to various degrees. The following step is to evaluate the unit root issue.

To confirm that all variables analysed are stationary, the current study conducts two-panel unit root evaluations, namely, CIPS and CADF unit root assessments. The results of Table 3 show that the tested models' variables are not integrated to the extent that

integration is after the first difference. However, the figure 2. represents QQ Plots for the non-normality of data.

Table 3 CD and CIPS and CADF Test Outcomes

Variables	CDS	*p-value*	CIPS		CADF	
			I(0)	I(I)	I(0)	I(I)
$InCO_2$	19.49***	0.000	-1.998	3.707**	-2.016	-3.658***
InGF	14.48***	0.000	-0.645	-6.339***	-1.242	-5.754***
InEG	23.98***	0.000	-0.868	-3.515***	-1.680	-5.186***
InFDI	3.46***	0.000	-1.880	-5.325***	-1.201	-5.280***
InCEC	5.15***	0.000	-1.779	-3.132**	-1.956	-3.247***
InURB	21.48***	0.000	-1.218	-5.696***	-0.417	-5.887***

Note "**, *** means significant at a 1 and 5% level"

Assessing the cointegration among the researched variables comes next after assessing cross-section dependence and unit root among the study variables. The current study made use of the slope heterogeneity evaluation recommended by Pesaran and Yamagata (2008). Table 5 displays findings. This demonstrates the importance of delta values and changed delta values. These evaluations offer compelling proof that slope heterogeneity is a problem in ASEAN countries. One possible explanation for the slope heterogeneity is the various economic structures of the studied nations.

Table 4 Slope Heterogeneity Test

$\hat{\Delta}$	P-value	$\hat{\Delta}_{Adj}$	P-value
4.841*	0.000	5.929*	0.000

Note: "* means significant at a 1% level"

3.3.2 Westerlund Cointegration Results

It also implies the interconnectedness of the ASEAN countries, with the effects of one shock extending to others. Additionally, we assessed the co-integration of the variables using the Westerlund method. The findings in Table 6 show that the null hypothesis of no co-integration is false. According to this finding, GF, EG, FDI, CEC, and URB move in unison over the long term.

Table 5 Westerlund Cointegration Outcomes

Statistics	Value	Z-value	*p*-value
Gt_t	-4.350	-2.331	0.01
Ga_t	-11.238	-4.965	0.00
Pt_t	-9.651	-4.754	0.00
Pa_t	-15.351	-6.580	0.00

Source: Authors compilation

3.3.3 Panel Nonlinear ARDL Results

The next stage is to evaluate how closely the variables under study are connected in both the short- and long-term once cointegration between the analysed variables has been confirmed. In this regard, the panel NARDL provided by Shin et al. (2014a) is used to evaluate the interrelationships among the facets. Additionally, in order to confirm the NARDL results, the study also uses ARDL testing methodology, as reported in table 8. The panel NARDL findings are displayed in Table 7. The outcomes demonstrate that the ECT is statistically significant and negative. Consequently, the outcomes show that the factors are combined.

The findings of the NARDL tests showed that the coefficients of economic growth are positive and significant in the short and long run. It alludes that a 1% rise in economic growth in the tested economies can contribute to an increase in carbon emissions of 1.2849% in the near term and 0.1375% over the long term. These results lead to the

logic that an increase in the level of economic growth will lead to an increase in the investment in the production and consumption of energy. Subsequently, it will lead to a boost in the level of environmental pollution in these economies. These results are supported by Tran (2021), (2022), Isiksal et al. (2022), Dingru et al. (2021b), and Yuping et al. (2021), who confirmed the positive nexus between economic growth and carbon emissions in their research work. Therefore, the results suggest that ASEAN economies' government authorities and economists must develop strategies and policies to attract green capital investment in green projects to achieve a sustainable and green economy that is friendly to the environment.

In addition, the results of the NARDL model demonstrated that a favourable change in CEC has a constructive effect on the improvement of environmental quality, while an unfavourable change in CEC has a destructive effect on the degree to which environmental quality is improved. In this instance, the data demonstrated that a one percent positive shift in CEC led to a reduction in the amount of carbon emission that was 1.9292% lower in both the long run and the short term. On the other hand, the data demonstrated that a 1% negative shift in CEC resulted in an increase in the amount of carbon emission that was about 1.8477% higher in the long run and 12.343 higher in the short term, respectively. These findings may be explained by the fact that a rise in the investment and output from environmentally friendly energy sources results in an improvement in the degree of environmental purity. These results are also supported by Abbas et al. (2021), (2020) and Adedoyin et al. (2020). Therefore, the results of this study recommend that ASEAN economies consider clean energy sources rather than relying primarily on harmful ecological sources, such as fossil fuels, which cause degradation of environmental quality. Consequently, ASEAN economies have estimated the target of 27 billion dollars yearly to invest in renewable energy to achieve

23% of the energy mix by 2025 (semi-2021). However, the region has potentially invested 12.1 billion in 2020 in terms of green bonds, green insurance, social loans, and sustainable bonds. The clean energy market still has much more room to grow and develop. As the sustainable economic development and high-growth sectors still demand a substantial green investment trajectory in clean energy, electric motor vehicles, and smart and green cities to mitigate the climate effects.

The empirical findings of the NARDL model showed that improving green finance has a positive effect, while decreasing green finance has a negative influence on the level of environmental stewardship in the nations under study. In this context, a one percent increase in green financing reduces carbon emissions by 0.0988% over the long run and 0.0192% over the short term, respectively. These findings are reinforced in addition by Zakari and Khan (2022), in 11-OECD economies, Chen and Chen (2021), Huang and Chen (2022), Zhou and Xu (2022), Wang et al. (2021) in China, Gao et al. (2022) in Asian economies, Mngumi et al. (2022) in BRICS, and Saeed Meo and Karim (2022) in the top ten green finance supporting economies. Therefore, this study suggests that ASEAN economies must develop green financial infrastructure to collect and distribute green funds as financial capital to build a green industry structure. It will successfully decrease the expense of acquiring green investment funds to facilitate the growth of the green industry, consequently reducing the share of high-polluting industries and carbon emissions. Additionally, ASEAN investors will be able to make financing decisions and invest in green projects while taking into account environmental impacts. As a result, green finance will affect not only producers, but also consumers to buy green products. Moreover, to tackle the challenge of environmental degradation, ASEAN countries have started green recovery initiatives such as the ASEAN Catalytic Finance Facility (ACFF). It will mobilize and promote

green investment in clean energy, transportation, sanitation, and agriculture sectors by using innovative green instruments such as climate credit, climate bonds, and environmental investment. This initiative is worth $4 billion and is expected to reduce 119 million tons of carbon emissions emitted by pollutant sectors. But according to the Asian Development Bank (ADB), such investment is not enough for ASEAN economies to mitigate climate impact, and there is still a 50 to 60% green financing gap in ASEAN countries. Therefore, ASEAN countries must take more green financing opportunities in terms of green bonds, green loans, green credits, and climate mitigation tools to naturalize countries from carbon emissions and promote green economic growth with a sustainable environment.

On the other hand, the empirical outcomes from the NARDL model illustrated that the coefficients of FDI^+ and FDI^- shocks are found to be negative (positive) and significant in long run only, while insignificant in short run. It highlights that a 1% increase in FDI^+ shocks in the studied economies raise carbon emissions by 0.2515% in the long term. However, decrease in FDI^- shocks raises carbon emissions by 0.0893 in long run. The ARDL models affirms the long run negative effect on FDI on carbon emission and shows robustness of ARDL results. The results are supported by Musah et al. (2021) in North Africa, Li et al. (2020) in G-20 economies, and Ali et al. (2020) in Pakistan. The results of the NARDL experiments revealed a similar pattern, demonstrating that the coefficients of urbanization are only positive and significant over the long term. It predicts that over time, an increase in carbon emissions of 0.4793 percent may result from a 1% growth in urbanization in the countries under consideration. The results are supported by Yuping et al. (2021) in Latin American countries, B. Talbi et al. (2022) in Tunisia, and F. V. Bekun et al. (2022) in Sub-Saharan Africa particularly, oil-producing and non- oil-producing economies. It is fact that urbanization is result of

the process of relocating significant numbers of permanent people to relatively compact regions, which ultimately culminates in the formation of densely populated metropolitan areas. In addition, the movement of people from rural agricultural areas to metropolitan areas that are not involved in agriculture. Therefore, the concentration of people in urban areas of ASEAN economies results in a significant rise in associated expenses, as well as a widening of existing social gaps and an adverse effect on the natural environment. Moreover, greater urbanization has a significant impact on the amount of energy that is used as a result of a number of variables, including the expansion of investment and industrialization, as well as the tremendous increase in the pace of home construction. Therefore, the ASEAN nations governments should design the policy to aware the urban people regarding the injurious effect of environmental dilapidation.

Table 6 Results of the Nonlinear ARDL

Variable	Coefficient	Std. Error	t-Statistic	Probability
Long Run Results				
InGDP	0.1375***	0.0917	1.9198	0.0876
InCEC(+)	-1.9292*	0.2494	-7.7332	0.0000
InCEC(-)	1.8477*	0.2583	7.1519	0.0000
InFDI(+)	-0.2515*	0.0521	-4.8229	0.0000
InFDI(-)	0.0893**	0.0399	2.2384	0.0280
InLGF(+)	-0.0988*	0.0112	-8.7814	0.0000
InGF (-)	0.0352*	0.0126	2.7856	0.0067
InURB	0.4793**	0.2156	2.2256	0.0295
Short Run Results				
ECT (-1)	-0.6918*	0.1727	-4.009	0.0000
InGDP	1.2849**	0.5574	2.3051	0.0210
InCEC(+)	-1.1922*	0.4509	-2.6441	0.0099
InCEC(-)	12.343*	0.4618	2.6728	0.0091
InFDI(+)	0.0026	0.0096	0.2782	0.7815
InFDI(-)	-0.0116	0.0219	-0.5042	0.6155
InLGF(+)	-0.0192***	0.0109	-1.7596	0.0823
InGF (-)	0.0045	0.0043	1.0375	0.3026
InURB	14.660	11.362	1.0091	0.3160
C	0.4714	0.4996	0.9436	0.3482
Root MSE	0.0561	Mean dependent var		0.0406

Source: *Authors Estimation*
Note: "*, ** and *** depicts 1%, 5% and 10% level of significance"

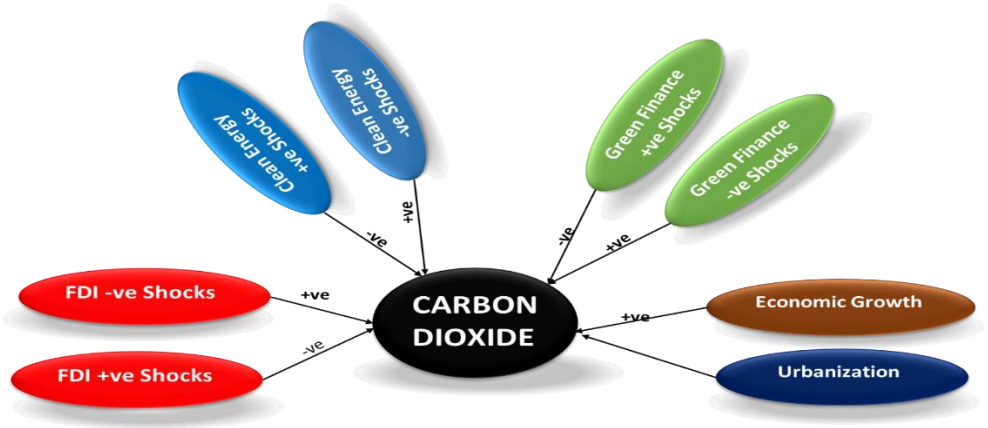


Figure 8 Graphical presentation of the long-term results

3.3.4 CS-ARDL Results

The outcome of CS-ARDL is depicted in Table 8. The GDP adversely effects the environment, however in contrast the GDP^2 enhances the natural environment in short and long run. This evidence the presence of "inverted U-Shaped Environmental Kuznets Curve" (EKC) in ASEAN economies. Our outcomes are consistent with Bilgili et al. (2016) and Bilal Aslam et al. (2021) who concluded that at the beginning the economic growth hampers the natural ecology but after peek point it starts enhancing quality of natural environment due to transformation of economic structure to the environmental friendly technologies. Moreover, the CS-ARDL outcomes reveals that CEC and GF substantially contributes the environment in the ASEAN economies. The outcomes are aligned with Mo et al. (2022) and Gao et al. (2022) in Asian countries and L. Li et al. (2022) in China. the Outcomes directs the ASEAN nations to boost green financing in the clean energy production to mitigate the environmental hazards, achieve the sustainable economic development, and meet the sustainable developments goals (SDG's). Furthermore, outcomes presents that the FDI markedly reduces the carbon emission in the long run in ASEAN economies in the long run. The outcomes submit that FDI in the ASEAN economies brings the opportunities to invest in innovative technologies, environmentally friendly industrial infrastructure, and sustainable social activities. Hence, it is concluded the ASEAN nation should make vivid and clear strategies in the long run to create opportunities for investing green funds in clean energy, attracts the FDI in the economies, boosts the economic development, and reduces the environmental degradation.

Table 7 Results of the CS-ARDL

Variable	Coefficient	Std. Error	z-Statistic	Probability
Long Run Results				
InGDP	1.3077	0.6569	1.993	0.0811
$InGDP^2$	-0.4264	0.1698	2.52	0.02
InCEC	-0.6626	0.3001	-2.21	0.027
InGF	-0.3739	0.2157	-1.73	0.083
InFDI	1.0382	0.543	1.91	0.056
Short Run Results				
ECT (-1)	-0.724	0.2169	-3.34	0.001
InGDP	1.0181	0.5574	1.827	0.079
$InGDP^2$	-0.7462	0.1712	-4.362	0.000
InCEC	-1.1607	0.5496	-2.11	0.035
InGF	-0.003	0.0044	-0.85	0.394
InFDI	0.0087	0.0075	1.17	0.242

Source: *Authors Estimation*
Note: "*, ** and *** depicts 1%, 5% and 10% level of significance"

3.3.5 Dumitrescu Hurlin Panel Causality Tests

In order to investigate the possible causal, interline between the variables that were analysed, we used the "Dumitrescu and Hurlin panel causality" evaluation. The panel's analysis of the causation is shown in Table 9. The results of this test demonstrated that, at the level of carbon emissions, there is a unidirectional causation relationship between green financing, economic development, foreign direct investment, and urbanization. These findings affirmed the results of NARDL, ARDL, and confirmed the significant influence of green finance, economic growth, foreign direct investment, and urbanization on the level of carbon emissions in the case of ASEAN countries. Figure 4. presents graphical representation of results.

Table 8 Dumitrescu Hurlin Panel Causality Tests

Null Hypothesis	W-Stat.	Zbar-Stat.	Prob.
$GF^{+} \neq CO_2$	6.979	3.746	0.000
$CO_2 \neq GF^{+}$	0.866	0.730	0. 651
$GF^{-} \neq CO_2$	6.568	2.560	0. 000
$CO_2 \neq GF^{-}$	0.795	0.121	0. 441
$EG \neq CO_2$	7.665	3.110	0. 000
$CO_2 \neq EG$	0.101	0.951	0. 151
$FDI^{+} \neq CO_2$	3.042	3.037	0.0024
$CO_2 \neq FDI^{+}$	1.244	0.1762	0.8601
$FDI^{-} \neq CO_2$	3.335	3.493	0.0005
$CO_2 \neq FDI^{-}$	2.135	1.588	0.1122
$CEC^{+} \neq CO_2$	6.748	3.445	0. 000
$CO_2 \neq CEC^{+}$	0.484	0.789	0. 663
$CEC^{-} \neq CO_2$	1.445	3.685	0. 651
$CO_2 \neq CEC^{-}$	0.888	0.379	0. 335
$URB \neq CO_2$	7.799	6.738	0. 000
$CO_2 \neq URB$	0.675	0.880	0. 4401

Source: *Authors estimations*

3.4 Conclusions and implications of the policy

In order to significantly recover natural environment suitability, along with strong impurity measurements, we should leverage financial resources to alter the resource allocation incentive structure. Consequently, green finance has emerged as crucial and essential to achieving the objective of a sustainable environment by reducing carbon emissions levels. Therefore, according to author's best knowledge, this study is the first study to utilize the Non-Linear Autoregressive Distributed lag (NARDL) model to inspect an asymmetric effect of green finance and clean energy on the carbon emissions level in ASEAN economies for the time period spanning from 2000 to 2020. Furthermore, this research study focuses on climate funds used to investigate their impact on sustainable environmental development. These are the findings of the study we carried out. The positive shocks in green finance, clean energy consumption, and

foreign direct investment have a negative effect on carbon emissions in the long run. However, negative shocks in green finance, clean energy consumption, and foreign direct investment increase the level of carbon emissions in the long term, leading to a worse environmental quality in ASEAN economies. Moreover, economic growth and urbanization enhances the environmental quality in the long run. These results are affirmed by the ARDL model. Based on the results of the study, suggestions and recommendations are proposed for the ASEAN economies under study.

The main implication of policy is that long-term solid economic policies should be adopted in the green economy. According to the analysis above, significant positive shocks in green finance and clean energy have a detrimental effect on CO_2 emissions. Hence, it is essential to implement a solid and long-term green finance strategy. Through extensive green funding, the growth of energy conservation can be secured. It was necessary to create the ASEAN countries' green finance policy framework as an all-encompassing industry chain. Green environmental policies and economic strategies can be developed in the following ways:

- To bridge the investment gap, green capital, which is necessary for ASEAN countries' SDGs, and build a climate-resilient infrastructure that can resist future shocks caused by climate change, a better legislative framework is required to create a green financial system with green environmental financing instruments, including green investment, bonds, loans, securities, and climate bonds. By utilizing financial instruments to assist green recovery activities, ASEAN countries will be better positioned to draw long-term investments and get their economies ready for a low-carbon, climate-resilient future.

- A classification system must be developed that is specifically suited to the demands of ASEAN nations for green instruments such as bonds, loans, and securities. Before issuing, the controlling third party must ensure that the instruments are green and assess and analyze the environmental benefits of initiatives and projects financed by these instruments. In addition, a team of environmental specialists familiar with green instruments must examine, observe, analyze, and note the specific characteristics of these investments made to support the green business.
- Green loan regulations, protocols, procedures, and policy improvement might be required. Certain customers should be selected and given special loans so they may acquire energy-efficient landscaping, greenhouses, and new energy cars in compliance with national construction certification requirements.

The study presents the second policy recommendation to strengthen the clean energy sector (solar, biomass, nuclear and wind) by injecting green finance capital, as a result, carbon emissions will be reduced over time. Due to the greater unit prices of clean energy sources compared with non-clean energy sources such as fossil fuels, the development of clean energy is now impeded. Therefore, the clean energy initiatives necessitate a large amount of green investment for the long term, specifically as under:

- The banking system must be encouraged to provide green finance credit at low rates, and reduced credit application processing time can ease the green finance credit process for timely clean energy initiatives by the clean energy industry. Furthermore, increased interest rates, taxes, and strengthening deb debt policies must be implemented to discourage investment in the fossil fuel industry.

- The importance of the clean energy market should be promoted. Furthermore, there should be a major increase in the number of clean energy-focused green firms.
- The ASEAN nations must ease and lower the barriers to entry, such as lowering review and approval processing charges, imposing low taxes, and lowering security deposit amounts for national and international clean energy companies.

Furthermore, the limitations of this research study provide direction for future research. Such as, future research can be done by indicating the time period before 2000 depending on the availability of data. The green credit, green bond, and green insurance can be taken as separately as components of green finance to examine the effect on sustainable economic development of regions other than ASEAN. Furthermore, green innovation and research & development (R&D) along with green finance, due to their mutually crucial role in mitigating environmental hazards, can be taken as independent antecedents in future study models.

CHAPTER 4

DO BANKING SECTOR DEVELOPMENT, ECONOMIC GROWTH, AND CLEAN ENERGY CONSUMPTION SCALE UP GREEN FINANCE INVESTMENT FOR A SUSTAINABLE ENVIRONMENT IN SOUTH ASIA? EVIDENCE FOR NEWLY DEVELOPED RALS CO-INTEGRATION

4.1 Introduction

The world's economies have all seen tremendous economic growth since the industrial revolution (Gallardo-Albarrán & de Jong, 2021). However, the escalating environmental issues brought on by economic development, such as global warming and sea level rise, have significantly jeopardized human health and social advancement (Chen & Chen, 2021). The South Asian nations are not left out as they are facing environmental challenges such as sea intrusion, ice melting, deforestation, heavy rainfalls, flooding, rising temperature, water salinity, and greenhouse gas emissions causing air pollution (Farhan Ahmed et al., 2022). Fighting these unwanted environmental challenges has created an opportunity for investment in green finance. Green finance has a reputation for being environmentally beneficial, and this is supported by much theoretical research. As Miroshnychenko et al. (2017), Yutao Chen and Feng (2019), X. Zhou et al. (2020) and Siedschlag and Yan (2020), Yufeng Chen and Ma (2021), and Zakari and Khan (2022) coped that Green finance has the ability to preserve the environment by doing well in terms of the environment. Therefore, based on this, the world has acknowledged the importance of green finance as a tool for achieving environmental sustainability under the Paris Agreement (Alliance for Financial Inclusion, 2019). Apparently, in 2019 the issuance of a green bond increased by $250b, equal to 3.5% of the total $7.15b in the green bond market (Ehlers et al., 2020). This indicates that investment in green finance is rapidly growing on a

worldwide scale, as a result of the acceleration of climate change (Zakari & Khan, 2022).

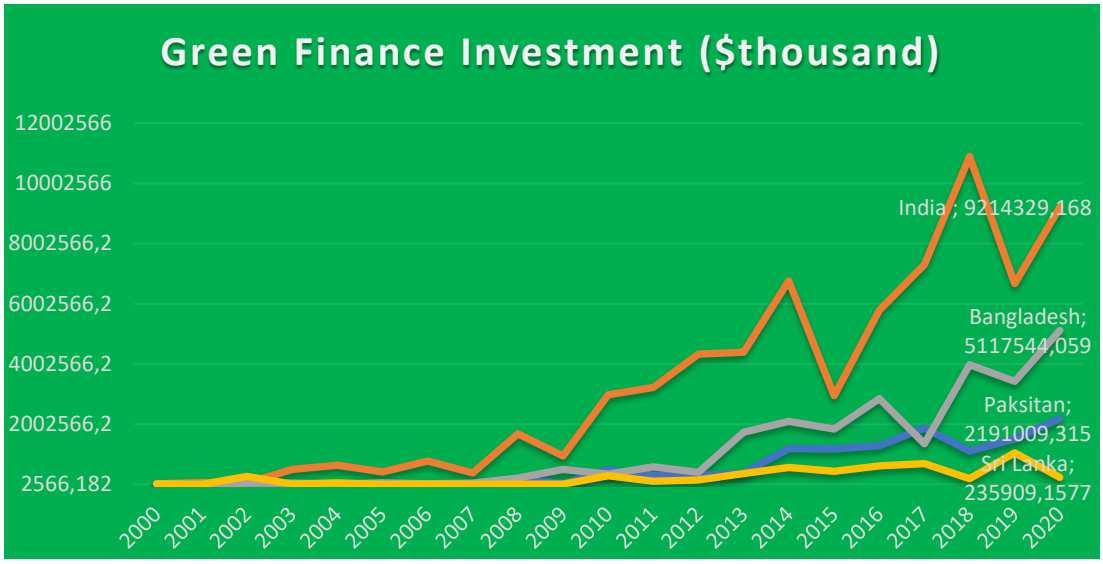


Figure 9 Green Finance investment in selected Asian Countries

The investment in green finance opportunities in selected South Asian nations (Pakistan, India, Bangladesh, and Sri Lanka) are presented in Figure 10. Therefore, the question of "how to scale up investment in green finance to reduce environmental hazards" has so inspired authors to research this subject in South Asian countries, given the significance of investment in green finance.

Many researchers have studied identified the banking sector development, economic growth, and renewable energy as determinants of carbon dioxide emissions (Ali & Seraj, 2022; M. Ali et al., 2022; Charfeddine & Kahia, 2019; Samour, 2019; Ahmed Samour et al., 2022; Yao & Tang, 2021; Zafar et al., 2019), but according to authors best knowledge none of them have role banking sector development, economic growth and clean energy consumption in captivating investment in green finance.

The banking sector's development is an important driver of environmental quality. The strategies aimed at attaining sustainability guarantee that money is flowing into

effective green technology, Technology transfer, and green finance efforts to support a green environment. Thus, measures relating to the development of the banking industry have a significant role in improving ecological integrity. The nexus between banking sector development and environmental quality has been tested by Zafar et al. (2019) in N-11 nations. They found that banking sector development enhances environmental quality. Similar shreds of evidence have been obtained by various researchers (Abid et al., 2022; Majeed et al., 2020; Park et al., 2018; Rafique et al., 2020). They deduced that financial development, including banking sector development, assigns funds to innovative and clean energy technologies along with green initiatives. This trend increases productivity, improves energy efficiency, and lowers pollution. An effective banking sector development framework expands the range of banking loans available for the creation of energy-efficient technologies. A solid banking sector development framework also lowers the cost of funding. In addition, businesses require long-term finance to create energy-efficient equipment, which in turn might lessen the intensity of carbon emissions.

Along with banking sector development, long-term economic growth is critical for green finance investment. Grossman and Krueger (1991) initially discovered the EKC and "stated an inverted U-shaped association between per capita GDP and environmental degradation. The outcomes reveal at the initial level; EG harms the environment (scale effect); after that, EG leads to less polluting activities (composition effect), and the final level of economic growth leads to technical progress, more spending in R&D, replacing dirty, eco-unfriendly, and obsolete technology, installing new and clean innovative, friendly technology (technique effects)." EKC has been "verified by (Akadiri et al., 2019; Diao et al., 2009; Dogan & Turkekul, 2016; Pata & Samour, 2022). According to SDGs 8 and 13, environmental sustainability and

economic growth, respectively, in emerging countries are difficult challenges (Sinha et al., 2018) and can be resolved with investment in green finance, clean energy, and innovative green technology (Rafique et al., 2020).” Therefore, long-term economic growth to investment in green finance keeps a crucial role.

Moreover, clean energy consumption is the more recognized solution to climate change mitigation and environmental problems. Several researchers including (Ali et al., 2022; Alvarado et al., 2021; Amin et al., 2020; Anwar et al., 2021; Yulong Chen et al., 2019; Khan et al., 2020) have considered clean energy as an eco-friendly source as compared to traditional sources of energy including oil, gas, and coal (Non-clean energy sources). It was discovered that investing in clean energy is the best course of action to promote environmental protection since it lessens reliance on insufficient resources. One of the key elements that greatly influences the growth of the green economy is clean energy (Ahmed et al., 2022). More notably, replacing clean energy using fossil fuels may considerably minimize negative externalities from the industrial process, promoting long-term economic growth (Sbia et al., 2014).

Therefore, this study contributes to the literature on investment in green finance by empirically investigating the role of banking sector development, economic growth, and clean energy consumption in alluring investment in green finance in South Asian states. Moreover, this study has taken carbon emissions, foreign direct investment, remittances, inflation, and trade openness as control variables. With respect to the methodological contribution, authors have adopted the newly developed novel RALS unit root test and RALS co-integration to investigate the stationary of data and long-term association of variables of interest. Moreover, this study enhances the literature by using Quantile Autoregressive Distributive Lag (QARDL) Model as an econometric approach to testing the association between variables across each quantile

to produce more valid and reliable outcomes. Given that this study connects investments in green finance with SDGs, it also assists policymakers in developing appropriate policies.

The remaining sections of the article are arranged as follows: Section 2 provides a synopsis of pertinent earlier research. In section 3, the data information, approach, and empirical approaches are introduced. Section 4 offers results and discussion. Finally, section 5 presents the conclusion and policy recommendations.

4.2 Methodology

4.2.1 Data

This study examines the influence of banking sector development, economic growth, clean energy consumption, carbon emissions, foreign direct investment, remittances, inflation, and trade openness on investment in green finance opportunities in South Asian economies, including Pakistan, India, Bangladesh, and Sri Lanka from 2000 to 2020. As suggested by Nawaz et al. (2021), the authors developed the following general logarithmic model.

$$lnGF_{it} = \beta_0 + \beta_1 lnBSD_{it} + \beta_2 lnEG_{it} + \beta_3 lnCEC_{it} + \beta_4 lnCO2_{it} + \beta_5 lnFDI_{it} + \beta_6 lnREM_{it} + \beta_7 lnINF_{it} + + \beta_8 lnTR_{it} + \mu_{it} \quad (1)$$

Where $lnGF$, $lnBSD$, $lnEG$, $lnCEC$, $lnCO2$, $lnFDI$, $lnREM$, $lnINF$, and $lnTR$ represents the natural logarithm of green finance, banking sector development, economic growth, clean energy consumption, foreign direct investment, carbon dioxide, foreign direct investment, remittances, inflation, and trade openness, respectively. However, β_0, β_1 to β_8, μ, *i,* and *t* denote intercept, coefficients for selected

variables of the study, residuals, numbers of countries under investigation, and time period of study. Moreover, Table 1 presents detailed information on the study variables.

Table 9 Variables information

Variables	Abb.	Definition and measurement	Source
Green Finance	GF	Adaptation and Mitigation finance	OECD
Banking Sector Development	BSD	"Domestic credit to the private sector by banks (% of GDP)"	WDI
Clean Energy Consumption	CEC	"Renewable energy consumption (% of total final energy consumption)"	WDI
Carbon emissions	CO_2	"Total emissions (thousand metric tons of CO2"	WDI
Foreign Direct Investment	FDI	"Foreign direct investment, net inflows (% of GDP)"	WDI
Remittances	REM	"Personal remittances received (% of GDP)"	WDI
Inflation	INF	Inflation, GDP deflator (annual %)	WDI
Economic growth	EG	Gross domestic product (% annual)	WDI
Trade Openness	TR	Trade (% of GDP)	WDI

Source: *Authors compilation*

4.2.2 Estimation procedure

We tested the variable's stability using "Augmented Dickey Fuller (ADF) and residual augmented least squares ADF (RALS-ADF)" stationary tests proposed by Im et al. (2014) to ensure consistent findings. Moreover, we examined the long-term association among variables by utilizing Granger (EG) co-integration test proposed by Engle and Granger (1987) and RALS-EG co-integration test proposed by Lee et al. (2015). The EG is a two-step co-integration test because of its residual's framework and conventional t-statistic. Therefore, in the 1st step, the stationary integration level and in the 2nd step, ordinary least square (OLS) is estimated if variables are I(1) as summarized under:

$$y_t = \vartheta\gamma_t + \rho_t \quad (2)$$

Later the ($\hat{\rho}$) residuals were retrieved, and we performed the ADF unit root test to measure the integration level with associated residuals as under:

$$\Delta\hat{\rho}_t = \varphi_0 + \varphi_1\hat{\rho}_{t-1} + \sum_{i-1}^{q}\varphi_{i+1}\,\Delta\hat{\rho}_{t-1} + \text{e}_t \quad (3)$$

The residual's higher moments offer information about non-normal residuals when errors in the equation have non-normal distribution. Therefore, the newly developed RALS co-integration econometric approach proposed by Im and Schmidt (2008) is utilized to leverage more accurate, robust, strong, and detailed information existing in non-normal errors in the linear model. Hence, following Lee et al. (2015), RALS is used as a supplement co-integration econometric to validate EG co-integration test results. RALS co-integration test combines the 2nd and third moments of the residuals to generate new term from traditional co-integration methods. To RALS, co-integration is derived from equation (3) as under:

$$\hat{\text{U}}_t = p(\hat{\rho}_t) - \hat{\in} - \hat{\rho}_t\,\hat{\cap}_t, t = 1,2,3 \ldots\ldots\ldots, T \quad (4)$$

Where $\hat{\rho}_t$ denotes the residual obtained from equation (3), however.

$$p(\hat{\rho}_t) = \left[\hat{\rho}_t{}^2, \hat{\rho}_t{}^3\right] \quad (5)$$

$$\hat{\in} = \frac{1}{T}\sum_{i=1}^{T} p(\hat{\rho}_t) \quad (6)$$

$$\hat{\cap}_t = \frac{1}{T}\sum_{i=1}^{T} p'(\hat{\rho}_t) \quad (7)$$

Furthermore, the equation below denotes the RALS term advanced by Meng et al. (2017)

$$\hat{\text{U}}_t = \left[\hat{\rho}_t^2 - m_2, \hat{\rho}_t^3 - \text{m3} - 3m_2\hat{\rho}_t\right] \quad (8)$$

Where $m_i = \text{T}^{-1}\sum_{i=1}^{T}\hat{\rho}_t^j$. Finally, the RALS co-integration test equation is presented in equation (9) by putting a value of $\hat{\text{U}}_t$ in equation (3).

$$\Delta\hat{\rho}_t = \varphi_0 + \varphi_1\hat{\rho}_{t-1} + \sum_{i-1}^{q}\varphi_{i+1}\,\Delta\hat{\rho}_{t-1} + \hat{\text{U}}_t\,\pi + \text{e}_t \quad (9)$$

The standard t-test is used to test The null hypothesis (φ_1 = 0), stating, "No Co-integration among examined variables ."Furthermore following equation (10) is used to obtain three asymptotic distributions of t-statistics.

$$t^* \rightarrow \rho.t + \sqrt{1-\rho^2}.Z \quad (10)$$

4.2.3 Quantile Autoregressive Distributed Lag (QARDL) Model

In this study, we have accessed the long-term results across the quantiles by employing the newly developed "Quantile Autoregressive Distributive Lag (QARDL) econometric model (Cho et al., 2015)." The QARDL model leaves behind traditional linear models due to three major reasons. First, it considers locational asymmetry. The outcomes depend on the outcome variable; green finance, as in our study, may diverge within the parameters of its conditional distribution, as indicated by (Yan et al., 2022). Secondly, it contemplates the long-term's association among regressed and regressor variables like green finance, banking sector development, economic growth, clean energy consumption, carbon emissions, foreign direct investment, remittances, inflation, and trade openness. Third, it outclasses the traditional linear ARDL model by allowing local asymmetry and assessing short and long-term outcomes throughout the quartiles of the conditional distribution. Moreover, it is lofty compared to non-linear models such as NARDL econometric model as it describes the asymmetry exogenously while setting a threshold to zero as compared to depending on a data-driven process. Therefore, based on the above competitive advantages, we have employed the QARDL model for modelling linkages more precisely between banking sector development, economic growth, clean energy consumption, carbon emissions, foreign direct investment, remittances, inflation, and trade openness with green

finance. Based on equation (1), the traditional ARDL model proposed by (Pesaran et al., 2001) is derived as under:

$$GF_{it} = \alpha + \sum_{i=1}^{p} \emptyset_{it} GF_{it-1} + \sum_{i=0}^{q} \omega_{it} BSD2_{it-1} + \sum_{i=0}^{r} \lambda_{it} EG_{it-1} + \sum_{i=0}^{s} \gamma_{it} ECE_{it-1} + \sum_{i=0}^{t} \theta_{it} CO2_{it-1} + \sum_{i=0}^{u} \partial_{it} FDI_{it-1} + \sum_{i=0}^{v} \vartheta_{it} REM_{it-1} + \sum_{i=0}^{w} \delta_{it} INF_{it-1} + \sum_{i=0}^{w} \tau_{it} TR_{it-1} + \in_t \quad (11)$$

Where ∈t denotes the white noise term explained as $GF_t - E\left[\frac{GF_{it}}{\infty_{it-1}}\right]$. ∞_{it-1} denotes the lowest **ϱ** – field formed by $GF_{it},\ BSD_{it}, EG_{it}, ECE_{it}, CO2_{it}, FDI_{it}, REM_{it}, INF_{it}, TR_{it}\ BSD_{it-1}, EG_{it-1} \ldots\ldots]$. However, *p,q,r,s,t,u,v,* and *w,* refer to lag orders obtained by Bayesian information criteria.

Moreover, as proposed by Cho et al. (2015), we have transformed equation (11) into a QARDL estimator as in the equation below:

$$\mathcal{Q}\Delta GF_{it} = \alpha(\tau) + \sum_{i=1}^{p} \emptyset_{it}(\tau) GF_{it-1} + \sum_{i=0}^{q} \omega_{it}(\tau) BSD2_{it-1} + \sum_{i=0}^{r} \lambda_{it}(\tau) EG_{it-1} + \sum_{i=0}^{s} \gamma_{it}(\tau) ECE_{it-1} + \sum_{i=0}^{t} \theta_{it}(\tau) CO2_{it-1} + \sum_{i=0}^{u} \partial_{it}(\tau) FDI_{it-1} + \sum_{i=0}^{v} \vartheta_{it}(\tau) REM_{it-1} + \sum_{i=0}^{w} \delta_{it}(\tau) INF_{it-1} + \sum_{i=0}^{w} \tau_{it}(\tau) TR_{it-1} + \in_t (\tau) \quad (12)$$

Where $\in_t (\tau) = GF_{it} - \mathcal{Q}\Delta GF_t \left(\frac{\tau}{\int_{it-1}}\right)$ denotes error correction term and is $\tau - th$ quantile evidenced GF_{it} with reference to the data sets $\int_{it-1}$ and $0 > \boldsymbol{\tau} < 1$. Furthermore, to elude probable serial correlation, equation (12) is further modified as under:

$$QAGF_{it} = \alpha(\tau)\rho GF_{it-1} + \propto_{bsd} BSD_{it-1} + \propto_{eg} EG_{it-1} + \propto_{ece} ECE_{it-1} + \propto_{co2} CO2_{it-1} + \propto_{fdi} FDI_{it-1} + \propto_{rem} REM_{it-1} + \propto_{inf} INF_{it-1} + \propto_{tr} TR_{it-1} + \sum_{i=1}^{p} \emptyset_{it}(\tau)GF_{it-1} + \sum_{i=0}^{q} \omega_{it}(\tau)BSD2_{it-1} + \sum_{i=0}^{r} \lambda_{it}(\tau)EG_{it-1} + \sum_{i=0}^{s} \gamma_{it}(\tau)ECE_{it-1} + \sum_{i=0}^{t} \theta_{it}(\tau)CO2_{it-1} + \sum_{i=0}^{u} \partial_{it}(\tau)FDI_{it-1} + \sum_{i=0}^{v} \vartheta_{it}(\tau)REM_{it-1} + \sum_{i=0}^{w} \delta_{it}(\tau)INF_{it-1} + \sum_{i=0}^{w} \tau_{it}(\tau)TR_{it-1} + \in_t (\tau)$$

(13)

Additionally, as proposed by Cho et al. (2015) equation (13) is modified for ECM as under:

$$QAGF_{it} = \alpha(\tau)\rho GF_{it-1} + \propto_{bsd} (\tau)BSD_{it-1} + \propto_{eg} (\tau)EG_{it-1} + \propto_{ece} (\tau)ECE_{it-1} + \propto_{co2} (\tau)CO2_{it-1} + \propto_{fdi} (\tau)FDI_{it-1} + \propto_{rem} (\tau)REM_{it-1} + \propto_{inf} (\tau)INF_{it-1} + \propto_{tr} (\tau)TR_{it-1} + \sum_{i=1}^{p} \emptyset_{it}(\tau)GF_{it-1} + \sum_{i=0}^{q} \omega_{it}(\tau)BSD2_{it-1} + \sum_{i=0}^{r} \lambda_{it}(\tau)EG_{it-1} + \sum_{i=0}^{s} \gamma_{it}(\tau)ECE_{it-1} + \sum_{i=0}^{t} \theta_{it}(\tau)CO2_{it-1} + \sum_{i=0}^{u} \partial_{it}(\tau)FDI_{it-1} + \sum_{i=0}^{v} \vartheta_{it}(\tau)REM_{it-1} + \sum_{i=0}^{w} \delta_{it}(\tau)INF_{it-1} + \sum_{i=0}^{w} \tau_{it}(\tau)TR_{it-1} + \in_t (\tau)$$

(14)

In the above equation (14), short-run effects of lag of GF on current GF are estimated by $\emptyset_* = \sum_{it=1}^{p-1} \emptyset_i$. However, short-run effects of proceeding BSD, EG, ECE, CO_2, FDI, REM, INF, and TR on current GF are assessed by $\omega_* = \sum_{it=0}^{q-1} \omega_i$, $\varphi_* = \sum_{it=0}^{r-1} \varphi_i$, $\lambda_* = \sum_{it=0}^{s-1} \lambda_i$, $\gamma_* = \sum_{it=0}^{t-1} \gamma_i$, $\theta_* = \sum_{it=0}^{u-1} \theta_i$, $\partial_* = \sum_{it=0}^{v-1} \partial_i$, $\vartheta_* = \sum_{it=0}^{w-1} \vartheta_i$, $\delta_* = \sum_{it=0}^{x-1} \delta_i$, and $\tau_* = \sum_{it=0}^{x-1} \tau_i$, respectively. Whereas, long-term co-integration of BSD, EG, ECE, CO_2, FDI, REM, INF, and TR antecedents is obtained by $\propto$ coefficients and employing formulas such as $\propto_{BSD*} = \frac{\propto BSD}{\rho}$, $\propto_{eg^*} = \frac{\propto EG}{\rho}$, $\propto \overline{CEC* = \propto CEC\rho}$, $\propto_{co2^*} = \frac{\propto CO2}{\rho}$, $\propto_{FDI*} = \frac{\propto FDI}{\rho}$, $\propto_{rem^*} = \frac{\propto REM}{\rho}$, $\propto_{inf^*} = \frac{\propto INF}{\rho}$, and $\propto_{tr^*} = \frac{\propto TR}{\rho}$, respectively. Where ρ

denotes the parameter defining the speed of adjustment to equilibrium and the value of ρ must be significantly negative. Additionally, we employed the Shapiro-Wilk estimator to explain the normal distribution of data, referring to null hypothesis (H_0) as variables data is normally distributed compared to alternative hypotheses (H_1) stating variables data is not normally distributed. Figure 2. denotes the methodological structure of the study.

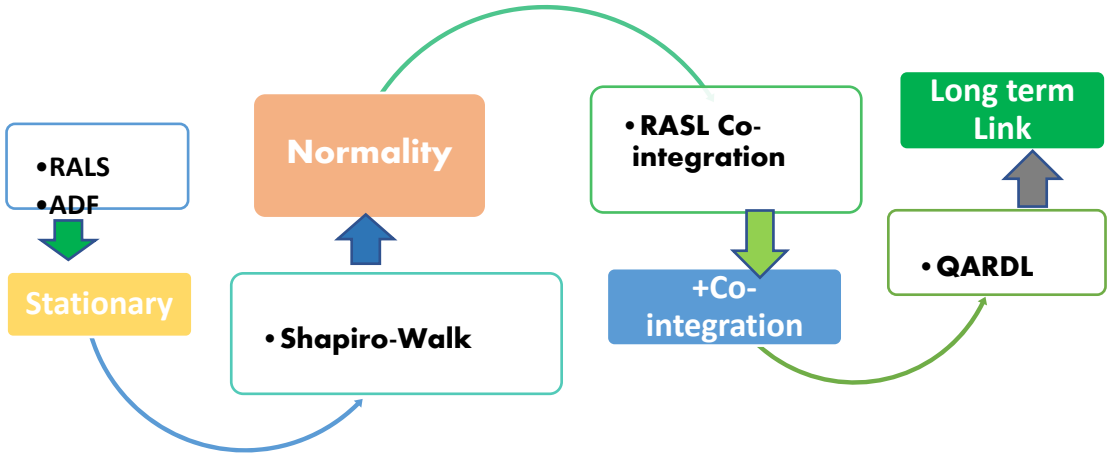


Figure 10 Research Methodology structure

4.3 Empirical Results and discussion

This study assessed the stationary of the studied variable utilizing ADF and RALS unit root tests. The outcomes are depicted in table 2. The study outcomes of ADF and RALS unit root present that all studied variables are stationary at level except GF, GDP, and FDI, which are stationary at the ^{first} difference. Therefore, the null hypothesis failed to indicate non-stationary variables of the study, enabling us to assess co-integration to assess the long-term association between variables of interest. Next to stationary, we assessed the normality of variables while employing the Shapiro-Wilk normality estimator. The outcomes are shown in table 3. The outcomes for all variables are less than 0.01 p-values signifying the rejection of the null hypothesis. Therefore, it is concluded that normality does not exist. Figure 1. confirmed the outcomes of the

Shapiro-Wilk normality estimator, indicating that studied variables deviate from the normal distribution.

Table 10 ADF and RALS-ADF Unit root test results

Variables	**ADF**	**RALS-ADF**	ρ^2
GF	-0.99	-1.79	0.86
BSD	-2.65**	-5.85***	0.90
EG	-0.24	-1.42	0.70
CEC	-2.93**	-7.29***	0.96
CO2	-2.99**	-7.04***	0.79
FDI	-0.13	0.00	0.54
INF	-2.65*	-6.50***	0.84
REM	-3.01***	-5.61***	0.99
TR	-2.65*	-5.40***	0.92
ΔGF	-2.79**	-3.12*	0.89
ΔGDP	-2.74**	-3.12*	0.72
ΔFDI	-3.14***	-5.04***	0.77

Source: Author's estimations

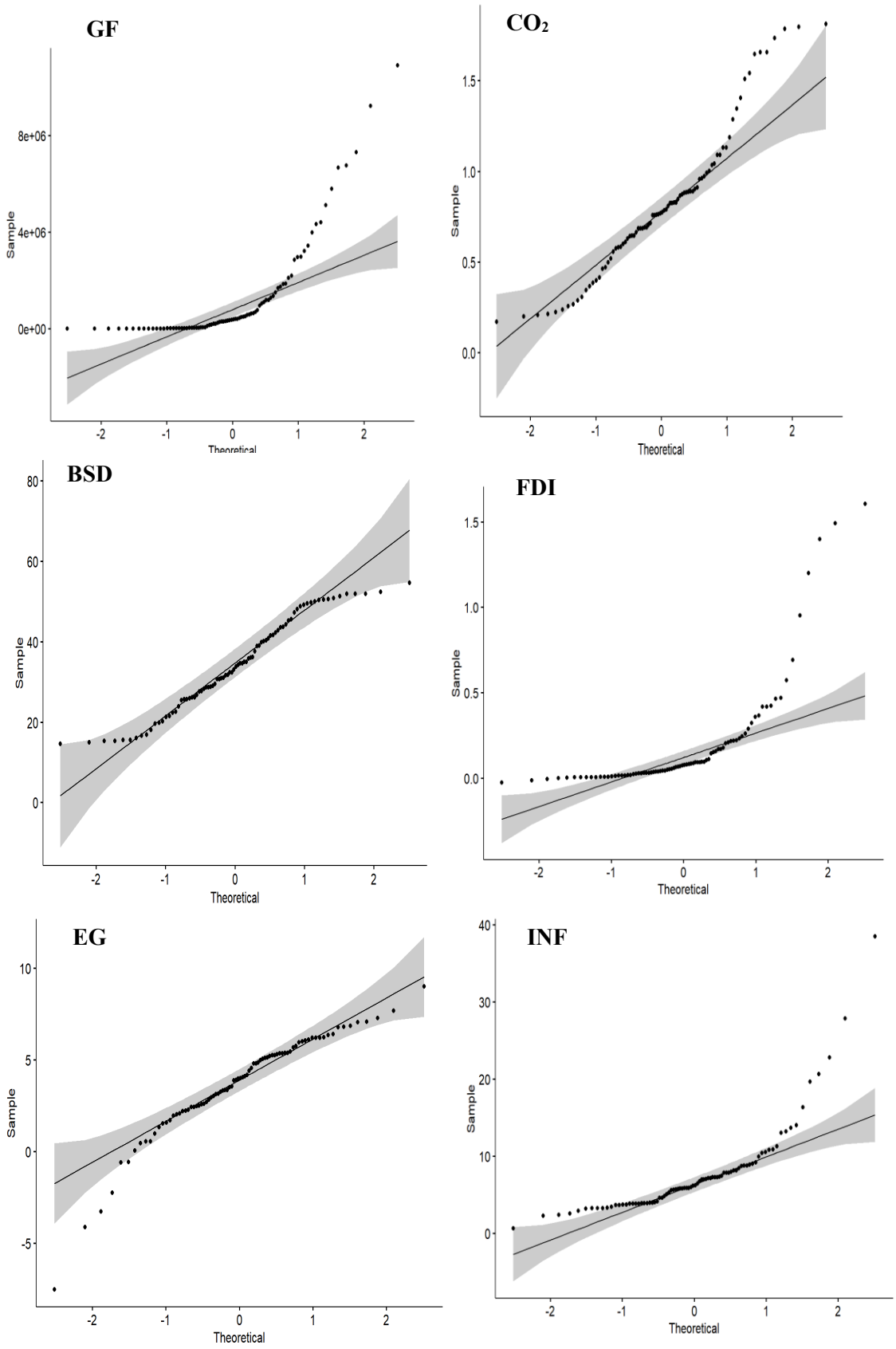
Note: "***, **, and * indicate significance at 1%, 5%, and 10% respectively. The 1%, 5%, and 10% critical values for the ADF are -3.58, -2.93, and -2.60 respectively. The 1%, 5%, and 10% critical values for the RALS-ADF are -3.75, -3.30, and -3.05 respectively."

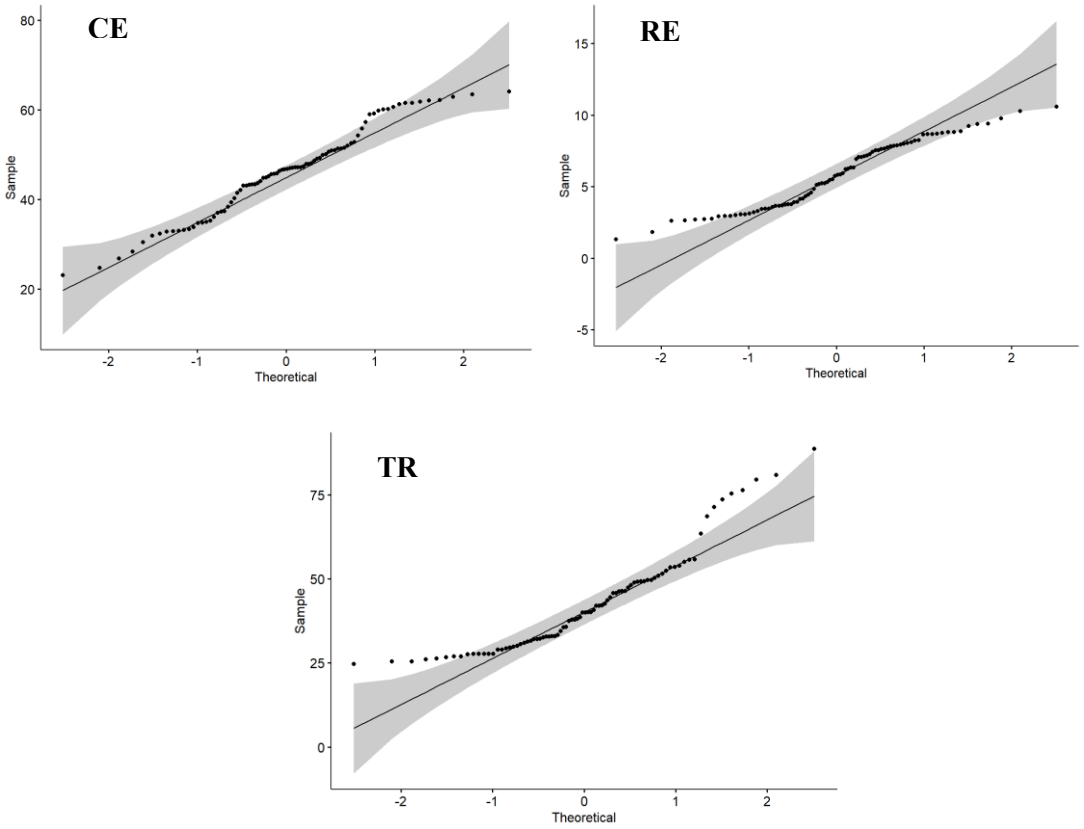
Table 11 Shapiro-Wilk normality test

Variables	W	P-values
GF	0.65	0.000
BSD	0.95	0.005
EG	0.92	0.000
CEC	0.97	0.050
CO2	0.93	0.000
FDI	0.59	0.000
INF	0.72	0.000
REM	0.94	0.002
TR	0.88	0.000

Source: Author's estimations

Figure 11 Graphs of normality





Moreover, to assess the effective long-term association, we utilized EG and RALS co-integration estimators in the presence of non-normality. The results of EG and RALS co-integration are presented in table 4. The EG test outcome is -4.27 less than the -3.98 critical value (CV), and the RALS test outcome is -4.25 less than the -4.19 CV. The results suggest that the EG test and RALS co-integration estimators' outcomes are significant at 10% and 5% significance levels, respectively. Therefore, both test outcomes revealed the existence of a long-term connection between green finance, banking sector development, economic growth, clean energy consumption, carbon emissions, foreign direct investment, remittances, inflation, and trade openness. Additionally, non-normality in the variable suggests us use QARDL to effectively assess the effect of banking sector development, economic growth, clean energy consumption, carbon emissions, foreign direct investment, remittances, inflation, and trade openness on green finance.

Table 12 RALS co-integration test results

Methods	K	Test statistics	ρ^2
EG	0	-4.27	0.82
RALS-EG	0	-4.25	

Source: Author's estimations

Note: "***, **, and * indicate the significance in 1%, 5%, and 10% respectively; K shows the optimum lag length found using recursive statistics; the 1%, 5%, and 10% critical values for the EG test are -5.02, -4.32 and -3.98 respectively; the 1%, 5%, and 10% critical values for the RALS-EG test are -4.80, -4.19 and -3.88 respectively."

The QARDL long-run estimations are presented in table 5 and figure 4. The outcomes depict the long-term association between explanatory variables (BSD, EG, CEC, CO_2, FDI, REM, INF, TR) and the outcome variable (GF) as evidenced by $\propto$. Moreover, long-term parameters of the lag green finance coefficients (ρ) are significantly positive throughout all quantiles, from 0.05 to 0.95. This depicts that green finance in South Asian countries the present is determined by the past preceding level of green finance for all quintiles. Moreover, long-term parameters of banking sector development coefficients ($\propto_{i2}$ $(\boldsymbol{\tau})BSD$) show a significant and positive influence on green finance throughout all quantiles from q0.5 to q0.95. The outcomes depict that at low to middle quantiles, i.e., q0.05 to q0.4, rapid growth and development in the banking sector boosts the investment in green finance; however, banking sector development positive influence lessens through middle to upper quantile, i.e., q0.05 to q0.95 in Asian economies. The outcomes of this study are in line with previous researchers (Nawaz et al., 2021), who concluded that Domestic financing to the private sector is essential for greening the energy industry and reducing the consequences of climate change on the world. The results of this study reveal that the banking sector is a vital component of robust green economic growth and environmental sustainability while investing in green finance initiatives. The banking sector in South Asia knows climate change is a problem and sees it as an opportunity. Leading banks, though deeply, know how to tackle the risk and opportunity, and that's why climate change is now incorporated into

their strategies but at a slower response. We have not seen the region's banking sector actively playing the role of the green financing champion of the future. For instance, in State Bank of Pakistan issued green banking guidelines in 2017 (Afridi et al., 2021), and Bangladesh Bank formed the Sustainable Finance department (SFD) in 2015 (Ibrahim et al., 2022) for green financing initiatives and green banking in India is still at nascent stage (Sharma & Choubey, 2022) as it started issuing green financing in 2008. The region's banking sector development is still facing challenges of deepening and developing the green banking sector in terms of infrastructure for green financing services, cost, and risk of providing green credit. Therefore, it is strongly suggested to create prudent green finance policies, strengthen green foundations and infrastructure, develop strong green prudential regulations, and remove green capital account restrictions. In this way, South Asian economies must develop a strong banking sector to provide potential opportunities for business sectors to invest green funds in R&D to develop innovative technologies beneficial to the environment.

Additionally, the outcomes of economic growth ($\propto_{i3} (\tau) EG$) illustrate that it has a significantly positive association with green finance throughout the quantiles except for q0.8. The outcomes reveal that an increase in economic growth will enhance investment in green finance. The outcomes of the study suggest that business units, corporations, and industries are liable to keep the environment green under corporate social responsibility (CSR) (Carroll, 1979), which reveals that industries make special efforts to a green environment through green financing. Moreover, the economic growth of the country is based on the production and manufacturing of products that improve continuously by utilizing green and clean technologies, green initiatives, and green investment (Zhang et al., 2021). Therefore, sustainable economic growth leads to balanced green economic growth while employing green financing as a driver to

hunt new potential environmental-friendly opportunities. Given the above, ASEAN member countries must develop industry-level regulations, strategies, and policies to attract green financing facilities alongside economic growth to reduce the ecological imbalance caused by carbon emissions.

Furthermore, clean energy consumption ($\propto_{i4}(\tau)CEC$) is positive and significant at all quantiles from q0.05 to q0.95. These results are as expected. The outcomes reveal that a rise in clean energy consumption will scale up the investment in green finance. The results are in line with (Nawaz et al., 2021), who investigated a positive association between N-11 and BIRCS member economies. The outcome of the study reveals that as clean energy consumption boosts investment in green finance in South Asian countries. Moreover, the outcomes for carbon emissions ($\propto_{i5}(\tau)CO2$) show that it has a negative and significant relationship with green finance at all quantiles except q0.95. The outcomes present that through q0.05 to q0.6 influence of CO_2 green finance investment gradually increases, and later quantiles positive influence slows down and becomes negative at q0.95. The results are in line with (Nawaz et al., 2021). CO_2 is the problem that causes climate and environmental degradation (Stocker et al., 2014), and reducing CO_2 and limiting temperature below $1.5C^0$ has become a challenge for the world, including South Asian countries under the Paris Agreement. For instance, according to the Asian Disaster Preparedness Centre (ADPC), globally, India, Bangladesh, and Pakistan account 7.1%, 0.61%, and 0.24% of carbon emissions. However, in terms of per capita emissions, India, Pakistan, Sri Lanka, and Bangladesh accounts for 1.8, 0.9, 0.9, and 0.5 metric tons of carbon emissions. Accordingly, increasing carbon dioxide's pathetic role in South Asia attracts green finance initiatives to mitigate its harmful effects on human lives and keep the environment clean. Keeping in view the studied countries have started the taking initial measure and initiatives of

going green such as Bangladesh's world's first climate prosperity known as the Mujib Climate Prosperity Plan plan), Pakistan's National Climate Change Policy, and India's National Actions Plan. But these initiatives are not enough; hence, concerned authorities, governments, the banking sector, business units, and environmentalists must form strong policies and strategies to scale up green finance to mitigate the effect of hazards generated by emissions of carbon dioxide.

Table 13 Quantile Autoregressive Distributed Lag (QARDL) results

Quantile(τ)	$\alpha_0(\tau)$	$\rho_{i1}(\tau)\boldsymbol{GF}_i$	$\propto_{i2}(\tau)BSD$	$\propto_{i3}(\tau)EG$	$\propto_{i4}(\tau)\boldsymbol{CEC}$	$\propto_{i5}(\tau)CO2$	$\propto_{i6}(\tau)FDI$	$\propto_{i7}(\tau)REM$	$\propto_{i8}(\tau)INF$	$\propto_{i9}(\tau)TR$
0.05	1.651**	0.910**	0.152**	0.193**	0.266**	0.326**	0.856**	0.215**	-0.005**	0.073**
0.1	1.068**	0.881**	0.160**	0.180**	0.265**	0.558**	0.848**	0.226**	-0.017**	0.073**
0.2	6.378**	0.422**	0.130**	0.291**	0.146**	0.986**	0.389**	0.174**	-0.026**	0.052**
0.3	6.730**	0.427**	0.178**	0.176**	0.161**	2.556**	1.131**	0.243**	-0.039**	0.052**
0.4	8.246**	0.313**	0.186**	0.170**	0.159**	2.675**	1.581**	0.219**	-0.004**	0.042**
0.5	10.652**	0.251**	0.156**	0.121**	0.175**	2.080**	0.905**	0.206**	-0.007**	0.062**
0.6	11.787**	0.262**	0.113**	0.027**	0.154**	2.316**	0.402**	0.313**	-0.002**	0.049**
0.7	12.750**	0.157**	0.092**	0.039**	0.182**	1.085**	0.367**	0.204**	-0.014**	0.081**
0.8	12.018**	0.228**	0.090**	-0.022**	0.190**	1.590**	0.070	0.121**	-0.028**	0.067**
0.9	14.970**	0.074**	0.053**	0.019**	0.206**	0.077**	-0.248**	0.190**	-0.100**	0.108**
0.95	1.537**	0.021**	0.027**	0.026**	0.163**	-0.719**	-0.256**	0.284**	-0.020**	0.080**

Source: Author's estimation.

Note: If variables coefficients are in between the lower and upper bounds or inside of the confidence interval, that parameter is statistically significant at a 5% significance level.

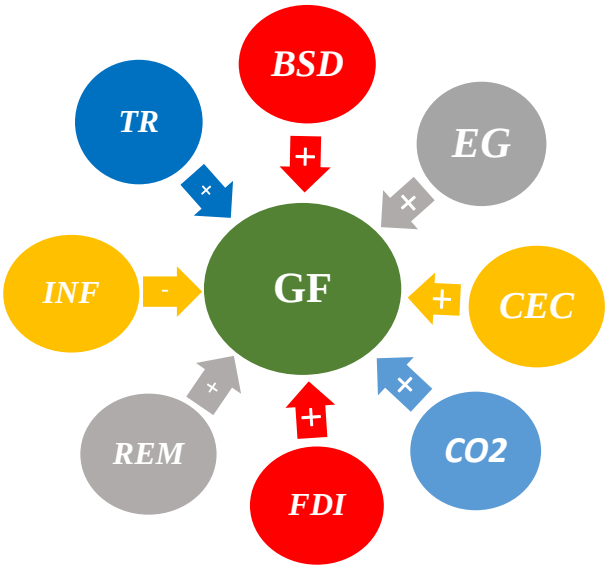


Figure 12 Graphical representation of QARDL results

Moreover, foreign direct investment ($\propto_{i6}(\tau)FDI$) is positive and significant from q0.05 to q0.7 except for q0.7 however, FDI is negative and significant from q0.9 to q0.95. The FDI has a powerful influence in the middle of quantiles, i.e., q0.3 to q0.5. The outcomes present that an increase in FDI scale up the investment in green finance in South Asian country members. The results are in line with Nawaz et al. (2021) and Desalegn et al. (2022). Our study results demonstrate that foreign direct investment is equally important in captivating green financing to South Asian countries and aids in reducing the consequences of climate change. Given Desalegn et al. (2022), many economies are targeting FDI. It implies that green financing grows in tandem with the FDI factor. According to World Bank (2022), worldwide, the FDI inflows in 2020 were 1.26 trillion, out of which South Asian countries account for 68.96 billion. However, in terms of technical cooperation grants, FDI inflows in Pakistan, India, Bangladesh, and Sri Lanka account for 0.209 billion, 0.535 billion, 0.196 billion, and 0.049 billion,

respectively. These refer to any unrestricted financial aid provided to boost a nation's technical capability without identifying specific projects to funds. To this viewpoint, capital and technology inflows are necessary for South Asia's ability to spend more on green and clean emerging technology.

Moreover, personal remittances ($\propto_{i7} (\tau) REM$) have a positive influence on investment on green finance investment throughout the quantiles, i.e., q0.05 to q0.95. The results depict that as inflation increases, investment in green finance decreases. The outcomes are in line with (Adams & Cuecuecha, 2013; Bjuggren & Dzansi, 2008; Gyimah-Brempong & Asiedu, 2014). Since raises capital costs and has an impact on green investment. Secondly, rising inflations raise nominal interest rates leading to leverage in the company's debt interest payment. Consequently, business units may not be able to borrow to undertake a green investment project even project is beneficial to the environment. This is particularly valid during times of severe inflation. The outcomes of this study employ that the consequences of inflation on green investment are significant. The fiscal impacts of variation in inflation are unclear and rely on several antecedents, including the tax system, public debt, and how closely inflation affects demand for green funds. Therefore, for Central Banks of studied economies, controlled low inflation must be one of the main objectives, including sustainable economic growth to fetch more green investment in the country for eco-friendly initiatives.

In the same vein, as expected, inflation ($\propto_{i8} (\tau) INF$) is significantly negatively associated with GF as the coefficients of REM are negative from q0.05 to 0.95. The outcomes confirm that an increase in personal remittances augments green finance investment. Our outcomes are reminiscent of Madsen (2003) and Frimpong and Marbuah (2010).

A plausible explanation of our outcomes is that personal remittance in South Asian economies has been a significant factor in fostering green financing depending upon institutional quality and infrastructure. There are substantial in terms of stability, growth rate, and share of GDP. According to World Bank (202the South Asian countries' remittances grew 3.8% from 2019 to 4.2% in 2020. Hence, the remittance will stimulate green financing. We expect the positive role of the South Asian economies in terms of institutional quality and financial development in providing the enabling environmental role for identifying and marshalling the needed financial resource to exploit green financing opportunities and boosts the effect of remittance on green finance as remittance should be channelled and leveraged for green financing opportunities. Hence, a sound policy regime is required in South Asian economies.

Finally, from q0.05 to q0.95, the influence of trade openness ($\propto_{i9}(\tau)TR$) is positive and significant on green finance investment. As the trade openness increases, that increase the investment in green finance. The results are supported by Mohsen (2015). Trade openness has made export and import simpler, and manufacturers are encouraged to grow and enhance their output and investment in the nation. It boosts economic growth besides creating attractive and potential opportunities for green investment in terms of green technology, and the application of green financing initiatives will reduce the harmful environmental effects, and sustainable environmental quality will be enhanced. According to Wu (2022), trade openness will promote green finance in compliance with Paris Agreement, which in turn will reduce water, air, and land-based pollution, in turn, reduce greenhouse gases, resultantly enhanced energy efficiency, and adoption of eco-friendly and climate advantages.

4.4 Conclusion and policy recommendations

This study investigated the nexus between banking sector development, economic growth, clean energy consumption, foreign direct investment, remittances, inflation, and trade openness on green finance investment in the South Asian economies from 2000-2020. This study employs the newly developed novel RALS co-integration test along with the Quantile Autoregressive Distributive Lag (QARDL) econometric modelling approach to address the long-run effects of antecedents on green finance across a range of quantiles. The existing literature has focused on traditional approaches to variables other than green finance, which is the need of the hour in the climate change perspective. Therefore, using modern methodologies such as the RALS Unit root test, RALS co-integration test, and QARDL model on green financing distinguishes this work from existing work and contributes to the existing literature. A unique technique is applied to help policymakers create a solid foundation for policymaking in order to achieve sustainable development objectives by 2030. This research has shown how important it is for South Asian nations to set up programs to decrease the systemic risks that climate change entails and to stimulate the necessary funding to engage in green finance to lessen these risks and their effects.

The findings of QARDL disclose that BSD, EG, CEC, FDI, REM, INF, and TR significantly influence green finance investment in South Asia. In particular BSD, ECE, REM, and TR are positively significant across the quantiles (q0.05 to q0.95), however, $CO_{2,}$ FDI, and EG have a significant and positive association with green finance except for q0.8, q0.9, and q.95, respectively. Therefore, the BSD, EG, FDI, REM, and TR are found as vivacious drivers and have impending attributes to attract

and scale up the green finance investment to fight against climate hazards, keeping sustainable economic development in South Asian countries. On the flip side, as expected, INF has a significant negative effect on the explained facet of the study.

4.4.1 Theoretical contribution

The empirical findings of the study contribute to the existing body of knowledge on GF, BSD, CEC, CO2, FDI, EG, REM, INF, and TR in the case of South Asia in a number of different ways. First, based on the concept of the impact investing approach (Theory of Financial Social Entrepreneurship) our research is first to look at the association between GF, BSD, CEC, CO2, FDI, EG, REM, INF, and TR in the case of South Asia, which is the prime contribution of our research in term of theoretical contribution. Previous researchers have focused on the Tragedy of the Commons (Ortmann & Veit, 2023; Stein, 2022), contingency theory (Dai et al., 2022), Environmental, Social, and Governance (ESG) Criteria (Qoyum et al., 2022). Secondly, our research has used newly developed economic techniques such as RALS Unit root test, RALS co-integration test, and QARDL model on green financing distinguishes this work from existing work and contributes to a body of knowledge. Hence, theoretical farmwork and econometrical models utilized can be employed in any new situation and new geographical location for validation purposes. Third, our research findings add to the existing body of knowledge by taking the green finance investment as an explained factor that has been ignored before in general and in the case of South Asian economies in particular. Lastly, our research validated the Impact Investing theory which involves investing in companies and projects that have a positive social or environmental impact, as well as financial returns. Impact investors

seek to support businesses that are working to solve environmental and social challenges, while also generating profit without harming the environment.

4.4.2 Practical implications

Green finance investments have become a yardstick to mitigate environmental effects on human lives; hence based on the results of this study, the following six major policy recommendations are suggested to attract and scale up green finance to escalate eco-friendly environment in South Asian economies selected for the study.

First, the South Asian economies must develop Green Central Banking Department (GCBD) to steer green transformation, which can actively contribute to a green financial system and economy. It will promote green credit and investment behavior in the banking sector, along with exploring climate and environmental risks. Second, to develop a strong banking sector, central banks of South Asian countries must focus on policy areas, including micro and macro green prudential regulations, green credit allocation processes, and guidelines. Furthermore, Central banks must require adopting Environmental and Social Risk Management Standards (ESRMS), allow lower reserve rates for green portfolios, and develop climate stress testing (CST). Third, the government of studied countries must augment into account environmental factors while forming wider economic policy for sustainable economic growth, resultantly scaling up green finance initiatives. Fourth, it is recommended that studied nations lower the trade barriers such as taxes and tariffs on international trade and adopt liberalization policies to attract green technology in the business units. Fifth, the South Asian economies should develop a strong financial and economic environment to encourage FDI and REM in the country in order to finance potential green

initiatives. Finally, the Central Banks of South Asian countries must safeguard low and sustainable inflation by understanding theoretically and empirically price stability for luring green finance projects. It can be possible to develop monetary policy in accordance with the climate and environmental risks.

Moreover, the study proposes to embrace Fin-Tech, research, and development expenditure in the existing study model additionally to explore deep insight into attracting green finance investment in the region. Additionally, our study is limited in terms of the unavailability of data before 2000 on green financing.

CHAPTER 5

"GREEN FINANCE INVESTMENT AND CLIMATE CHANGE MITIGATION IN OECD-15 EUROPEAN COUNTRIES: RALS AND QARDL EVIDENCE"

5.1 Introduction

Protection of the environment in parallel with the promotion of environmentally friendly economic development is generally recognized as an essential factor in the long-term survival of the world's economies (Li et al., 2021; Nawaz et al., 2021). As a result, increasing patterns in global carbon emissions have piqued the interest of environmentalists and, in particular, environmental policymakers. On climate change, scientific shreds of evidence are so clear that the world must act quickly to avoid catastrophic repercussions. Consequently, investment in green finance has emerged as a critical tool to address the existential challenges posed by climate change (Nawaz et al., 2021). Green finance gained popularity in the 1980s and continues to receive interest throughout the world. Green finance describes the circumstance in which economic goals are accomplished, considering environmental advantages. Green finance, as opposed to conventional methods of doing business in the financial sector, lays a larger focus on the advantages to the environment and pays closer attention to the preservation of the environment (Wang and Zhi, 2016). Moreover, it is considered a key technique and extensively utilized to support green economic growth, long term development, prevent environmental deterioration, and a feasible technique for reducing CO_2 emissions and conserving energy (Guo and Ling, 2017; Sandberg et al., 2019). The promotion of green economic development and the reduction of carbon

dioxide emissions are both impossible to achieve without green financing and green technology (Hao et al., 2021; Sohag et al., 2019).

Additionally, it's essential to invest in green financing initiatives like ecologically friendly energy sources like “wind, hydro, solar, geothermal, and biomass” if we want to achieve a world with no emissions of carbon dioxide. (Kirikkaleli and Sowah, 2020). Moreover, according to the Schmalensee (2012) renewable energy production and its use produces the green economic growth, which results environmental quality and reduces its degradation. Hence, the Kyoto Protocol encourages the world economies to reduce CO_2 emissions in order to encourage the use of renewable energy sources (Hao et al., 2021). Before COVID-19 outbreak, with less than a decade before 2030, overall investment in energy access was considerably behind what was anticipated to be required to meet SDG-7. The available energy access funds mostly skipped the nations with the highest access gap, and only a small portion of the already modest quantity of green finance was committed exclusively to renewables-based energy access systems. Later, the world economies considered the environmental quality as top priority, as a result, there was an increase in investment in green finance, which resulted in large investments in renewable energy capacity increasing by 2% in 2020 worldwide, reaching to 303.5 billion dollars, despite the economic crisis that was caused by COVID-19. With a total of USD 153.4 billion invested in renewable energy capacity, developing and emerging nations have maintained their lead over established economies for the sixth year in a row in terms of investment spending. According to the “International Energy Agency (2021),” investment levels in developed nations rose by 13% in 2020, while those in underdeveloped and emerging nations fell by 7%. In

2017, almost sixty percent of the overall financing for environmentally friendly initiatives, which came to 337 billion dollars, was allocated to energy projects. In 2018, green financial transfers from industrialized countries to developing nations reached 78.9 billion US dollars, of which 12.5 billion US dollars went to projects focusing on the creation of renewable energy. International green funds and multilateral development banks play a significant role in providing direct help to underdeveloped countries, while green finance products like green bonds achieved new highs for the second year in a row, rising 1.1 percent to USD 269.5 billion in 2020 (IEA,2021). More than 1,300 institutional investors and institutions with a combined value of around 15 trillion US dollars have committed to divesting from fossil fuel-related assets entirely or in part by the year 2020.

Moreover, a substantial body of research can be found in the scholarly literature that has “examined the causal relationship between economic growth and carbon emissions,” specifically within the framework of the “environmental Kuznets curve (EKC)” (Ben Jebli et al., 2022; Dogan and Inglesi-Lotz, 2020; Farooq et al., 2022; Khan et al., 2022; Pata, 2018; Pata and Caglar, 2021; Rashid Gill et al., 2018; Ulucak and Bilgili, 2018; Usman et al., 2019). Nevertheless, there is a dearth of scholarly investigations pertaining to the allocation of funds in green finance towards renewable energy projects within the OECD EU-15 nations. Eventually, the objective of this study is to fill this void, and to estimate carbon emission-green finance relationship in OECD-15 European countries over the period 1995-2020. We selected the OECD-15 European countries because of accelerating economic development, resulting in an ever-increasing demand for energy. The European countries accounts for 25.04% of

global GDP and caused 7.73% of carbon emission in 2019 as compared to rest of world committed to reduce greenhouse gas emissions 55% by 2030 by investing 1.2 trillion USD funds for European Green New Deal. This plan intends to make "Europe a climate-neutral continent by 2050" by executing activities, such as investing in renewable energy generation, renewables in buildings, and transportation electrification. The non-homogeneous qualities of the nation's make the sample appear appealing. The results of this study have the potential to inform the formulation of effective strategies aimed at promoting environmental sustainability by major global powers.

Our contribution to green finance investment literature is four-fold. First, to our limited knowledge no study have investigated the role of economic growth and carbon emission along with other antecedents on green finance investment, even though several studies (Dogan and Inglesi-Lotz, 2020; Farooq et al., 2022; Khan et al., 2022; Rashid Gill et al., 2018; Usman et al., 2019) exist examined the relationship between economic growth, CO_2 emissions, and environment-related taxes among others. Second, this study is the first to utilize the latest available data from OECD-15 European countries to investigate the association of interest. Third, this study synthesizes the role of economic growth, foreign direct investment, remittances, inflation, gross capital formation, trade openness, and human capital in explaining green finance investment. Fourth, this is first study according to best of author's knowledge, to apply most recent, newly developed and refined methodology. Firstly, this work utilizes a stronger and newly developed Residual Augmented Least Squire (RALS) cointegration approach to investigate the role of economic growth and carbon

dioxide emission along with additional antecedents such as foreign direct investment, remittances, gross fixed capital, trade, and human capital on green finance in OECD-15 European countries. We chose the RALS cointegration approach based on flowing facts and advantages over conventional cointegration test such that (1) it is more powerful and strong as it utilized the information in non-normal errors (H. Lee et al., 2015). (2) The RALS process avoids the usage of nonlinear estimating techniques by using "nonlinear moment conditions associated with non-normal errors." In nonlinear cointegration tests, misidentifying the functional form leads to power loss, which is avoided by RALS cointegration approach. (3) When there is no knowledge about nonmorality, the power of RALS-based tests is comparable to other "single equation-based cointegration tests" (Lee et al., 2015; Oh et al., 2020). In addition to the RALS cointegration approach, we employ newly developed "Quantile Autoregressive Distributed Lag (QARDL)" approach to investigate green finance nexus in OECD-15 European countries in long run. Existing studies in literature have focused on traditional and ordinary approaches, while ignoring the time horizon QARDL approach. Hence application of RALS cointegration approach and QARDL methodology distinguish this work form previous work to produce more reliable, meaningful, and unbiased outcomes to policymakers to develop strong policy framework to meet sustainable development goals by 2030.

The rest of the study is arranged in the following manner. Section (2) overviews the existing literature. Sections (3) provide a full overview of the theoretical framework, data, and methods. Section (4) delves into the analysis and interpretation of empirical findings. Section (5) brings the research to a close and discusses policy implications.

5.2 Empirical Methodology and Data

5.2.1 Data

This research study explores and analyses the asymmetric long-term effect of carbon dioxide (CO_2), foreign direct investment (FDI), remittances (REM), inflation (INF), capital (GFCF), trade openness (TR), life expectancy (LE) used as proxy of human capital, on green finance (GF) in OECD-15 European economies. Following Nawaz et al. (2021), we developed research model in logarithmic form as under:

$$lnGF_{it} = \beta_0 + \beta_1 lnCO2_{it} + \beta_2 lnFDI_{it} + \beta_3 lnREM_{it} + \beta_4 lnINF_{it} + \beta_5 lnGFCF_{it} + \beta_6 lnTR_{it} + \beta_7 lnLE_{it} + \mu_{it} \quad (1)$$

This research employed annual data from 1990 to 2020, which were then converted into quarterly data using the quadratic match-sum method (Lahiani et al., 2019). This technique may be used to data to correct cyclical anomalies, and it is also quite user-friendly (Akram et al., 2022). Table 1 summarizes the data.

Table 14 Variable's description, measurement and data sources

Variables	Definition and measurement	Source
GF	"Renewable energy consumption (% of total final energy consumption)"	WDI-World Bank (2020)
CO2	"Total emissions (thousand metric tons of Co2)	
FDI	"Foreign direct investment, net inflows (% of GDP)"	
REM	"Personal remittances, received (% of GDP)"	
INF	"Inflation, GDP deflator (annual %)"	
GFCF	"Gross fixed capital formation (% of GDP)"	
TR	"Trade (% of GDP)"	
LE	"Life expectancy at birth, total (years)"	

Source: Authors estimations

Note: "TR = trade openness; REM = Remittances; GF = Green Finance; INF = Inflation; GFCF = Gross fixed capital formation; FDI = Foreign Direct Investment; LE= Life expectancy (Human Capital), CO_2 = Carbon dioxide"

5.2.2 Estimations Procedure

The stability of the variables is initially assessed through the application of the "Augmented Dickey Fuller (ADF) and Residual Augmented Least Squares ADF (RALS-ADF) stationary tests, as suggested by Im et al. (2014)." Table 1 presents results of stationary tests. In addition, to investigate cointegration among study variables "Engle and Granger (EG) cointegration test" suggested by Engle and Granger (1987) and "RALS-EG cointegration test" suggested by H. Lee et al. (2015) are used. The RALS cointegration method is chosen specifically for its unique benefits that are not encompassed within conventional models. First, the cointegration analysis based on the RALS method considers the valuable information present in non-normal errors, which is disregarded by other tests discussed in existing literature. Second, the utilization of higher moment information in the presence of non-normality enhances the power of "RALS-based unit root tests and RALS-based cointegration tests" compared to conventional methods. Third, in contrast to linear framework-based tests, nonlinear cointegration tests exhibit reduced statistical power when confronted with non-normal errors. The "RALS estimator mitigates power loss by employing a linear model framework that relies on conventional least square estimation" when confronted with non-normal errors.

The EG test was designed to be a two-step cointegration test because of the framework of residuals and the standard t-statistics by Engle and Granger (1987). The stationary level of integration is calculated in the first stage of the test, and then "ordinary least squares (OLS) regression" is estimated in the second step if variables were I(1). The model under summarizes this step:

$$y_t = \beta z_t + \mu_t \quad (2)$$

The ($\hat{u}_t$) the residuals were obtained and subjected to the "Augmented Dickey-Fuller (ADF) unit root test" in order to assess the degree of integratio

$$\Delta\hat{u}_t = \Phi_0 + \Phi_1\hat{u}_{t-1} + \sum_{i-1}^{q}\Phi_{i+1}\Delta\hat{u}_{t-1} + \upsilon_t \quad (3)$$

Higher residual moments reveal nonnormal residuals if the test equation errors have a nonnormal distribution. Im and Schmidt (2008) used the RALS approach to leverage the "additional high-moment information available in nonnormal errors in linear model frameworks." When the error term has a nonnormal distribution, the RALS technique can produce stronger, more consistent and robust findings. Lee et al. (2015) employed the RALS methodology as a supplementary tool to augment the "EG cointegration test." The proposed approach presents an innovative idea by combining the second and third moments of the residuals obtained from traditional cointegration tests. Eq. (3) was augmented by the following term to implement the RALS procedure:

$$\hat{w}_t = p(\hat{u}_t) - \hat{E} - \hat{u}_t\hat{O}_t,\ t = 1,2,3,4,5\ldots,\ T$$

Whereas $\hat{u}_t$ is residuals acquired from equation (3) above, however.

$$p(\hat{u}_t) = \left[\hat{u}_t^2, \hat{u}_t^3\right] \quad , \hat{E} = \frac{1}{T}\sum_{i=1}^{T} p(\hat{u}_t) \quad , \hat{O}_t = \frac{1}{T}\sum_{i=1}^{T} p'(\hat{u}_t)$$

Furthermore, equation bellow denotes "RALS term advanced by Meng et al. (2017)"

$$\hat{w}_t = \left[\hat{u}_t^2 - m_2,\ \hat{u}_t^3 - m3 - 3m_2\hat{u}_t\right] \quad (4)$$

Where, $m_i = \mathrm{T}^{-1} \sum_{i=1}^{T} \hat{u}_t^j$. Additionally, RALS cointegration regression is presented in eqation (5) as under by adding $\hat{w}_t$ in eqaution (3).

$$\Delta \hat{u}_t = \Phi_1 \hat{u}_{t-1} + \sum_{i-1}^{q} \Phi_{i+1} \Delta \hat{u}_{t-1} + \hat{w}_t \gamma + \upsilon_t \quad (5)$$

The standard t-test is employed to evaluate the null hypothesis (Φ1 = 0) stating "No Cointegration among examined variables". Furthermore, the equation (6) is utilized to derive the three asymptotic distributions of t-statistics.

$$t^* \rightarrow \rho . t + \sqrt{1} - \rho^2 . Z \quad (6)$$

Moreover, this research study examines long-term stability nexus across the quantiles, by employing newly developed the "Quantile Autoregressive Distributive Lag (QARDL)" estimation model of (Cho et al., 2015). For three reasons, the QADRL model outperforms linear models. First, as indicated by Akram et al. (2022), Godil et al. (2021), Yan et al. (2022), and Razzaq et al. (2020) takes into account locational asymmetry, findings and components may vary depending on the context of the dependent variable, in our case green finance within its conditional distribution. Second, the QARDL approach considers long term nexus as our case of carbon emissions, foreign direct investment, remittances, inflation, gross capital formation, trade openness, and life expectancy with green finance. Third, the QARDL approach is superior to linear approaches (ARDL) as it allows locational asymmetry, addresses long term and short-term association across quartiles of conditional distribution. Furthermore, It outperforms non-linear approaches such as (NARDL) (Shin et al., 2014), in which non-linearity is defined exogenously since the threshold is set to zero rather than decided through a data-driven process. For these reasons, the QARDL is a

good contender for modelling non-linear and asymmetric linkages more precisely among study facets. The mathematical expressions for the QARDL are present in bellow.

The traditional ARDL approach, as presented by Pesaran et al. (2001) is as follow:

$$REC_{it} = \alpha + \sum_{i=1}^{p} \emptyset_{it} REC_{it-1} + \sum_{i=0}^{q} \omega_{it} CO2_{it-1} + \sum_{i=0}^{r} \lambda_{it} FDI_{it-1} + \sum_{i=0}^{s} \gamma_{it} REM_{it-1} + \sum_{i=0}^{t} \theta_{it} INF_{it-1} + \sum_{i=0}^{u} \partial_{it} GFCF_{it-1} + \sum_{i=0}^{v} \vartheta_{it} TR_{it-1} + \sum_{i=0}^{w} \delta_{it} LE_{it-1} + \varepsilon_t \quad (7)$$

Where, ε_t shows error term defined as $REC_t - E[\frac{REC_{it}}{\pounds_{it-1}}]$. The $\pounds_{it-1}$ is the lowest $\boldsymbol{\varrho}$ – field produced by

$[REC_{it}, CO2_{it}, FDI_{it}, REM_{it}, INF_{it}, GFCF_{it}, TR_{it}, LE_{it}, CO2_{it-1}, FDI_{it-1} \dots \dots]$ and

p,q,r,s,t,u,v, and *w,* are lag orders presented by Bayesian information criteria.

Furthermore, we transformed ARDL model equation (1) into following QARDL model equation as suggested by Cho et al. (2015).

$$Q\Delta REC_{it} = \alpha(\tau) + \sum_{i=1}^{p} \emptyset_{it}(\tau) REC_{it-1} + \sum_{i=0}^{q} \omega_{it}(\tau) CO2_{it-1} + \sum_{i=0}^{r} \lambda_{it}(\tau) FDI_{it-1} + \sum_{i=0}^{s} \gamma_{it}(\tau) REM_{it-1} + \sum_{i=0}^{t} \theta_{it}(\tau) INF_{it-1} + \sum_{i=0}^{u} \partial_{it}(\tau) GFCF_{it-1} + \sum_{i=0}^{v} \vartheta_{it}(\tau) TR_{it-1} + \sum_{i=0}^{w} \delta_{it}(\tau) LE_{it-1} + \varepsilon_{it}(\tau) \quad (8)$$

Where, $\varepsilon_{it}(\tau) = REC_{it} - Q\Delta REC_t(\frac{\tau}{\int_{it-1}})$ Kim and White (2003) is error correction term defined and is the $\tau - th$ quantile as proved by of REC_t depending on the information

set $\int_{t-1}$ and $0 > \boldsymbol{\tau} < 1$. The QARDL estimation equation (2) can be further illustrated as below to avoid chance of potential serial correlation.

$$\begin{aligned} QΔREC_{it} = {} & \alpha(\tau) + \rho REC_{it-1} + \Upsilon_{co2} CO2_{it-1} + \Upsilon_{fdi} FDI_{it-1} + \Upsilon_{rem} REM_{it-1} + \Upsilon_{inf} INF_{it-1} \\ & + \Upsilon_{gfcf} GFCF_{it-1} + \Upsilon_{tr} TR_{it-1} + \Upsilon_{le} LE_{it-1} \\ & + \sum_{i=1}^{p} \emptyset_{it}(\tau) REC_{it-1} + \sum_{i=0}^{q} \omega_{it}(\tau) CO2_{it-1} + \sum_{i=0}^{r} \lambda_{it}(\tau) FDI_{it-1} \\ & + \sum_{i=0}^{s} \gamma_{it}(\tau) REM_{it-1} + \sum_{i=0}^{t} \theta_{it}(\tau) INF_{it-1} + \sum_{i=0}^{u} \partial_{it}(\tau) GFCF_{it-1} + \sum_{i=0}^{v} \vartheta_{it}(\tau) TR_{it-1} \\ & + \sum_{i=0}^{w} \delta_{it}(\tau) LE_{it-1} + \varepsilon_{it}(\tau) \end{aligned} \tag{9}$$

Furthermore, according to Cho et al. (2015) above the QARDL estimation equation (3) can be modified to ECM form as under:

$$\begin{aligned} QΔREC_{it} = {} & \alpha(\tau) + \rho(\tau)(REC_{it-1} - \beta_{co2}(\tau) CO2_{it-1} - \beta_{fdi}(\tau) FDI_{it-1} - \beta_{rem}(\tau) REM_{it-1} \\ & - \beta_{inf} INF_{it-1} - \beta_{gfcf} GFCF_{it-1} - \beta_{tr} TR_{it-1} - \beta_{LE} LE_{it-1}) \\ & + \sum_{i=1}^{p} \emptyset_{it}(\tau) REC_{it-1} + \sum_{i=0}^{q} \omega_{it}(\tau) CO2_{it-1} + \sum_{i=0}^{r} \lambda_{it}(\tau) FDI_{it-1} \\ & + \sum_{i=0}^{s} \gamma_{it}(\tau) REM_{it-1} + \sum_{i=0}^{t} \theta_{it}(\tau) INF_{it-1} + \sum_{i=0}^{u} \partial_{it}(\tau) GFCF_{it-1} + \sum_{i=0}^{v} \vartheta_{it}(\tau) TR_{it-1} \\ & + \sum_{i=0}^{w} \delta_{it}(\tau) LE_{it-1} + \varepsilon_{it}(\tau) \end{aligned} \tag{10}$$

The cumulative short-term effect of preceding REC on present REC consumption are gauged by $\emptyset_* = \sum_{it=1}^{p-1} \emptyset_i$. Whereas, short term effect of previous CO_2, FDI, REM, INF, GFCF, TR, and LE on the present REC consumption are assessed as $\omega_* = \sum_{it=0}^{q-1} \omega_i$, $\varphi_* = \sum_{it=0}^{r-1} \varphi_i$, $\lambda_* = \sum_{it=0}^{s-1} \lambda_i$, $\gamma_* = \sum_{it=0}^{t-1} \gamma_i$, $\theta_* = \sum_{it=0}^{u-1} \theta_i$, $\partial_* = \sum_{it=0}^{v-1} \partial_i$, $\vartheta_* = \sum_{it=0}^{w-1} \vartheta_i$, and $\delta_* = \sum_{it=0}^{x-1} \delta_i$, respectively. However, long term cointegration of

CO_2, FDI, REM, INF, GFCF, TR, and LE, parameters is determined by beta ($\boldsymbol{\beta}$) and employed following formula as $\beta_{co2^*} = -\frac{\Upsilon CO2}{\rho}$, $\beta_{fdi^*} = -\frac{\Upsilon FDI}{\rho}$, $\beta_{rem^*} = -\frac{\Upsilon REM}{\rho}$, $\beta_{inf^*} = -\frac{\Upsilon INF}{\rho}$, $\beta_{gfcf^*} = -\frac{\Upsilon GFCF}{\rho}$, $\beta_{tr^*} = -\frac{\Upsilon TR}{\rho}$, and $\beta_{le^*} = -\frac{\Upsilon LE}{\rho}$, respectively. Where ρ represents parameter for speed adjusting essential to be significant and negative.

In addition to that we utilized Shapiro-Wilk test to explore the normality of data distribution, stating null hypotheses as variables are normally distributed as compared to alternative hypothesis that variables are not normally distributed. Moreover, the "Cross-sectional dependency test" is employed to examine the presence of cross-sectional dependence among the economies under study. Additionally, a correlation test is conducted to investigate the connection among the parameters, while the "variance inflation factor (VIF)" is employed to evaluate the existence of multicollinearity among the antecedents involved in the study.

5.3 Results and Discussion

When it comes to determining and scaling up green funding in OECD-15 European nations, we performed "cross-sectional dependence test." Table 2 presents the outcomes, which indicate that the "null hypothesis of no cross-sectional dependency" among the studied nations has been accepted. Moreover, we carried the "Variance Inflation Factor Test" (VIF) to assess the multicollinearity a problem among the independent facets. Table 3 demonstrates that all variables have VIF values below 5, indicating no multicollinearity. Additionally, we have performed "ADF and RALS-ADF unit root test" to check the stationary of variables results are shown in Table 4. ADF results show that all variables are nonstationary at level except CO_2 which is non-

stationary at 1st difference whereas, RALS-ADF results found that all variables are nonstationary at level. Hence, null hypothesis is failed to reject in all series indicating nonstationary among all variables. Therefore, results enable us to carry out cointegration relationship between the series.

Table 15 Cross-Sectional Dependence Test

Test	Statistic	Prob.
Breusch-Pagan LM	16.41	0.12
Pesaran scaled LM	4	0.27
Pesaran CD	-1.64	0.1

Source: Authors estimations

Table 16 Variance Inflation Test

Variable	Coefficient Variance	Uncentered VIF
TR	$1.90e^{+08}$	1.38
REM	$6.00e^{+09}$	1.11
GF	$7.80e^{+08}$	3.13
INF	$5.90e^{+08}$	1.19
GFCF	$1.80e^{+09}$	1.1
FDI	$2.40e^{+11}$	1.32
LE	$7.30e^{+08}$	3.31
CO_2	$8.90e^{+11}$	3.57

Source: Authors estimations

Note: "TR = trade openness; REM = Remittances; GF = Green Finance; INF = Inflation; GFCF = Gross fixed capital formation; FDI = Foreign Direct Investment; LE= Life expectancy (Human Capital), CO_2 = Carbon dioxide"

Table 17 ADF and RALS-ADF Unit Root test

Variables	ADF	RALS-ADF	ρ^2
lnGF	-3.268**	-14.732***	0.963
$lnCO_2$	0.805	-2.837*	0.765
$\Delta lnCO_2$	-2.810*	-3.838***	0.949
lnFDI	-3.009**	-10.334***	0.879
lnREM	-4.255***	-8.748***	0.963
lnINF	-2.929**	-4.998***	0.841
lnGFCF	-4.058***	-10.340***	0.959
lnTR	-4.714***	9.365***	0.860
lnLE	-3.904***	-20.700***	0.908

Source: Authors estimations

"Note: ***, **, and * represent the significance level at 1%, 5%, and 10% respectively. Furthermore, ADF critical values are -3.58, -2.93, and -2.60 at 1%, 5%, and 10% respectively. However, RALS-ADF critical values are -3.75, -3.30, and -3.05 at 1%, 5%, and 10% respectively." "TR = trade openness; REM = Remittances; GF = Green Finance; INF = Inflation; GFCF = Gross fixed capital formation; FDI = Foreign Direct Investment; LE= Life expectancy (Human Capital), CO_2 = Carbon dioxide"

Results in Table 5 are of Shapiro-Wilk normality test, evidenced p-values less than 0.01 suggesting rejecting null hypothesis of normality of all variables of study. Hence, results employ that non-normality exists. Additionally, in figure 1 graphical distribution indicates that all variables of study deviate from theoretical distribution. Therefore, RALS-EG cointegration test is more effective to extract cointegration association among the variables in the presence of nonmorality.

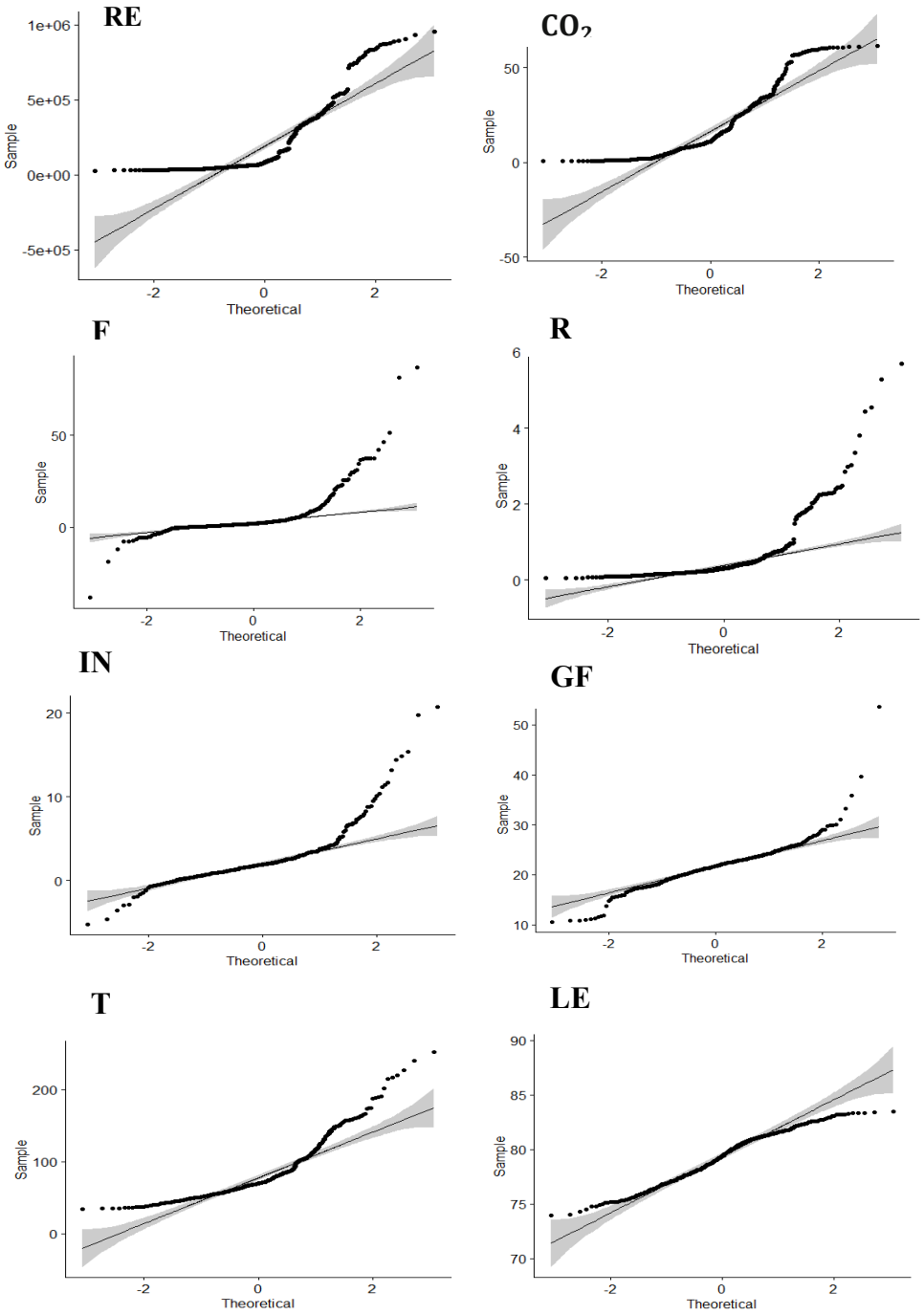
Table 18 Shapiro-Wilk normality test

Variables	W	P-Values
REC	0.857	0.000
CO_2	0.754	0.000
FDI	0.596	0.000
REM	0.602	0.000
INF	0.766	0.000
GFCF	0.887	0.000
TR	0.852	0.000
LE	0.974	0.000

Source: Authors estimations

Note: "TR = trade openness; REM = Remittances; GF = Green Finance; INF = Inflation; GFCF = Gross fixed capital formation; FDI = Foreign Direct Investment; LE= Life expectancy (Human Capital), CO_2 = Carbon dioxide"

Figure 13 Graphs of normality



In addition, "EG and RALS-EG cointegration test" results are depicted in table 6. The value of test statistics for EG cointegration test is -5.870, which is less than critical

value (-5.02) at 1% significance level. Hence, null hypotheses indicating no cointegration is rejected. The value of test statistics for RALS-EG is -4.260, which is smaller than critical values (-4.19) at 5% significance level, so rejects null hypotheses. To sum up, the "EG and RALS-EG test" results evidence the existence of cointegration association between green finance, carbon dioxide, foreign direct investment, remittances, inflation, gross fixed domestic product, trade openness and human capital. Furthermore, the correlation test results are presented in Table 7.

Table 19 RALS Cointegration

Method	k	Test Statistics	ρ^2
EG	0	-5.870***	-
RALS-EG	0	-4.260**	0.862

Source: Author
Note: "***, **, and * shows significance level at 1%, 5%, and 10% respectively, whereas K indicates optimum lag length found using recursive *t*-statistics. However, -5.02, -4.32, and – 3.98 are EG critical values at 1%, 5%, and 10% respectively and -4.80, -4.19, and 3.88 are critical values for RALS-EG at 1%, 5%, and 10% respectively."

Table 20 Correlation Test

Variables	TR	REM	GF	INF	GFCF	FDI	LE	CO2
TR	1							
REM	0.37	1						
GF	0.43	0.34	1					
INF	0.07	-0.02	0.16	1				
GFCF	0.24	0.01	-0.07	-0.04	1			
FDI	0.18	-0.34	-0.29	-0.05	0.21	1		
LE	0.37	-0.06	-0.46	-0.24	0.25	0.52	1	
CO2	0.09	-0.48	-0.38	-0.15	-0.07	0.47	0.53	1

Source: Authors estimations
Note: "TR = trade openness; REM = Remittances; GF = Green Finance; INF = Inflation; GFCF = Gross fixed capital formation; FDI = Foreign Direct Investment; LE= Life expectancy (Human Capital), CO_2 = Carbon dioxide"

5.3.1 QARDL long term results

In this study, table 8 presents the long-term coefficients estimation results of QARDL estimator employed after finding existence of cointegration relationship among all

variables of study. All quintiles have substantially positive long-term lag green finance coefficients (ρ) values. This illustrates how historical levels of green financing across all quintiles define green finance in the OECD-15 European nations today. These results are in line with Wong et al. (2013) conducted research in this area and discovered that OECD nations had higher energy efficiency as a result of large-scale technological innovation. OECD nations are at the forefront of renewable energy usage and energy efficiency technical innovation. For instance, in the 20 years between 1998 and 2017, the use of renewable energy in OECD countries increased by more than eightfold, from "36.6 million metric tons of oil equivalent to 304.9 million metric tons of oil equivalent" (Alam and Murad, 2020). According to Nawaz et al. (2021) green finance has influence on climate change mitigation strategies of the treated nations. Europe announced financial incentives to encourage investment in green energy in 2020, but further stimulus packages are needed for clean recovery and renewables, such as renewable power production, building energy retrofits, renewable heat, renewable hydrogen, and electric vehicles.

Additionally, interestingly long term cointegration parameters (Υ_{gdp}) of carbon dioxide are zero but significantly negative throughout all quantiles. The results indicate that surprisingly carbon dioxide does not influence investment in green finance in context of OECD-15 European countries. As a result, environmental issues about CO_2 emissions had no stimulus on the development of green finance in the OECD-15 European nations. These findings might be attributed to the relatively small sample period examined, or to quirks in how certain factors interact with long-term green financing trends in these nations. The results align with previous study Vural (2021)

for selected Latin American Countries, da Silva et al. (2018) for sub-Saharan Africa and Hussain and Rehman (2021) for Pakistan, Rehman et al. (2021) for Pakistan and Sadorsky (2009) for G7 countries. However our results are in contrast with Omri et al. (2015) for sixty four countries around the world, Rasoulinezhad and Saboori (2018) for common wealth of independent state, Apergis and Payne (2014) central America, Salim and Rafiq (2012) for emerging economies and Omri and Nguyen (2014) for 64 global countries. Additionally, the issue of climate change is caused by CO_2, which has led to the development of the Paris Agreement, which aims to stop global temperatures increasing above 1.5 degrees Celsius beyond pre-industrial levels using market and non-market tools (Nawaz et al., 2021). Europe is committed to reduce 55% of greenhouse emissions by 2030 and has invested 1.2 trillion USD under the European Green New Deal. To do so the Europe has closed many coal plants in 2020.

Furthermore, long-run coefficients (Υ_{fdi}) of foreign direct investment across all quantiles are positive and significant. This employs that the increase in the foreign direct investment levels increases the investment in green finance in the long run. These results substantiates the findings of Mukhtarov et al. (2018) for oil rich economies, W. Lee (2013) for G20 economies, Qamruzzaman and Jianguo (2020) for lower income countries, Ji & Zhang (2019) for China, Wei et al. (2022) for 30 provinces of China, Shahbaz et al. (2021) for the developing countries, and Ergun et al. (2019) for Africa. Foreign direct investment in green finance will replace the pollutant and environmental unfriendly technologies to clean and friendly resulting increasing clean energy consumption to promote environmental quality in OECD-15 European countries. In addition to that FDI plays an important role in drawing green

capital to the energy industry, which helps to alleviate the consequences of climate change. It is quite significant and has a direct association. It implies that when foreign direct investment rises, so does green financing. In order to scale up green finance, foreign direct investment (FDI) is a key aspect. According to Xie et al. (2020), global FDI was $1.9 trillion, with a large portion of that flowing to developing nations. This claim from the analysis has been supported by other investigations. Such as Xie et al. (2020) and Sun et al. (2020) who said the amount of FDI inflows indicated the flow of FDI at the provincial level in China and Nawaz et al. (2021) in B-11 and BRICS economies.

Also, long run cointegration coefficient (Υ_{rem}) of remittance has negative and insignificant association with investment in green finance throughout (q05, q10 q20, q30, q40, q90 and q95) quantiles, while quantiles (q50, q60, q70, and q80) remittance cointegration coefficients (Υ_{rem}) have positive and significant association with investment in green finance. Hence, results suggest that asymmetric remittance supports investment in green finance and further indicates that low quantiles and last two high quantiles does not affect the investment in green finance. In addition to that, cointegration coefficients (Υ_{inf}) of inflation across all quantiles are negative and significant with green finance coefficients. This indicates that the rise in the level of inflation decreases the level of investment in green finance. These outcomes are in agreement with Nawaz et al. (2021) who investigated the nexus between inflation and investment in green finance in N-11 and BRICS. They found that there is a significant negative relationship between the two in these economies.

For quantiles q5, q10, q20, q30, q50, q60, q70, q80, q90, and q95 the long run coefficients (Υ_{gfcf}) of gross fixed capital formation are positive and significant with investment in green finance, whereas q40 only the quantile reveals negative and significant association for green finance. Therefore, it revealed that domestic capital is significant in attracting the investment in green finance in OECD-15 European countries. The results are in line with Qamruzzaman and Jianguo (2020) who investigated association in lower income countries and found significantly positive nexus between capital formation and renewable energy. It implies that OECD-15 European nations must increase their capacity to develop green financing policies that prioritize renewable energy capacity growth keeping in view the important role of capital formation. Furthermore, for all quantiles trade openness has positive and significant association in long run coefficients (Υ_{tr}) with green finance. This infers that the increase in the long-run level of trade openness boosts the investment level in green finance. The inferences are in agreement with previous literature (Alam and Murad, 2020) who found positive association in OECD countries, Amri (2017) for developing and developing countries, Nasreen and Anwar (2014) for Asian countries, Vural (2021) for Latin American Countries, and Omri et al. (2015) for 64 countries around the world. As international trade grows technology will advance, the OECD-15 European countries are motivated and compelled to invest and spend more in green financing to produce environmentally friendly outcomes, including renewable energy production.

Cointegration coefficients (Υ_{le}) of human capital for all quatiles are positive and significant indicating increasing level of human capital supports increase in investment

level of green finance, except q10 and q95 quantile coefficient which have negative and significant association with green finance. It is presented that higher human capital implies better education resulting awareness in nationals. As a result, if a country has more human capital, its citizens will have greater living standards, which may influence their decision to engage in green finance to safeguard the environment. As a result, a higher proportion of renewables in a country's energy consumption is expected. The results are in line with Ergun et al. (2019) for Africa while utilizing GLS regression on the data ranging from 1990 to 2013. Therefore, the remarkable conclusion of this study is that lag of renewable energy, foreign direct investment, gross fixed capital formation, trade openness and human capital all together are the integral facets to investment in green finance especially when it comes to judging the potential to invest in climate mitigation projects in OECD-15 European countries.

Table 21 QARDL long term estimations

Quantiles	Constant	Long Run coefficients							
(τ)	α(τ)	GF(τ)	$CO_{2(\tau)}$	FDI(τ)	REM(τ)	INF(τ)	GFCF(τ)	TR(τ)	LE(τ)
0.05	0.533	0.964**	-0.000***	0.004***	-0.005	-0.023**	0.009**	0.011***	0.461**
	(635)	(0.016)	(0.000)	(0.002)	(0.369)	(0.012)	0.018)	(0.004)	(0.087)
0.1	0.188	0.998**	-0.000***	0.003***	-0.024	-0.004**	0.003**	0.010***	0.323
	(0.791)	(0.02)	(0.000)	(0.003)	(0.500)	(0.018)	(0.026)	(0.005)	(0.123)
0.2	0.734	0.987***	-0.000***	0.003***	0.027	-0.008***	0.003***	0.003***	0.244**
	(0.362)	(0.009)	(0.000)	(0.002)	(0.207)	(0.005)	(0.007)	(0.003)	(0.086)
0.3	0.467	0.990***	-0.000***	0.001***	0.034	-0.003***	-0.003***	0.001***	0.108**
	(0.231)	(0.007)	(0.000)	(0.001)	(0.120)	(0.004)	(0.004)	(0.002)	(0.071)
0.4	0.244	0.989***	-0.000***	0.001***	0.021	-0.002***	0.005***	0.0002***	0.074**
	(0.187)	(0.005)	(0.000)	(0.001)	(0.103)	(0.002)	(0.004)	(0.001)	(0.018)
0.5	0.234	0.989***	-0.000***	0.001***	0.027**	-0.003***	0.006***	0.001***	0.072**
	(0.145)	(0.006)	(0.000)	(0.001)	(0.081)	(0.001)	(0.002)	(0.001)	(0.021)
0.6	-0.270	0.978***	-0.000***	0.001***	0.081**	-0.002***	0.007***	0.001***	0.035**
	(0.130)	(0.005)	(0.000)	(0.005)	(0.043)	(0.001)	(0.002)	(0.001)	(0.018)
0.7	0.243	0.971***	-0.000***	0.001***	0.053**	-0.002***	0.006***	0.002***	0.025***
	(0.161)	(0.005)	(0.000)	(0.001)	(0.080)	(0.002)	(0.003)	(0.001)	(0.019)
0.8	0.065	0.968***	-0.000***	0.0003***	0.044**	-0.0004***	0.006***	0.002***	-0.009**
	(0.189)	(0.007)	(0.000)	(0.001)	(0.098)	(0.002)	(0.004)	(0.001)	(0.025)
0.9	0.289	0.954***	-0.000***	0.0005***	-0.026	-0.001***	-0.009***	0.0005***	0.010*
	(0.334)	(0.008)	(0.000)	(0.001)	(0.121)	(0.004)	(0.005)	(0.004)	(0.057)
0.95	0.913	0.957**	-0.000***	0.002***	-0.081	-0.005***	-0.007***	0.0002***	0.126
	(0.449)	(0.012)	(0.000)	(0.002)	(0.163)	(0.006)	(0.006)	(0.004)	(0.100)

Source: Authors estimations Note: Parentheses indicates probability values such as * $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

Note: "TR = trade openness; REM = Remittances; GF = Green Finance; INF = Inflation; GFCF = Gross fixed capital formation; FDI = Foreign Direct Investment; LE= Life expectancy (Human Capital), CO_2 = Carbon dioxide"

5.4 Conclusion and policy implications

In the previous literature, many scholars have examined the nexus between many different antecedents and green finance by employing traditional econometric approaches but nexus between investment in green finance and its facets has not been explored before while applying newly developed the Quantile Autoregressive-Distributed Lag (QARDL) methodology and RALS cointegration approach in OECD-15 European countries for the period spanning from 1990-2020. The application of RALS cointegration approach and QARDL methodology distinguish this work form previous work to produce more reliable, meaningful, and unbiased outcomes to policymakers to develop strong policy framework to meet sustainable development goals by 2030. This methodology has demonstrated the necessity for the OECD-15 European countries to stablish initiatives to mitigate the systemic risks, climate change poses, and to catalyse the required funds to invest in green finance to reduce these risks and consequences.

The results obtained from the QARDL shows that lag of green finance, foreign direct investment, fixed capital formation, trade openness, and life expectancy (proxy for human capital) motivate investment in green financing whereas, carbon dioxide (CO_2) emissions and inflation have negative association with investment in green finance. However, remittances have insignificant association with variable of interest. Furthermore, certain antecedents would support OECD-15 European countries to access funds to invest in green finance and implement initiatives pertaining to mitigate climate change issues. Such as the results depicts that the lag of green finance is important to OECD-15 European countries to fight this risk of climate change while

investing in green financing and implementing green macroeconomic policies. Additionally, foreign direct investment is another vital driver of the investment in green finance. The OECD-15 European countries attracts foreign direct investment to invest in green renewable energy and it has become the yard stick to generate funds to investment in green finance.

Major result-oriented policies and implications for the OECD-15 European countries are as under:

- The OECD- European countries should work together to establish an environment that encourages foreign direct investment in order to expend green finance. These countries can develop policies such as reduced tax laws and restrictions to assist FDI inflows. The purpose of the FDI inflow must be conditional on investment in renewable energy, technology, and R&D.
- We suggest the OECD economies boost the remittance by encouraging the human capital to invest in the home countries clean initiatives. This may be possible with the development of green banking infrastructure to under the strategic guidelines of the central banks of the studied nations. This will provide also opportunities to industries and businesses to obtain a green loan for investing in green opportunities such as renewable energy projects.
- Governments and authorized departments of OECD-15 European countries must encourage and promote green bond market development and issue green bonds by non-corporate entities as pension funds (give example of one European country here). Furthermore, they must develop green finance investment legislation, impose green taxes, and take measures to start green

finance initiatives. These strategic steps will help the OCED nations to pursue the environmental objectives within the time frame.

- Green bonds standards, procedures and principles must be set and followed to invest in green financing initiatives (Projects) such as green bonds to mitigate climate change. This would enable complete transparency, openness, and full disclosure to investment in green finance initiatives as stated. Green bond proceedings will help the industries of OECD nations to invest in environmentally friendly technologies and research and development.
- The OECD nations must launch the greenhouse gas emissions awareness programs to educate the people of Europe to focus on benefits environmental quality. Moreover, initiatives such as tree plantation drives must be initiated, and people of Europe must be encouraged to plant more trees to keen the environment healthy for healthy living.
- Finally, policymakers of OECD economies must encourage international trade through trade liberalization policy, as trade openness is resulted as major vehicle and medium to transit and transfer green technology, technical knowledge, and create competitive advantage. They must develop mechanisms to promote investment in green energy projects through trade openness.

The limitation of present research work is that our study is limited to OECD-15 European countries due to unavailability for other OECD economies, hence generalizability of work is limited to studied economies. The time period of our study is limited to 1990 to 2020, due to unviability of data. Moreover, we have used quantitative methods to estimate the outcomes of the study. Therefore, in the future

potential researchers can take all OECD countries to investigate the association of investment in green finance while incorporating other antecedents such as economic growth, technological innovation, financial market development and globalization to enrich literature on green finance. It would improve the theoretical and empirical applicability along with broad policy suggestions and implications. Moreover, future research can be carried out considering quantitative and qualitative methods together to enrich literature methodologically.

CHAPTER 6

HOW CAN G5 COUNTRIES LEARN FROM GL5 GREEN LEADER COUNTRIES TO DECREASE ENVIRONMENTAL DEGRADATION WHILE HAVING GREEN PRODUCTIVITY?

6.1 Introduction

Since the 1960s, climate temperature, soil dryness, resource scarcity, and pollution have caused an ecological catastrophe and resource conundrum that must be tackled globally (Hao et al., 2018; Ali and Seraj, 2022; Ali et al., 2022; Joof et al., 2022). Many nations are developing their own green economies to adapt to the changing global climate and growing environmental dangers and to meet carbon neutrality objective by 2050. The aim is to attain environmentally inclusive growth of sustainable development goals which refers to the coordinating economic growth, limiting natural resource depletion, and sustainable environmental (Lee & Lee, 2022b). The green productivity is a key indicator of a nation's ability to address environmental issues, improve sustainability, and maintain economic growth. As a result, the question of how to foster growth in green productivity has been receiving a lot of attention from policymakers and academics, as we enter in a new era of economic development.

According to conventional Solow growth and endogenous growth theories, a sustainable economy merely requires technical development which is measured by total factor productivity (TFP) increase (Lee & Lee, 2022b). However, TFP metrics omit numerous resource and environmental societal advantages (Tian & Lin, 2017). The limitation is especially noticeable when energy and the environment turn out to be the primary factors inhibiting economic development since some of the inputs used in

production must be moved to environmental governance activities, which results in inaccurate policy recommendations (Liu et al., 2020). The Asian Productivity Organization's 1990s concept of green productivity solves this problem. According to concept, green productivity is a dynamic approach that boosts productivity and environmental performance. Similarly, in theory, the traditional financing approaches do not consider the element of environmental protection policy. The possible rewards, hazards, and costs associated with environmental conditions must be included into investment and finance choices as well as potential environmental repercussions. Therefore, green finance emerged as potential opportunity to tackle this problem.

Theoretically, "green finance" refers to financial industry views on environmental conservation as a fundamental principle. In everyday tasks, the focus is to preserve natural world, control environmental hazards, and advance societal sustainability via managing social and economic resources. Significant ecological effects must be considered when making investment and financial choices, potential rewards, hazards, and costs associated with environmental circumstances must be factored into routine in everyday operations. We believe that green investment and providing green financing opportunities through financial institutions take into account the environmental evaluation and focus on preserving the natural environment and foster green growth. Green finance differs from conventional finance quite noticeably because it places a strong emphasis on how society as a whole benefit from the environment. Many academics advocate for the preservation of the natural world and the growth of green finance (Jiang et al., 2020; Pulvirenti et al., 2015; Cuspilici et al., 2020). It uses environment preservation as criterion to assess the efficiency of business

units and instructs them to pay close attention to ecological balance along with green economy.

The objective of our study is to explore the factors which helps to accelerate decarbonization and green productivity simultaneously. Moreover, in doing so, we aim to learn more about how the G5 and GL5 economies have adapted to the shift toward greener financial practices and, in turn, how their green production has grown. The issue of green economy has been extensively studied in the literature for decades. Since then, academics have extensively studied green finance and green productivity growth to determine economic sustainability (Yan et al., 2020; Lee & Lee, 2022b; Ren et al., 2022; Song et al., 2022) particularly in China. Most of the earlier researchers used total factor productivity index (TFP) as an indicator of green economy; see for instance (Amri et al., 2019; Beugelsdijk et al., 2017; Coomes et al., 2019; Pan et al., 2022; Wen et al., 2023; Yaqoob et al., 2022). These studies used TFP without taking in account the undesirable outcomes such as carbon emissions and waste products which harm the environmental quality. Thus, TFP is conservative, conventional, traditional, and orthodox approach.

Due to draw backs of the TFP, a few recent studies used the green total factor productivity (GTFP) (Cao et al., 2021; Liu et al., 2020; Ren et al., 2022; Song et al., 2022; Wu et al., 2022; Yan et al., 2020) taking in account the energy constraint such as total energy used in production activity along with environmental performance. The researchers (Jin et al., 2020; Li et al., 2021; Wang et al., 2021) evidenced that GTFP is better indicator to sustainable economic development, as it takes in account the desired outcomes such as gross domestic product and undesired constraints such as waste

products including carbon emissions in the index. Therefore, we examine the role of green finance, environmental technology innovation, environmental policy stringency, renewable energy, and industrial structure on GTFP. We utilize GTFP index as explained antecedent and green finance (GF), environmental technological innovation (ETI), environmental policy stringency (EPS), renewable energy (REN), and industrial structure (INDS) as explanatory antecedents. Our study is worthy effort to gain insights and understanding the issue of what cause changes in green productivity and guides governments and policymakers to improve green economy development.

Unlike previous research work which remained focused in the context of China, we have taken G5 and GL5 economies in our study. G5 boost their economy at the cost of environmental degradation and GL5 economies develop their epicentre at green environment with green economy. According to World Economics[11] the G7 economies accounts for 27% of the global GDP and 14% of global GDP growth in the past 10 years and GL5 economies are ranked top 5 economies on their progress and commitment toward building a low-carbon future. Further, the world Atlas[12] stated that G7 association consists of world's biggest and most developed economies such as United States of America (USA), the home of world's largest economy with total GDP U.S.$21.143 trillion, Japan, the world's 3rd largest economy with total GDP U.S.$5.08 trillion, known as land of rising sun, Germany the world's 4rth largest and Europe's largest economy with total GDP U.S.$3.86 trillion, United Kingdom (UK) world's 6th largest economy with total GDP U.S.$ 2.83 trillion, France world's 7th

[11] World Economic https://worldeconomics.com/Regions/G7/
[12] "World Atlas https://www.worldatlas.com/articles/group seven-g7-countries.html"

largest economy with total GDP U.S.$2.72 trillion, Italy world's 8th largest economy with total GDP U.S.$2 trillion, and Canada world's 10th largest economy with total GDP U.S.$1.74 trillion.

Due to economic growth and industrialization the energy consumption of the G7 economies has been increased from 42691Twh in 2020 to 44508Twh in 2021 (4.28% growth rate), resulting major contribution in carbon emissions as shown in figure bellow:

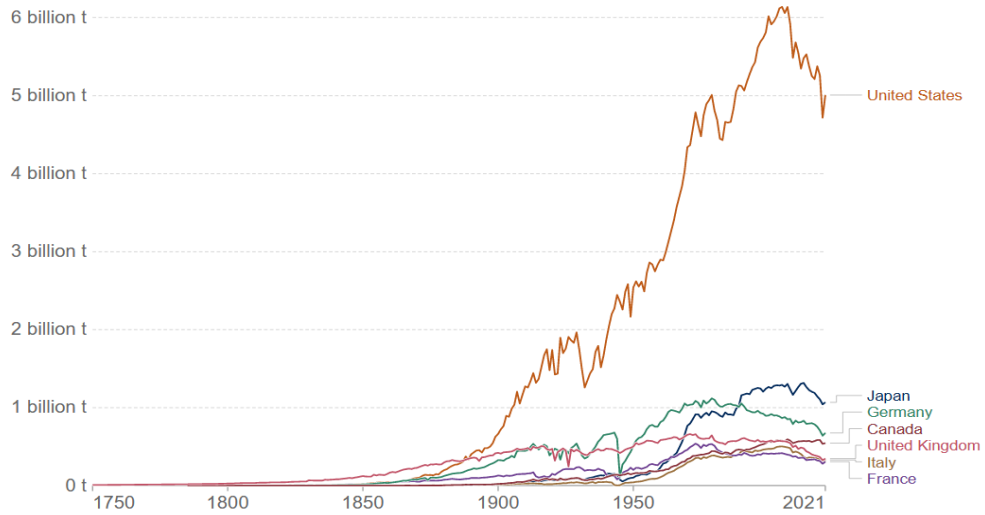


Figure 14 Carbon emissions in study economies

Source: "Our World in Data (https://ourworldindata.org/co2-emissions)"

On the other hand, green future index of GFI report (2022) indicates future progression and commitment toward building a low carbon future for developed economies. According to the report, Denmark, Norway, France, Ireland and Netherlands[13] are considered world's top 5 green leader economies pivoting toward clean energy,

[13] According to "GFI report (2022) the Iceland has been listed as top of the green leaders, following Denmark, Norway, France, Ireland and Netherlands based on their progress and commitment toward building a low-carbon future. These initiatives position Iceland13 well for meeting its 2040 carbon neutral goal."

industry, agriculture, and society through investment in renewables, innovation, and green finance. These economies are actively developing activities in carbon pricing, policy structures, investment programs for innovative sustainable sectors, and vehicle emissions to accelerate the regions decarbonization. Using ample geothermal and hydropower resources, these economies are world leaders in clean energy production. They are also pursuing green hydrogen for transportation and fostering local industry innovation around carbon capture technology. Such as Denmark and Norway are actively transitioning their oil and gas-dependent economies to become green leaders. Denmark has been decommissioning fossil fuel energy for several years. In December 2020, Denmark became the largest producer of hydrocarbons in Europe and abandoned issuing new oil and gas exploration licenses, with the aim of eliminating fossil fuel-related businesses by 2050. Additionally, Ireland is one of the global leaders in reforestation efforts and green buildings (GFI Report 2022).[14]

The aim of current study is to explore how G5 economies (France, Germany, Japan, UK and USA) can learn from green 5 leaders' economies (Denmark, Norway, France, Ireland, and Netherlands) to accelerate decarbonization while having productivity. Additionally, we aim to gain further insights on the development of green finance policy and the resulting green productivity change of G5 and GL5 economies for the period 2000-2020. Moreover, investigating a workable green development model adopted by GL5 will provide rapid solution to transform and advance green development and mitigate serious economic and environmental issues faced by G5. In this context, G5 economies will meet the 2050 climate commitments discussed at the

[14] "Green finance index (GFI) Report 2022 https://mittrinsights.s3.amazonaws.com/GFI/Report2021.pdf"

Paris Climate Change Conference, 2015. Because of background, we feel compelled to evaluate green total factor productivity (GTFP) and the driving forces that influence GTFP within the framework of the dual goals of economic growth and carbon neutrality.

The contribution of our research is summarized as: First, it is evidenced from the literature that majority of research on green finance, environmental technology innovation, and green total factor productivity has been conducted in context of China (Cao et al., 2021; Ren et al., 2022; Song et al., 2022; Wu et al., 2022; Yan et al., 2020). Therefore, our study is first to fill the gap and to explore the antecedents of green total factor productivity in G5 and GL5 economies. The outcomes of addressing this gap may provide guidance to the governments, policymakers, environmentalists, stakeholders, and economic units in G5 and GL5 economies. The findings may aid in policymaking to improve green economic growth, reduce energy cost, enhance living standards, preserve ecological balance, and to meet sustainable development goals (SDGs) 7 (affordable and clean energy), SDGs 8 (decent work and economic growth), SDGs 9 (industry, innovations, and infrastructure), and SDGs 13 (climate action).

Second, unlike previous works on traditional productivity that mainly considers good output, we apply the “super-efficiency slacks-based measure” model known as super-SBM model. Supper SBM takes into account energy consumption in addition to labor and capital as inputs, carbon emissions and gross domestic product as undesirable and desirable outcomes. Therefore, Super SBM model solves the potential omission problem of energy and environmental constraints.

Third, in contrast to previous studied (Lee & Lee, 2022; Cheng & Jin, 2022; Tong et al., 2022) who applied traditional models such as, "pooled ordinary least squares (POLS), the random effect (RE), the fixed effect (FE), the two-way fixed effect (Two-way FE), and the generalized method of moments (GMM) models," we employ Panel Autoregressive Distributed Lag (PARDL) model to explain the long and short-run influence of factors of interest on GTFP. The PARDL model helps to overcome the problem of spurious regression and provide robust and consistent inferences.

Finally, we extend research models of Lee & Lee, (2022) and Tong et al., (2022)[15] by adding more antecedents in the model such as environmental technological innovation, environmental policy stringency, renewable energy, and industry structure in the model in the context of G5 and GL5 group economies. Addition of antecedents provides additional insights considering the importance of the connection between green finance and green productivity and by doing so, detailed information about the causes of green productivity is achieved. In addition, we draw answer to the central question based on the expansion of new framework. Moreover, the findings of our study will shed light on the mechanisms by which environmentally responsible investments, technological policy, renewable energy, and industrial structure may bring benefit to the economy and the environment via the promotion of green economic growth and green productivity.

Overall, we uncover that connectedness between green finance, renewable energy, and green productivity is substantial where green finance opportunities are major

[15] Lee & Lee, (2022) conducted the study in context of China and Tong et al., (2022) explored this relationship in context of Asian Region.

transmitter of green total factor productivity in G5 and GL5 economies. However, in magnitude renewable energy is major transmitter of green total factor productivity in GL5 as compared to G5 economies. In addition, dynamic connexon between environmental technology and green productivity is significant, where technology innovation can transform the traditional economic development into green economic development in both group of economies. Moreover, influence of policy stringency and industrial structure reveal significant negative influence on green productivity.

The paper continues as follows. Section 2 summarizes pertinent research. Section 3 presents the data, empirical model, and methods. Section 4 covers estimate findings. Section 5 derives policy conclusions.

6.2 Methodology

6.2.1 Data

This research investigates the role of green finance, environmental policy stringency, environmental technological innovation, renewable energy, and industry structure in promoting the green total factor productivity in the great five (G5) and top five green leader (GL5) for the time period spanning from 2000 to 2020. The sample countries G5 are selected out of G7 based on the availability of data. The sample countries include France, Germany, Japan, UK, USA The sample of the top five green leaders (GL5) includes Denmark, Norway, France, Ireland and Netherlands. This selection of sample is based on GFI report (2021)[16] and availability of data. We exclude Iceland

[16] "GFI Report 2022https://mittrinsights.s3.amazonaws.com/GFI/Report2021.pdf. MIT Technology review insight produced the green factor index 2021. The report produced a ranking of 76 economies on their progress and commitment toward building a low-carbon future."

from the investigation, which is at top of green leaders list due to unavailability of data. Table 2 presents the detailed description of the variables.

Table 22 Variable's description, measurement, and data sources

Abbreviation	Variables	Definition and measurement	Source
GTFP	Green Total Factor Productivity	Score of Super Slack SBM model	DEA
GF	Green Finance	Climate-related development finance - Commitment - Current USD thousand	OECD
ETI	Environmental Technological Innovation	Number of patent trends of technologies that enabled further growth of renewable energy technologies.	IRENA
EPS	Environmental Policy Stringency	Environmental Policy Stringency	OECD
INDS	Industrial Structure	Industry (including construction), value added (Annual % of growth)	WDI
REN	Renewable energy	Total Renewable Gigawatt-hours (GWh)	IRENA

Source: Authors compilation

Note: "DEA stands for Data Envelopment Analysis; OECD stands for Organization of Economic Coordination and Development https://stats.oecd.org/Index.aspx?DataSetCode=EPS; IRENA refers to International Renewable Energy Agency https://www.irena.org/Data; WDI refers to World Development Indicators World Development Indicators | DataBank (worldbank.org)"

6.2.1.1 Super- Slacks-Based Measure (SBM)

We use green total productivity index as dependent variable. This index is developed using the Super-Slack-Based Measure (SBM) model. According to Cob-Douglas production function, we measure the output of unit as presented in the equation (1)

$$Y = AL^{\beta}K^{\alpha} \qquad (1)$$

Where, Y is output, A is total factor productivity, L is labor, K is capital and α and β are output elasticities for capital and labor respectively. Equation (1) is modified to obtain total factor productivity as under in equation (2)

$$A = Y/L^{\beta}K^{\alpha} \qquad (2)$$

The effectiveness of production and the state of the environment should both be taken into account throughout economic growth; nevertheless, it is impossible for a single index to quantify both of these aspects simultaneously. Thus, green total factor productivity index (GTFP) accurately measures economic health and environmental quality (Cao et al., 2021; Wu et al., 2022). It takes into account three input factors such as capital, labor, and energy consumption and two output factors. The one is desired output such as gross domestic product (GDP) and another is undesired output such as CO_2. Therefore equation (3) can be modified as under:

$$A = GDP\ CO_2/L^{\beta}K^{\alpha}E^{\gamma} \qquad (3)$$

Therefore, energy consumption and CO_2 are used to enhance the Cobb–Douglas production function. Additionally, this study in line with previous studies (Ren et al., 2022; Wu et al., 2022) employed the Super- Slacks-Based Measure (SBM) method suggested by Tone, (2003) to calculate the GTFP of the great five (G5) and Green five leader (GL5) economies. At time t, consider N number of decision making unites (DMUs), utilizing $W_{-Vector}$ of input factors

$$X_{it} = (x_{1it}, x_{2it}, x_{3it}, \dots\dots\dots x_{Wit})\varepsilon R_W^+ \quad (4)$$

To generate $Q_{1-Vector}$ of desirable outputs and $Q_{2-Vector}$ to produce undesirable outputs

$$y_{it}^{\vartheta} = y_{1it}^{\vartheta}, y_{2it}^{\vartheta}, y_{3it}^{\vartheta} \dots\dots\dots y_{Qit}^{\vartheta})\varepsilon R_{Q1}^+ \quad (5)$$

$$y_{it}^{\delta} = y_{1it}^{\delta}, y_{2it}^{\delta}, y_{3it}^{\delta} \dots\dots\dots y_{Qit}^{\delta})\varepsilon R_{Q2}^+ \quad (6)$$

All factors are under non-zero assumption. The production set is then defined as:

$$P = ((x, y^k, y^l)/x \geq X\pi, y^k \leq Y^k\pi, y^l \geq Y^l\pi, \pi \geq 0) \quad (7)$$

Where π is no negative intensity vector of weights assigned to all inputs-output factors. Under resource and environmental constraints, the mathematical form of the SBM model with undesirable output (Tone, 2003) for GTFP can be expressed as under:

$$\rho^* = \min \frac{1-\frac{1}{m}\sum_{j=1}^{M}\frac{s_{j0}^-}{x_{j0}}}{1+\frac{1}{Q_1+Q_2}\left(\sum_{p=1}^{Q_1}\frac{s_p^{\vartheta}}{y_{po}^{\vartheta}}+\sum_{q=1}^{Q_2}\frac{s_q^{\delta}}{y_{qo}^{\delta}}\right)} \quad (8)$$

$$s.t.\begin{cases} x_{j^0} = \sum_{j=1}^{M} x_j\,\pi_j - s_i^- \\ y_{p^0}^{\vartheta} = \sum_{j=1}^{Q_1} y_p^{\vartheta}\,\pi_p - s_p^{\vartheta} \\ y_{q^0}^{\delta} = \sum_{j=1}^{Q_2} y_q^{\delta}\,\pi_q + s_q^{\delta} \\ s_i^- \geq 0, s_p^{\vartheta} \geq 0, s_q^{\delta} \geq 0, \pi \geq 0 \end{cases} \quad (9)$$

In equation (8) the optimal solution of the objective function is ρ^*, which indicates the target efficiency value in the range [0,1]; and $s = \left(s_i^-, s_p^{\vartheta}, s_q^{\delta}\right)$ is a slack vector crosponding to the abudance of inputs, scarcity of desirable outputs and excess of undesirable outputs, respectivily. for a given evaluated DMU, it is efficient if and only $\rho^* = 1$ and all slack variables are equal to 0. When $\rho^* < 1$, the DMU is inefficient, but can be efficient through decreasing the excess inputs and undesirable outputs and increasing the shortage of desirable outputs. However, there may be multiple efficient DMUs with an efficiency value of 1 simultaneously. Given the efficiency value is bounded from 0 to 1, further distinguishing the efficiency among these efficient DMUs

is impossible. To solve this difficulty, Tone (2003) proposes a super-SBM model with undesirable outputs as:

$$\rho^{**} = \min \frac{\frac{1}{m}\sum_{j=1}^{M}\frac{\bar{x}}{x_{j0}}}{1+\frac{1}{Q_1+Q_2}\left(\sum_{p=1}^{Q_1}\frac{\bar{y}^{\vartheta}}{y_{po}^{\vartheta}}+\sum_{q=1}^{Q_2}\frac{\bar{y}^{\delta}}{y_{qo}^{\delta}}\right)} \tag{10}$$

$$s.t.\begin{cases} \bar{x} \geq \sum_{k=1,\neq 0}^{M} x_{jk}\,\pi_k \\ \bar{y}^{\vartheta} \leq \sum_{k=1\neq 0}^{Q_1} y_{pk}^{\vartheta}\,\pi_k \\ \bar{y}^{\delta} \geq \sum_{k=1\neq 0}^{Q_2} y_{qk}^{\delta}\,\pi_k \\ \bar{x} \geq x_{jk}, \bar{y}^{\vartheta} \leq \bar{y}_{pk}^{\vartheta}, \bar{y}^{\delta} \geq \bar{y}_{qk}^{\delta}, \pi_k > 0 \end{cases} \tag{11}$$

Here, ρ^{**}represents the super efficiency value of the evaluated DMU whose value can be larger than 1; and, $\bar{x}, \bar{y}^{\vartheta}, \text{and } \bar{y}^{\delta}$ are the mean vector of inputs, desirable output, and undesirable output, respectively. Table 1 presents the input-output indicators used in the super-SBM model.

Table 23 Input-Output variables

Variable	Type	Description	Source
Labor	Input	Labor force, total	WB
Capital	Input	Gross fixed capital formation (constant 2015 US$)	WB
Energy	Input	Energy use (kg of oil equivalent per capita)	WB
GDP	Desired Output	GDP per capita (constant 2015 US$)	WB
CO_2	Undesired Output	CO2 emissions (metric tons per capita)	WB

Source = *Author's compilation*
Note: *WB = "World Bank* World Development Indicators | Databank (worldbank.org)*; GDP = Gross Domestic Product; CO_2 = Carbon dioxide"*

6.2.2 Econometric Model

We developed following research model to investigate the role of green finance, environmental technology innovation, environmental policy stringency, and industry in promoting the green total factor productivity in the great five (G5) and top five green leader (GL5).

$$lnGTFP_{it} = \beta_0 + \beta_1 lnGF_{it} + \beta_2 lnETI_{it} + \beta_3 lnEPS_{it} + \beta_4 lnINDS_{it} + \beta_5 lnREN_{it} + \mu_{it} \quad (12)$$

Where, $lnGTFP_{it}$ refers to green total factor productivity; $lnGF_{it}$ refers to the green finance; refers $lnETI_{it}$ refers to environmental technological innovation; $lnEPS_{it}$ refers to the environmental policy stringency; $lnINDS_{it}$ refers to the Industry; $lnREN_{it}$ refers to renewable energy, β_0 denotes the intercept; β_1 to β_5 presents the coefficients of the explanatory variables; i and t denotes the country and time period and μ_{it} denotes the error term.

We employed Liven, Lin, & Chin (LLC), Augmented Dicky Fuller (ADF), and Philips Peron (PP) unit root tests to investigate stationary of the data. However, to reveal the cointegration among the facets of study we used Padroni residual cointegration test. Additionally, we employ Autoregressive Distributed Lag model to investigate the long and short run association of explanatory facts and explained facet. The equation (12) is modified for PARDL model and presented as under:

$$\Delta lnGTFP_{it} = \beta_0 + \sum_{i=1}^{k} \beta_1 lnGTFP_{t-1} + \sum_{i=1}^{k} \beta_2 lnGF_{t-1} + \sum_{i=1}^{k} \beta_3 lnETI_{t-1} + \sum_{i=1}^{k} \beta_4 lnEPS_{t-1} + \sum_{i=1}^{k} \beta_5 lnINDS_{t-1} + \sum_{i=1}^{k} \beta_6 lnREN_{t-1} + \vartheta_1 lnGTFP_{t-1} + \vartheta_2 lnGF_{t-1} + \vartheta_3 lnETI_{t-1} + \vartheta_4 lnsEPS_{t-1} + \vartheta_5 lnINDS_{t-1} + \vartheta_6 lnREN_{t-1} + \lambda ECT_{t-1} + \mu_{it} \quad (13)$$

In Eq (13), Δ is the operator of first difference. $lnGTFP$, $lnGF, lnETI, lnEPS, lnINDS,$ and $lnREN$ are variables of the examined model in logarithm form, and k is optimal for lags. $\lambda \mathrm{ECT_{t-1}}$ is the Error-correction term ($\mathrm{ECT_{t-1}}$), the finding of ECT must be negative and statistically significant to affirm the speed of adjustment from convergence to equilibrium. The present work uses advanced techniques to promote the cointegration level amid the selected variables.

6.3 Results and discussion

6.3.1 Descriptive, Unit root and cointegration estimations

The descriptive statistics for the G5 countries and GL5 countries is presented in Table (3). The outcomes show that the average values of GTFP for G5 economies is 0.74 and for GL5 is 0.65 whereas median for G5 is 0.75 and for GL5 is 0.81. The values indicate that although the GL5 countries are focusing on GTFP as close as G5. Moreover, for G5 group countries, green finance has mean value 2475753, and median value 1266231; ETI has mean value 9735.93 and median 6181; EPS has mean value 2.91 and median value 3.03 and industry has mean value 0.58 and median value 1.38. Additionally, for GL5 group countries, green finance has mean value 683445.4, and median value 243520.7; ETI has mean value 3743.74 and median 1741.87; EPS has mean value 3.03 and median value 3.03 and industrial structure has mean value 1.79 and median value 1.15. It means that GL5 are focused more on the environmental

policy stringency and industry as compared G5 economies to produce green total factor productivity. Besides, for G5 economies, REN has mean value 64414.08 and median value 38996, and for GL5 economies REN has mean value 15602.36 and median value 7109.4, suggesting that the G5 economies focus on renewable energy more as compared to GL5 economies to boost green total productivity as it is vital to meet the goal of carbon neutrality.

In addition, the outcomes of LLC, ADF, PP Unit root tests for both group economies are presented in Table 4. The outcomes of all three tests reveal that GTFP, GF, EPS and REN are stationary at the first difference for both group of economies. However, LLC test results for G5 group economies presents that ETI is stationary at level and ADF and PP results shows it is stationary at first difference. Likewise, the INDS is stationary at the level in all tests results for both groups. Hence, it can be concluded that there is mixed order I(0) and I(1) of stationary in the data. In addition to that, we used the Pedroni Residual Cointegration test as it extends the Engle-Granger two-step (residual-based) cointegration framework and produces the robust results as compared to Engle-Granger two step approach. The results for the cointegration test are depicted in Table 5. The outcomes evidenced that the existence of association in the long run among the variables of study.

Table 24 Descriptive Statistics

G5 Countries						
	GTPF	**GF**	**ETI**	**EPS**	**IND**	**REN**
Mean	0.74	2473753	9735.93	2.91	0.58	64414.08
Median	0.75	1266231	6181	3.03	1.38	38996
Maximum	1	15045588	31434	4.89	14.7	292949
Minimum	0.3	14.29	123	1.22	-15.29	2893
Std. Dev.	0.18	2964081	10087.93	0.85	4.15	60128.27
Skewness	-0.09	1.61	0.9	-0.27	-1	1.67
Kurtosis	2.23	5.47	2.47	2.63	7.07	5.73
Observations	105	105	105	105	105	105
GL5 Countries						
	GTPF	**GF**	**ETI**	**EP**	**IND**	**REN**
Mean	0.65	683445.4	3743.74	3.03	1.79	15602.36
Median	0.81	243520.7	1741.87	3.11	1.15	7109.4
Maximum	1	7543434	12239.02	4.89	74.39	55573.9
Minimum	0.05	241.99	467.74	1.17	-11.23	367.5
Std. Dev.	0.31	1257710	4008.74	0.85	8.28	15319.77
Skewness	-0.4	3.19	1.16	-0.24	6.54	0.72
Kurtosis	1.51	13.99	2.79	2.28	58	2.23
Observations	105	105	105	105	105	105

Note: GTFP stands green total factor productivity, GF stands for green finance, ETI stands for environmental technological innovation, EPS stands for environmental policy stringency, INDS stands for industrial structure and REN stands for renewable energy.

Table 25 Unit Root Test

G5 Countries				
Variable	**Unit Root Test**	**Levin, Lin & Chu**	**ADF**	**PP**
GTPF	**Level**	0.48	0.83	0.69
	1st Difference	0.00*	0.00*	0.00*
GF	**Level**	0.99	0.99	0.98
	1st Difference	0.00*	0.00*	0.00*
EPS	**Level**	0.99	1	1
	1st Difference	0.00*	0.00*	0.00*
IND	**Level**	0.00*	0.00*	0.00*
	1st Difference	-	-	-
ETI	**Level**	0.02**	0.27	0.76
	1st Difference	0.00*	0.00*	0.00*
REN	**Level**	0.63	0.93	0.94
	1st Difference	0.00*	0.00*	0.00*
GL5 Countries				
Variable	**Unit Root Test**	**Levin, Lin & Chu**	**ADF**	**PP**
GTPF	**Level**	0.41	0.73	0.78
	1st Difference	0.00*	0.00*	0.00*
GF	**Level**	0.93	0.99	0.98
	1st Difference	0.00*	0.00*	0.00*
EPS	**Level**	0.99	1	1
	1st Difference	0.00*	0.00*	0.00*
IND	**Level**	0.00*	0.00*	0.00*

	1st Difference	-	-	-
ETI	**Level**	0.82	0.99	1.00
	1st Difference	0.00*	0.00*	0.00*
REN	**Level**	0.55	0.99	0.92
	1st Difference	0.00*	0.00*	0.00*

Note 1: All statistics shows the P-Value. Note 2: Null hypothesis: Unit root. Note 3: *, **, and *** show the significance level at 1%, 5%, and 10%. Note 3: GTFP stands green total factor productivity, GF stands for green finance, ETI stands for environmental technological innovation, EPS stands for environmental policy stringency, INDS stands for industrial structure and REN stands for renewable energy.

Table 26 Pedroni Residual Cointegration Test

G5 Countries				
Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	**Prob.**	**Weighted Statistic**	**Prob.**
Panel v-Statistic	0.42	0.34	-0.98	0.83
Panel rho-Statistic	-1.16	0.12	-0.16	0.43
Panel PP-Statistic	-7.32	0.00*	-5	0.00*
Panel ADF-Statistic	-2.82	0.01*	-1.49	0.07***
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	**Prob.**		
Group rho-Statistic	-2.04	0.02**		
Group PP-Statistic	-6.56	0.00*		
Group ADF-Statistic	-1.48	0.08***		
GL5 Countries				
Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	**Prob.**	**Weighted Statistic**	**Prob.**
Panel v-Statistic	-0.13	0.55	0.03	0.48
Panel rho-Statistic	-0.58	0.28	-0.32	0.37
Panel PP-Statistic	-6.38	0.00*	-6.62	0.00*
Panel ADF-Statistic	-1.82	0.03*	-2.7	0.00*
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	**Prob.**		
Group rho-Statistic	-2.15	0.03*		
Group PP-Statistic	-8.33	0.00*		
Group ADF-Statistic	-2.52	0.01*		

Note: *, **, and *** show the significance level at 1%, 5%, and 10%.

6.3.2 Main Panel ARDL (PARDL) estimations

The outcomes of PARDL long and short run model are presented in Table 6. The outcomes reveal the positive coefficients (0.01) of GF with GTFP at 1% significance level for G5 economies in long run respectively. The 1% increase in the GF enhances the GTFP by 0.01% in case of G5 in long run. This suggests the direct effect of GF on GTPF. Besides, the association between GF and GTFP in GL5 is not significant. Moreover, surprisingly, in case on GL5 economies, we find significant but negative

coefficient (-0.01) of GF with GTFP in short run, may be due to limited data set. However, GF does not affect GTFP in case of G5 economies in short run. These results are in line with Lee & Lee, (2022), Liu et al., (2021), and Tong et al., (2022) who found positive link between GF and GTFP in China and Asian Region. They claim that green finance may foster a win-win scenario for the environment and the economy, encouraging green production and green economic growth. This implies that G5's government, stakeholder, environmentalist, and policymakers must focus on solving financial restraints. The environmentally friendly activities, demand a well-functioning green financing system such as investment decarbonization programs, geothermal and hydropower resources, and green hydrogen. The G5 economies are actively transitioning their oil and gas dependent economies to sustain their position to meet the SDG goals. In addition to that GL5 economies should focus on green investment and should reduce its dependency on the fossil fuel energy, like Denmark is the biggest European hydrocarbon producer, stopped awarding new oil and gas exploration licenses in December 2020 with the goal of ending fossil fuel-related enterprises by 2050 (British Broadcasting Corporation[17]). It is recommended to G5 and GL5 economies to be more inclined in participating green economy and green initiatives that can promote environmental balance and meet carbon neutrality objectives as described by SDG's and Paris Agreement.

Moreover, the PARDL outcomes in Table 6 disclose positive coefficients (0.08 and 0.08) of ETI with GTFP at 10% and 1% significance level in long run for G5 and GL5 economies respectively. The 1% increase in the ETI enhances the GTFP by 0.08% in

[17] BBC Denmark set to end all new oil and gas exploration - BBC News

both group of economies in long run. This suggests that the ETI boosts the GTPF. However, the scale of magnitude of ETI is same in case of G5 and GL5 economies. Additionally, in short run we found negative and insignificant coefficient (-0.02) of ETI with GTFP in case G5 economies, suggesting no relationship between ETI and GTFP. Whereas coefficient (0.06) of ETI with GTFP is significant at 1% in case of GL5 in short run. This suggest that the ETI has influence on the GTFP in GL5 only in short run. The outcomes are in line with Wang et al., (2022), Wang et al., (2020), and Zhou et al., (2019). Their results depict that innovated, improved, and efficient technologies are driving factors to green total factor productivity. Thus, ETI plays vital role to enhance the GTFP in the GL5 as compared to G5. For instance, according to GFI report (2021), US is major innovation hub with plenty of technology that can be deployed at home or to export for tackling climate change, but still there are challenges as US stimulus spending on energy infrastructure post-pandemic is still weighted toward fossil fuels and carbon-intensive industries and is second largest carbon emitter in the world. According to Vivid Economics,[18] nearly $100 billion in stimulus funds have been given to the aviation, transport, and shipping industries (without conditions for cleaning up). Therefore, the G5 economies are suggested to gear up business unites to invest in green R&D initiatives to promote green and carbon capturing technology innovation such as green hydrogen to foster GTFP and to obtain carbon neutrality.

[18] Vivid Economic, https://www.vivideconomics.com/wp-content/uploads/2020/04/2004249-Stimulus-Green-Index-summary-report.pdf

Table 27 Panel ARDL Results

G5 Countries		
Dependent Variable: GTPF	**Coefficient**	**Prob.**
Long-run (Pooled) Coefficients		
lnGF	0.01	0.01*
lnETI	0.08	0.00*
lnEPS	-0.01	0.15
lnINDS	-0.01	0.22
lnREN	0.01	0.05**
C	0.81	0.00*
Short-run (Mean-Group) Coefficients		
ECM (-1)	-0.66	0.01*
ΔGF	0.01	0.45
ΔETI	-0.02	0.32
ΔEPS	0.10	0.09***
ΔINDS	0.01	0.51
ΔREN	0.02	0.03**
GL5 Countries		
Dependent Variable: GTPF	**Coefficient**	**Prob.**
Long-run (Pooled) Coefficients		
lnGF	0.02	0.11
lnETI	0.08	0.07***
lnEPS	-0.05	0.00*
lnINDS	-0.01	0.01*
lnREN	0.05	0.14
C	0.97	0.00*
Short-run (Mean-Group) Coefficients		
ECM (-1)	-0.49	0.02*
ΔGF	-0.01	0.07***
ΔETI	0.06	0.09***
ΔEPS	0.03	0.39
ΔINDS	0.01	0.01*
ΔREN	-0.01	0.46

Note: *, **, and *** show the significance level at 1%, 5%, and 10%. Note 3: GTFP stands green total factor productivity, GF stands for green finance, ETI stands for environmental technological innovation, EPS stands for environmental policy stringency, INDS stands for industrial structure, REN stands for renewable energy and ECT stands for Error Correction term.

Additionally, Table 6 shows the negative coefficients (-0.01) of EPS with GTFP and insignificance, suggesting the no effect of EPS on GTFP in long run in the case of G5 economies. Besides, the relationship between ETI and GTFP is negative and significant, in the case of GL5 economies, as witnessed by coefficient (-0.05) significant at a 1 percent significance level. This suggests that the influence of EPS is

significantly inverse on GTFP in the case of GL5 economies. Moreover, in short run, we found positively significant coefficient (0.10) of EPS with GTFP at 10% significance level, signifying the direct association of EPS on GTFP in case of G5 economies. Whereas the link between EPS and GFTP not significant in case of GL5 economies. The outcomes are in line with (Xiaosheng Li et al., 2021; Li et al., 2021). The results validate the Porter's hypothesis in the short run only which suggests that in G5, the strict environmental policy can induce the efficiency and encourage innovations that help improve commercial competitiveness and stimulate the technology transmission process. This will benefit productivity of the countries and environmental quality. However, in long run, the restriction hypothesis is proved claiming that EPS raises production costs, reduces investment, and lowers social GTFP in case of GL5. The EPS may reduce the total factor productivity for the manufactures (Gray 1987), industry (Barbera & McConnell 1990), and firms (Boyd & McClelland 199) as it enhances restriction on capital investments. This is similar to the results obtained by Lanoie et al. (2011), Tang et al. (2020), and Hou et al. (2020). The result implies that G5 and GL5's current environmental policy stringency cannot lead to "win-win" situations, in which green economic development as well as environmental quality cannot be improved in long run. This means that the collaborative mechanisms of pollution control have not yet been established across the both group of economies. Furthermore, the ARDL outcomes disclose insignificantly negative coefficient (-0.01) of INDS with GTPF, in case of G5 economies in long run. This reveals that there is not significant association between INDS and GFTP. Whereas the coefficient of INDS (-0.01) is negative and significant with GTFP at 1% significance level, in long run, for

the GL5 economies. Additionally, in short run INDS does not show association with GTFP in case of G5 economies, whereas, in case of GL5, the results witnessed the significant positive coefficient (0.01) at 1% significance level. Hence, it can be concluded that our study provides the unique results of inverted U-shaped curve between INDS and GTFP for the GL5 economies. The outcomes are in line with (Lee & Lee, 2022; Song & Li, 2019) who revealed that green productivity is reduced by industrialization. This reveals that industry structures in GL5 are still dependent on fossil fuel energy sources and consumes more resources to produce more economic growth at the cost of environmental quality. Therefore, proportion of secondary industry restricts, rather than promotes the green TFP and win-win situation for economy and environment. Moreover, the increase in the proportion of industry in GL5 economies prevents green TFP growth when they intensely compete for industrial investment projects that causes pollution. Therefore, it is suggested to both group of economies to gear up the transition process of the industry structure from fossil fuel dependent energy sources to clean energy sources to promote green total factor productivity and environmental quality.

Moreover, the PARDL results in Table 6 reveal positive coefficients (0.01 and 0.97) of REN with GTFP at 5% and 1% significance level in long run for G5 and GL5 economies respectively. The 1% increase in the REN enhances the GTFP by 0.01% and 0.97% in case of G5 and GL5 economies in the long run, respectively. This suggests that the REN boosts the GTPF. However, the scale of magnitude of REN in GL5 is greater in case of GL5 compared to GL5 economies. This suggest that the REN has higher influence on the GTFP in GL5 as compared to G5 in long run. Additionally,

in short run we found positive and significant coefficient (0.02) of REN with GTFP at 5% significance level, in case G5 economies. Whereas coefficient (-0.01) of REN with GTFP is insignificant in case of GL5. These outcomes are in line with Taşkın et al. (2020), Apergis & Payne (2010), Inglesi-Lotz (2016) and Aydin (2019) who found that the REN enhances the green growth. Hence, our hypothesis is validated by the fact that the use of REN sources of energy may contribute to the promotion of sustainable economic development by reducing the rate of environmental deterioration. Our results as predicted that REN is vital component of GL5 economies as compared to the G5 economies. Therefore, the G5 nations must consider investing capital in the REN energy initiatives.

Furthermore, the table 6 shows the estimation of "Error Correction term" (ECT-1). As predicted the ECT-1 has negative and significant coefficient (-0.66) at 1% significance level, in the case of G5 economies. The same results haven obtained for GL5 economies, where the ECT-1 has negative and significant coefficient (-0.49) at 5% significance level. This suggest that GTFP is far away from its equilibrium level, and it adjust (convergence) by almost 66% in case of G5 economies and 49% in case of GL5 economies within the first year.

Table 28 ARDL robustness test results

Variable	Denmark		USA	
	Coefficient	**Prob.**	**Coefficient**	**Prob.**
Long-run Coefficients				
lnGF	0.01	0.09***	0.02	0.09***
lnETI	-0.05	0.23	0.35	0.09***
lnEPS	0.05	0.04**	0.01	0.25
lnINDS	-0.01	0.01*	-0.08	0.23
lnREN	0.08	0.23	0.01	0.01*
C	1.14	0.00*	0.79	0.00*
Short-run Coefficients				
ECM (-1)	-1.38	0.00*	-1.18	0.00*
ΔGF	0.01	0.06***	0.02	0.03**
ΔETI	-	-	-	-
ΔEPS	0.05	0.07**	0.03	0.09***
ΔINDS	0.01	0.24	0.01	0.02**
ΔREN	-	-	0.06	0.35

Note: *, **, and *** show the significance level at 1%, 5%, and 10%. Note 3: GTFP stands green total factor productivity, GF stands for green finance, ETI stands for environmental technological innovation, EPS stands for environmental policy stringency and INDS stands for industrial structure, and REN stands for renewable energy.

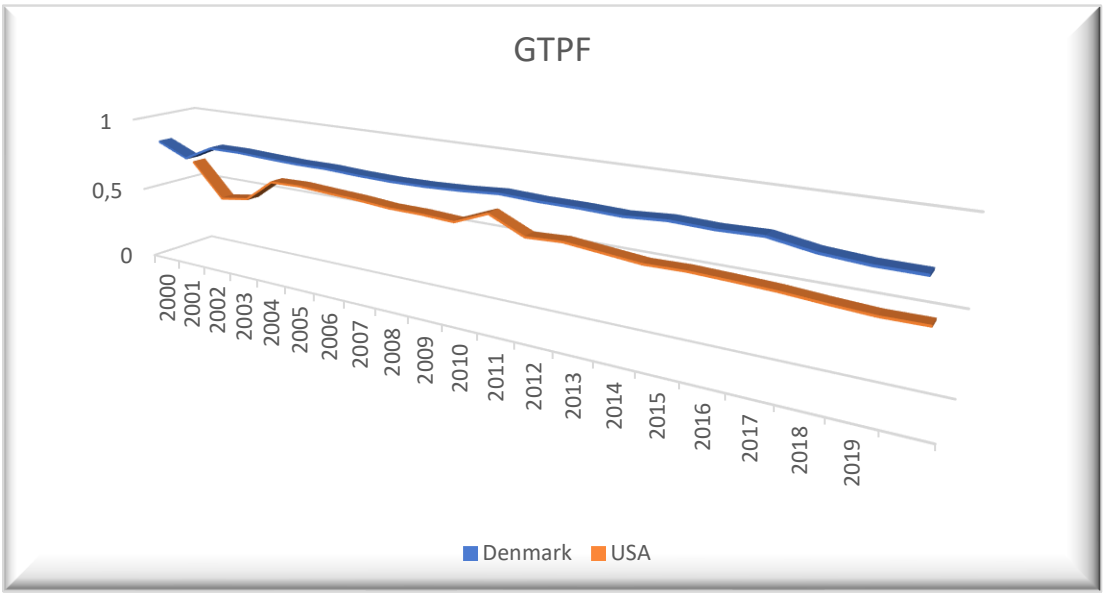


Figure 15 Comparison of green total factor productivity

6.3.3 Robustness estimation

For robustness check we employed ARDL estimation model using time series data. We pick Denmark from GL5 sample and USA from G5 economies sample. Among the GL5 economies, we chose Denmark because of its dedication and progress in establishing a low-carbon future. Similarly, we selected the United States as the biggest and most important economy in G5 and the globe, accounting for around 20% of global production. The closer look at the results in the Table 7 affirms the main estimation results from Panel ARDL results in Table 6. The positive coefficients 0.02 and 0.02 assure the linear link of GF and ETI with GTFP in long run for Denmark and USA respectively. This indicates that GF and ETI boosts the GTFP in the Denmark and USA. Moreover, the EPS reduces the GTFP in Denmark as it has negative association, but EPS enhances the same in the context of USA in the long run. In addition, the coefficient of REN is positive and significant for USA as compared to Denmark. This implies that USA invest more amount of funds to innovate and produce more renewable sources as compared to Denmark. Besides the ARDL outcomes in Table 7 depicts that INDS has negative and substantial effect on GTFP in Denmark in contrast to USA in long run. Therefore, industry structure needs transformation in Denmark. It must replace old, traditional, obsolete, environmental unfriendly infrastructure to innovate. This will surge the green productivity without harming the environment. Overall, graphical representation in Figure 1 affirms that Denmark being leader in the green index takes into account environmental balance components while increasing the productivity of country as compared to USA.

6.4 Conclusion and policy remarks

In light of the depletion of energy resources and the deterioration of the natural environment, the pursuit of sustainable development has evolved into a goal that is shared by all nations. Green total factor productivity (GTFP) is metric of green productivity that blends economic growth with environmental conservation. It is approach, tactic, and strategy to encourage environmentally responsible growth of economy and society. The key to long-term success is elucidating the role of green financing in promoting GTFP's growth. Therefore, we inspect the role of green finance, environmental technological innovation, environmental policy stringency, renewable energy, and industry structure in promoting green total factor productivity in G5 and GL5 economies.

Using Super SBM Model with desirable and undesirable outputs for measuring green total factor productivity metric and the Panel Autoregressive Distributed Lag (ARDL) Model to elucidate the short- and long-term link among the variables, our study evidence that green finance, environmental technological innovation, and renewable energy have positive and significant link with green total factor productivity. However, this linkage is stronger in GL5 economies as compared to G5 economies which suggest that green finance and renewable energy boosts green productivity more in GL5 than G5 economies. They are key drivers to mitigate environmental hazards.

On the other hand, we uncover the current environmental policy stringency and industry structure considerable inverse effect on green total factor productivity on both group of economies, i.e., G5 and GL5. These findings signify that current stringency to environmental policy and industrial structure reduce the green total factor

productivity as a whole. Therefore, the policy recommendations and their implementations in G5 and GL5 economies, based on the outcomes of this study, can further enhance the chances for both group economies to achieve green productivity and environmental quality in compliance with sustainable development goals (SDG's) and Paris agreement. With these major insights in hand, our study provides helpful recommendations and policy implications to policymakers and governments regulatory agencies, environmentalists, green investors, institutional investors, and portfolio managers to appreciate the study's findings, especially when considering green investment, technological innovation, the strictness of environmental policy, renewable energy, and industrial structure.

Our study provides four folded implications to G5 and GL5 environmental and sustainable development policy. First, the governments of G5 and GL5 need to put efforts on measures to improve their green finance strategy and rapidly build a comprehensive green financing infrastructure. Additionally, green finance promotional strategy should be developed as it will assist the business units to allocate the capital in green initiatives and to transform clean industry. This will lead support to the green productivity and stability and clean and friendly environment. Second, the environmental technological innovation should be encouraged at greater pace while investing major proportion of funds to R&D. G5 economies must learn from GL5 economies experiences, where R&D in clean technology is fuelling the GTFP (Lee & Lee, 2022). Therefore, the authorities should focus on technological innovation considering quality levels rather than limiting up production costs and boosting economy at the cost of environment. The management should put great emphasize to

link economy and sustainability to bolster green production and environment simultaneously. Third, the industrial restructuring and transformation from fossil fuel based to renewable and clean energy based is key driver to GTFP and green environment. Therefore, the governments of G5 and GL5 should put forth serious effort to encourage the expansion of green industry to attain the goal of boosting productivity while also bettering environmental performance. Fourth, the authorities should revisit the stringent environmental policies that would require businesses to green their operations, innovate with environmentally friendly technologies, and prioritize measures to reduce energy consumption and greenhouse gas emissions.

Finally, our work addresses a vacuum in the literature, on how green finance, environmental technological innovation, environmental policy stringency, renewable energy, and industry structure affect green total factor productivity. There are several queries which remained unresolved and should be specified, providing alternative avenues for future research. This research quantitively explore the linear association between the studied variable ignoring non-linear linkage. Moreover, to acquire a full picture of green total factor productivity and environment, it would be fascinating to investigate how green financing influences green total factor productivity under various market situations or countries while taking into account other factors such as financial development, economic growth, and natural resource. Additionally, Sustainable development incorporates all three realms of economic, environmental, and social sectors. Last, our focus remains on economic and environmental performance. However, to expand green productivity growth study, social impact might be considered in the future

CHAPTER 7

CONCLUSION AND POLICY RECOMMENDATIONS

7.1 Conclusion

Global apprehension around climate change is increasing. The desire to grasp the consequences on the environment and to take action has rapidly increased in recent years. In this regard, the banking sector has a significant opportunity to provide a solution in the form of environmentally friendly financial solutions and may fulfill the requirements of carbon-conscious enterprises in order to battle and protect our planet. The role of green finance is to “develop green industry mechanisms in areas including transportation, building, water preservation, clean energy production, storage, and distribution, which ultimately results in emissions and waste reduction, biodiversity habitat protection, and pollution control.”

In addition to that, green finance is an organized financial activity that has been developed to assure a better result for the environment. Green funding is an essential component in the achievement of a number of the “United Nations' Sustainable Development Goals.” In light of the depletion of energy resources and the deterioration of the natural environment, the pursuit of sustainable development has evolved into a goal that is shared by all nations. Green total factor productivity (GTFP) is metric of green productivity that blends economic growth with environmental conservation. It is approach, tactic, and strategy to encourage environmentally responsible growth of economy and society. The key to long-term success is elucidating the role of green financing in promoting GTFP's growth.

Despite its importance in combating climate change, green finance has a significant investment gap. Green financing is a feasible way to close the gap in green investment. In spite of the potential benefits of green finance in green renewable energy technologies, this topic has received little attention. Investment in green energy projects while injecting green funds draws attention since it eliminates the negative consequences of fossil fuels while also conserving the environment resulting the total green factor productivity. Based on the above facts, this study investigated the green finance role in four different cases and produced the conclusions and policy recommendations.

In case 1, this study utilizes the Non-Linear Autoregressive Distributed lag (NARDL) model to inspect an asymmetric effect of green finance and clean energy on the carbon emissions level in ASEAN economies for the time period spanning from 2000 to 2020. The outcomes revealed that the positive shocks in green finance, clean energy consumption, and foreign direct investment have a negative effect on carbon emissions in the long run. However, negative shocks in green finance, clean energy consumption, and foreign direct investment increase the level of carbon emissions in the long term, leading to a worse environmental quality in ASEAN economies. Moreover, economic growth and urbanization enhances the environmental quality in the long run. These results are affirmed by the ARDL model.

In case 2, this study employs the newly developed novel RALS co-integration test along with the Quantile Autoregressive Distributive Lag (QARDL) econometric modelling approach to address the long-run effects of antecedents on green finance across a range of quantiles. The existing literature has focused on traditional

approaches to variables other than green finance, which is the need of the hour in the climate change perspective. Therefore, using modern methodologies such as the RALS Unit root test, RALS co-integration test, and QARDL model on green financing distinguishes this work from existing work and contributes to the existing literature. A unique technique is applied to help policymakers create a solid foundation for policymaking in order to achieve sustainable development objectives by 2030. This research has shown how important it is for South Asian nations to set up programs to decrease the systemic risks that climate change entails and to stimulate the necessary funding to engage in green finance to lessen these risks and their effects.

The findings of QARDL disclose that BSD, EG, CEC, FDI, REM, INF, and TR significantly influence green finance investment in South Asia. In particular, BSD, ECE, REM, and TR are positively significant across the quantiles (q0.05 to q0.95), however, $CO_{2,}$ FDI, and EG have a significant and positive association with green finance except for q0.8, q0.9, and q.95, respectively. Therefore, the BSD, EG, FDI, REM, and TR are found as vivacious drivers and have impending attributes to attract and scale up the green finance investment to fight against climate hazards, keeping sustainable economic development in South Asian countries. On the flip side, as expected, INF has a significant negative effect on the explained facet of the study.

In case 3**,** applying newly developed the Quantile Autoregressive-Distributed Lag (QARDL) methodology and RALS cointegration approach in OECD-15 European countries for the period spanning from 1990-2020. The application of RALS cointegration approach and QARDL methodology distinguish this work form previous work to produce more reliable, meaningful and unbiased outcomes to policymakers to

develop strong policy framework to meet sustainable development goals by 2030. This methodology has demonstrated the necessity for the OECD-15 European countries to stablish initiatives to mitigate the systemic risks, climate change poses, and to catalyze the required funds to invest in green finance to reduce these risks and consequences.

The results obtained from the QARDL shows that lag of green finance, foreign direct investment, fixed capital formation, trade openness, and life expectancy (proxy for human capital) motivate investment in green financing whereas, carbon dioxide (CO_2) emissions and inflation have negative association with investment in green finance. However, remittances have insignificant association with variable of interest. Furthermore, certain antecedents would support OECD-15 European countries to access funds to invest in green finance and implement initiatives pertaining to mitigate climate change issues. Such as, the results depicts that the lag of green finance is important to OECD-15 European countries to fight this risk of climate change while investing in green financing and implementing green macroeconomic policies. Additionally, foreign direct investment is another vital driver of the investment in green finance. The OECD-15 European countries attracts foreign direct investment to invest in green renewable energy and it has become the yard stick to generate funds to investment in green finance.

In case 4, Using Super SBM Model with desirable and undesirable outputs for measuring green total factor productivity metric and the Panel Autoregressive Distributed Lag (ARDL) Model to elucidate the short- and long-term link among the variables, our study evidence that green finance, environmental technological

innovation, and renewable energy have positive and significant link with green total factor productivity. However, this linkage is stronger in GL5 economies as compared to G5 economies which suggest that green finance and renewable energy boosts green productivity more in GL5 than G5 economies. They are key drivers to mitigate environmental hazards.

On the other hand, we uncover the current environmental policy stringency and industry structure considerable inverse effect on green total factor productivity on both group of economies, i.e., G5 and GL5. These findings signify that current stringency to environmental policy and industrial structure reduce the green total factor productivity as a whole. Therefore, the policy recommendations and their implementations in G5 and GL5 economies, based on the outcomes of this study, can further enhance the chances for both group economies to achieve green productivity and environmental quality in compliance with sustainable development goals (SDG's) and Paris agreement. With these major insights in hand, our study provides helpful recommendations and policy implications to policymakers and governments regulatory agencies, environmentalists, green investors, institutional investors, and portfolio managers to appreciate the study's findings, especially when considering green investment, technological innovation, the strictness of environmental policy, renewable energy, and industrial structure.

7.1.1 Theoretical contribution

The empirical findings of the study contribute to the existing body of knowledge on green finance, total green factor productivity, and environmental quality in different ways.

Based on the concept of the Impact Investing Approach (Theory of Financial Social Entrepreneurship) our research is first to look at the association between green finance and environment case of South Asia, ASEAN, and OECD economies which is the prime contribution of our research in term of theoretical contribution. Previous researchers have focused on the Tragedy of the Commons (Ortmann & Veit, 2023; Stein, 2022), contingency theory (Dai et al., 2022), Environmental, Social, and Governance (ESG) Criteria (Qoyum et al., 2022). Our research findings add to the existing body of knowledge by taking the green finance investment as an explained factor that has been ignored before in general and in the case of South Asian, ASEAN, and OECD economies in particular.

Moreover, our research validated the Impact Investing theory which involves investing in companies and projects that have a positive social or environmental impact, as well as financial returns. Impact investors seek to support businesses that are working to solve environmental and social challenges, while also generating profit without harming the environment. Finally, our work addresses a vacuum in the literature on green economy theory, on how green finance, environmental technological innovation, environmental policy stringency, renewable energy, and industry structure affect green total factor productivity.

7.1.2 Methodological contributions

This research has used newly developed economic techniques such as RALS Unit root test, RALS co-integration test, NARDL, PARDL, and QARDL model on green financing distinguishes this work from existing work and contributes to a body of knowledge. Hence, econometrical models utilized can be employed in any new situation and new geographical location for validation purposes.

7.1.3 Practical implications

Green finance investments have become a yardstick to mitigate environmental effects on human lives; hence based on the results of this study, the following six major policy recommendations are suggested to attract and scale up green finance to escalate eco-friendly environment in South Asian economies selected for the study.

First, the South Asian economies must develop Green Central Banking Department (GCBD) to steer green transformation, which can actively contribute to a green financial system and economy. It will promote green credit and investment behaviour in the banking sector, along with exploring climate and environmental risks. Second, to develop a strong banking sector, central banks of South Asian countries must focus on policy areas, including micro and macro green prudential regulations, green credit allocation processes, and guidelines. Furthermore, Central banks must require adopting Environmental and Social Risk Management Standards (ESRMS), allow lower reserve rates for green portfolios, and develop climate stress testing (CST). Third, the government of studied countries must augment into account environmental factors while forming wider economic policy for sustainable economic growth, resultantly scaling up green finance initiatives. Fourth, it is recommended that studied

nations lower the trade barriers such as taxes and tariffs on international trade and adopt liberalization policies to attract green technology in the business units. Fifth, the South Asian economies should develop a strong financial and economic environment to encourage FDI and REM in the country to finance potential green initiatives. Finally, the Central Banks of South Asian countries must safeguard low and sustainable inflation by understanding theoretically and empirically price stability for luring green finance projects. It can be possible to develop monetary policy in accordance with the climate and environmental risks.

7.2 Policy recommendations

Based on the outcomes of the study in case 1, the primary and significant policy implication is that the green economy should implement durable long-term economic policies. Implementing a robust and enduring green financing strategy is crucial. By allocating substantial resources to green finance, we can ensure the sustainable development of energy conservation. The creation of the ASEAN nations' green finance policy framework was vital to establish a comprehensive industrial chain.

Green environmental policies and economic plans may be formulated using the following methods:

1. In order to address the investment gap and support the Sustainable Development Goals (SDGs) of ASEAN countries, it is essential to establish a robust legislative framework that facilitates the development of a green financial system. This system should include various green environmental financing instruments such as green investment, bonds, loans, securities, and

climate bonds. The objective is to attract green capital and promote the construction of climate-resilient infrastructure capable of withstanding future climate change-related shocks. By using financial tools to support green recovery initiatives, ASEAN nations may enhance their ability to attract sustainable, long-term investments and prepare their economies for a future that is both low-carbon and resilient to climate change.

2. An ASEAN-specific categorization system must be created to cater to the requirements of green financial products such bonds, loans, and securities. Prior to issuance, the overseeing third party must verify that the instruments meet the criteria for environmental sustainability and evaluate and scrutinize the ecological advantages of initiatives and projects funded by these instruments. Furthermore, a group of environmental experts well-versed in sustainable tools should thoroughly assess, monitor, evaluate, and document the distinct attributes of these expenditures made to bolster the eco-friendly enterprise.
3. There may be a need for enhancements in the rules, protocols, processes, and policies related to green loans. Specific clients should be chosen and provided with exclusive financing to enable them to get energy-efficient landscaping, greenhouses, and new energy vehicles in accordance with national building certification mandates.

Moreover, a second policy suggestion is to enhance the clean energy industry (including solar, biomass, nuclear, and wind) by infusing green financing capital. Consequently, this would lead to a gradual reduction in carbon emissions. The

progress of clean energy is now hindered by the higher cost per unit of renewable energy sources in comparison to non-clean energy sources like fossil fuels. Thus, the clean energy efforts need a substantial amount of green investment in the long run, particularly as shown below:

1. The banking sector should give green finance loans at cheap rates, and shortened credit application processing time may help the clean energy industry implement clean energy projects quickly. To deter fossil fuel investment, interest rates, taxes, and other debt policies must be raised.
2. Promote clean energy market significance. Green enterprises focusing on renewable energy should also expand significantly.
3. ASEAN states must minimize entrance barriers for national and international renewable energy enterprises by cutting review and approval processing fees, taxes, and security deposit amounts.

Based on the results of the case study 2, green finance investments have become a yardstick to lessen environmental consequences on human lives; six primary policy proposals are used to attract and scale up green finance to improve eco-friendliness in South Asian nations studied.

1. South Asian nations must establish a Green Central Banking Department (GCBD) to lead green transformation and promote a green financial system and economy. It will encourage green banking lending and investment and examine climate and environmental hazards.

2. To cultivate a robust banking industry, the central banks of South Asian nations should prioritize policy domains such as micro and macro green prudential laws, green credit allocation procedures, and guidelines. In addition, it is imperative for Central banks to mandate the implementation of Environmental and Social Risk Management Standards (ESRMS), permit reduced reserve rates for green portfolios, and establish climatic stress testing (CST).
3. The governments of the investigated nations should take environmental considerations into consideration while developing broader economic policies to achieve sustainable economic development, hence expanding green financing projects.
4. It is advisable for countries that are being examined to reduce trade obstacles, such as taxes and tariffs, on international commerce and implement liberalization policies to attract green technology to their commercial sectors.
5. The South Asian countries must cultivate a robust financial and economic milieu to promote Foreign Direct Investment (FDI) and Renewable Energy Market (REM) inside the nation, with the aim of funding prospective green ventures.
6. The Central Banks of South Asian nations should prioritize the preservation of low and sustainable inflation by comprehensively studying both the theoretical and empirical aspects of price stability. This is essential in order to attract green financing initiatives. Developing monetary policy that aligns with climatic and environmental threats is feasible.

Based on the outcomes of the case study 3, major result-oriented policies and implications for the OECD-15 European countries are as under:

1. The OECD urges European nations to collaborate in creating a conducive environment that promotes foreign direct investment for the expansion of green finance. These nations may implement policies such as tax incentives and regulations to facilitate foreign direct investment (FDI) inflows. The FDI influx should be contingent upon investment in renewable energy, technology, and research and development (R&D).
2. We recommend that OECD nations enhance remittance flows by incentivizing individuals with high levels of human capital to participate in clean projects in their home countries. It may be feasible to establish green banking infrastructure in accordance with the strategic directives of the central banks of the countries being examined. Additionally, this will provide industries and enterprises the chance to get a green loan for investing in environmentally friendly ventures, such as renewable energy projects.
3. The governments and authorized departments of OECD-15 European nations should actively support and facilitate the growth of the green bond market. They should also encourage non-corporate institutions, such as pension funds, to issue green bonds. For instance, one European country that may take this initiative is... In addition, it is essential for them to formulate laws pertaining to green finance investments, implement green taxes, and undertake activities to initiate green finance programs. These strategic measures will assist the

OCED countries in achieving their environmental goals within the specified timeframe.

4. Adherence to established standards, methods, and principles is necessary when investing in green finance efforts, including green bonds, to address and reduce the impact of climate change. This will provide absolute transparency, candidness, and comprehensive disclosure for investments in green finance efforts, as mentioned. Green bond procedures will facilitate investments in environmentally sustainable technology and research and development for companies in OECD countries.
5. The OECD countries should initiate greenhouse gas emissions awareness campaigns to educate the people of Europe about the advantages of environmental quality. Furthermore, it is essential to launch tree plantation campaigns and motivate the citizens of Europe to engage in extensive tree planting activities to maintain a healthy environment conducive to a healthy lifestyle.
6. • Policymakers in OECD nations should actively promote international trade by implementing trade liberalization policies. This is crucial since trade openness serves as a significant means to facilitate the transfer and dissemination of green technology and technical knowledge, while also fostering competitive advantage. It is essential for them to establish systems that facilitate investment in environmentally friendly energy projects by promoting trade openness.

Based on the outcomes of the case study 4, four folded implications to G5 and GL5 environmental and sustainable development policy.

1. G5 and GL5 governments must enhance their green finance strategy and develop a comprehensive infrastructure quickly. Developing a green financing promotional strategy would help business units invest in green projects and change clean industries. This will promote green production, stability, and a clean environment.
2. Environmental technology innovation should be accelerated while spending heavily in R&D. G5 countries must learn from GL5 economies, where clean technology R&D drives GTFP (Lee & Lee, 2022). Thus, authorities should prioritize technical innovation and quality over manufacturing costs and economic growth at the expense of the environment. Management should prioritize linking economics and sustainability to boost green production and the environment.
3. GTFP and the environment depend on industrial restructuring and transition from fossil fuels to renewable and sustainable energy. Thus, G5 and GL5 governments should actively promote green industry to increase productivity and environmental performance.
4. The government should reconsider strict environmental rules that oblige firms to green their operations, develop with green technology, and prioritize energy and greenhouse gas reduction.

7.3 Limitation and future direction

This study provides various limitations and future directions to potential researchers. In case of 1, Depending on data availability, future research may indicate the era before 2000. Green credit, green bond, and green insurance may be examined individually as green finance components to assess sustainable economic growth beyond ASEAN. Future study models may also include green innovation, R&D, and finance as separate antecedents owing to their mutual importance in alleviating environmental threats. Moreover, in case study 2, The study advises adding Fin-Tech, and R&D spending to the study model to get deeper insight into green finance investment in the area. Our analysis is further constrained by the lack of green finance data before 2000. Additionally, in case study 3, due to lack of data for additional OECD economies, our analysis is confined to OECD-15 European nations. Due to data unavailability, our analysis covers 1990–2020. We also estimated research results quantitatively. Future researchers can take all OECD countries to study the relationship between green finance investment and other antecedents like economic growth, technological innovation, financial market development, and globalization to enrich green finance literature. Theories, empirical applications, and policy consequences would improve. Future studies may combine quantitative and qualitative methodologies to enhance literature. Finally, in the case of study 4, several unanswered questions should be mentioned to open new study areas. This study quantifies the linear relationship between the variables, excluding non-linear linkage. To fully understand green total factor productivity and environment, it would be interesting to study how green financing affects productivity in different markets or countries while taking into

account other factors like financial development, economic growth, and natural resources. Sustainable development covers economic, environmental, and social areas. Our last priority is economic and environmental performance. In future green productivity growth studies, social effects may be included.

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24.10.2023

Dear Prof. Dr. Turgut Tursoy

Your project **"Does green finance matter for evnvironmental sustainability and develeopment"** has been evaluated. Since only secondary data will be used the project does not need to go through the ethics committee. You can start your research on the condition that you will use only secondary data.

Prof. Dr. Aşkın KİRAZ

The Coordinator of the Scientific Research Ethics Committee