

**T.C.
SAKARYA UNIVERSITY
INSTITUTION OF SOCIAL SCIENCES
DEPARTMENT OF ECONOMICS**

**ESSAYS ON CIRCULAR ECONOMY, SHADOW
ECONOMY, POLITICAL STABILITY**

Muhammad SALAH UDDIN

PHD THESIS

Thesis Supervisor: Prof. Dr. Ali KABASAKAL

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Department: Economics

“This thesis was defended face to face on 30/07/2025 and was unanimously accepted by the jury members whose names are listed below.”

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Muhammad SALAH UDDIN

30/07/2025

THE PREFACE

Beginning my PhD journey in Economics was a daunting challenge. At the outset, the path ahead felt uncertain, and making tangible progress seemed almost impossible. Yet, through resilience and the unwavering support of those around me, this dissertation has found its shape.

With the consistent guidance and support of my supervisor, Prof. Dr. Ali Kabasakal, I was able to navigate these obstacles and make steady progress toward completing my thesis. His insightful advice, encouragement, and belief in my abilities made even the most difficult stages manageable. I am also deeply grateful to the members of my jury, Prof. Dr. Mustafa Akal and Assoc. Prof. Dr. Murat Güven, for their thoughtful feedback, constructive suggestions, and consistent academic support. Their expertise greatly enriched the quality and depth of my work.

This journey would not have been possible without the love and dedication of my beloved parents, whose belief in me has been my greatest strength. They have celebrated every small achievement along the way and reminded me, time and again, of the value of perseverance.

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ABBREVIATIONS

SE	: Shadow Economy
IQ	: Institutional Quality
HICs	: High-Income Countries
UMICs	: Upper-Middle-Income Countries
LMICs	: Lower-Middle-Income Countries
LICs	: Low-Income Countries
NRRs	: Natural Resource Rents
NRR	: Natural Resource rent
CE	: Circular Economy
ENS	: Environmental Sustainability
SDGs	: Sustainable Development Goals
MMQR	: Method Of Moments Quantile Regression
MG	: Mean Group Estimation
AMG	: Augmented Mean Group Estimation
FMOLS	: Fully Modified Ordinary Least Square
CCR	: Canonical Cointegration Regression
PS	: Political Stability
FE	: Formal Economies

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ABSTRACT	
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The management of natural resource rents (NRRs) poses significant challenges to the economic development of a country. It can lead to a ‘resource blessing’ or, conversely, a ‘resource curse’ particularly in the presence of a shadow economy (SE), where economic activities are poorly regulated and/or unrecorded by the government. Consequently, institutional quality (IQ) critically influences the outcomes of an effective management of NRR on development trajectories. The value added of the first article is the investigation of the combined effects of NRR and IQ on SE across country groups globally. Main findings reveal how NRR contributes to lowering SE in high-income countries (HICs), upper-middle-income countries (UMICs), and lower-middle-income countries (LMICs). However, increases in NRR in low-income countries (LICs) lead to increases in SE, with and without the moderation of IQ, thus validating the ‘resource curse’ hypothesis. Additionally, with the moderation of IQ, NRR significantly reduces SE across countries, except for LMICs and LICs. In addition, Natural resource rent (NRR) is the center of our living and economic development, yet it poses significant environmental threats. Preventing environmental degradation is undoubtedly vital for sustainable development. The circular economy (CE) can resolve the dilemma at this critical juncture. Therefore, the second article aims to investigate the dynamics between natural resource rent (NRR), CE, and environmental sustainability (ENS) to identify effective pathways for achieving sustainable development. It establishes three fundamental pillars: (1) efficient use of NRR, (2) sustainable production and consumption through CE, and (3) securing ENS to achieve UN's Sustainable Development Goals -8, 12 & 13 (SDGs 8, 12 & 13). The research underscores a trinity solution, emphasizing the interplay between NRR, CE, and ENS for sustainable development. The findings demonstrate that while direct extraction of NRR harms ENS, integrating NRR into CE practices significantly mitigates these adverse effects and promotes ENS. Our research provides valuable insights for policymakers and recommends the 'active' economic policy to achieve sustainable development through enhancing ENS. Furthermore, Political stability (PS) is a cornerstone of economic development, yet the role of the shadow economy (SE) in determining PS remains unexplored in literature. The third article addresses this significant gap by examining how shadow and formal economies (FE) influence PS across 124 countries from 1996 to 2018. The findings reveal that while the SE significantly undermines PS, the FE plays a vital role in enhancing PS. These results offer valuable insights for policymakers, emphasizing the importance of minimizing SE activities as a means to ensure PS and promote sustainable economic development.	
Keywords: Circular Economy, Environmental Sustainability, Natural Resources, Sustainable Development, Shadow Economy	

ÖZET	
Başlık: Döngüsel Ekonomi, Gölge Ekonomi, Dış Borç Üzerine Makaleler	
Yazar: Muhammad SALAH UDDIN	
Danışman: Prof. Dr. Ali KABASAKAL	
Kabul Tarihi: 30/07/2025	Sayfa Sayısı: x (ön kısım) + 112 (ana kısım)
Doğal kaynak rantlarının (NRR) yönetimi, bir ülkenin ekonomik kalkınması açısından önemli zorluklar teşkil etmektedir. Bu, özellikle ekonomik faaliyetlerin kötü düzenlendiği ve/veya hükümet tarafından kaydedilmediği bir gölge ekonomi (SE) varlığında, ‘kaynak nimetleri’ ya da tersine ‘kaynak laneti’ne yol açabilir. Sonuç olarak, kurumsal kalite (IQ), NRR'nin kalkınma süreçleri üzerindeki etkili yönetiminin sonuçlarını kritik bir şekilde etkiler. İlk makalenin katma değeri, NRR ve IQ'nun dünya çapında ülke gruplarındaki SE üzerindeki birleşik etkilerini araştırmaktır. Temel bulgular, NRR'nin yüksek gelirli ülkelerde (HICs), üst-orta gelirli ülkelerde (UMICs) ve alt-orta gelirli ülkelerde (LMICs) SE'yi nasıl azalttığını göstermektedir. Ancak, düşük gelirli ülkelerde (LICs) NRR'deki artışlar, IQ'nun moderasyonu ile ya da olmadan, SE'nin artmasına yol açmakta ve bu da ‘kaynak laneti’ hipotezini doğrulamaktadır. Ayrıca, IQ'nun moderasyonu ile, NRR tüm ülkelerde, LMIC'ler ve LIC'ler hariç, SE'yi önemli ölçüde azaltmaktadır. Ayrıca, Doğal Sermaye Stoku (NRR), yaşamımızın ve ekonomik kalkınmamızın merkezinde yer alırken, aynı zamanda önemli çevresel tehditler oluşturmaktadır. Çevresel bozulmayı önlemek, sürdürülebilir kalkınma için kuşkusuz hayati öneme sahiptir. Döngüsel ekonomi (CE), bu kritik dönemdeki ikilemi çözebilir. Bu nedenle, ikinci makale, doğal sermaye stoku (NRR), CE ve çevresel sürdürülebilirlik (ENS) arasındaki dinamikleri incelemeyi ve sürdürülebilir kalkınmayı sağlamak için etkili yolları belirlemeyi amaçlamaktadır. Üç temel sütun oluşturur: (1) NRR'nin verimli kullanımı, (2) CE aracılığıyla sürdürülebilir üretim ve tüketim, ve (3) ENS'yi güvence altına alarak BM'nin Sürdürülebilir Kalkınma Hedefleri - 8, 12 ve 13 (SDG'ler 8, 12 & 13) doğrultusunda sürdürülebilir kalkınmayı sağlamak. Araştırma, sürdürülebilir kalkınma için NRR, CE ve ENS arasındaki etkileşimi vurgulayan bir üçlü çözümü önermektedir. Bulgular, doğrudan NRR'nin çıkarılmasının ENS'yi olumsuz etkileyebileceğini, ancak NRR'nin CE uygulamaları ile entegrasyonunun bu olumsuz etkileri önemli ölçüde azalttığını ve ENS'yi desteklediğini göstermektedir. Araştırmamız, politika yapıcılar için değerli içgörüler sunmakta ve ENS'nin artırılması yoluyla sürdürülebilir kalkınmaya ulaşmak için ‘aktif’ ekonomik politika önerilerinde bulunmaktadır. Ayrıca, Siyasi istikrar (PS), ekonomik kalkınmanın temel taşlarından biridir, ancak gölge ekonominin (SE) PS'yi belirlemedeki rolü literatürde keşfedilmemiştir. Üçüncü makale, bu önemli boşluğu, 1996-2018 yılları arasında 124 ülke üzerinden, informal ve formal ekonomilerin (FE) PS üzerindeki etkilerini inceleyerek doldurmaktadır. Bulgular, SE'nin PS'yi önemli ölçüde zayıflattığını, ancak FE'nin PS'yi artırmada önemli bir rol oynadığını göstermektedir. Bu sonuçlar, politika yapıcılar için değerli içgörüler sunarak, PS'yi sağlamak ve sürdürülebilir ekonomik kalkınmayı teşvik etmek amacıyla SE faaliyetlerinin en aza indirilmesinin önemini vurgulamaktadır.	
Anahtar Kelimeler: Döngüsel Ekonomi, Çevresel Sürdürülebilirlik, Doğal Kaynaklar, Sürdürülebilir Kalkınma, Gölge Ekonomi	

INTRODUCTION

Natural Resources, Shadow Economy, and Institutional Quality

Natural Resource Rent (NRR) plays a crucial role as a driver of economic development. While NRR is of significant importance to the formal economy, it can often hinder economic growth by promoting the growth of the shadow economy (SE). Given the critical role of NRR in shaping economic outcomes, the first article of this study aims to investigate how NRR, with the moderation of institutional quality (IQ), influences the dynamics of the shadow economy. The Natural Resource Rent (NRR) encompasses revenues from resources like oil, minerals, timber, and gas (Ishak & Farzan Egan, 2020). Classical economists have long viewed these resources as beneficial to countries endowed with them, such as the USA and China (Singh et al., 2023) or middle-income countries (Topcu et al., 2020). In contrast, the ‘resource curse’ theory challenges this optimistic view, highlighting how heavy reliance on NRR can divert labour and capital away from potentially stable sectors, a phenomenon known as the ‘Dutch Disease’ (Corden & Neary, 1982). The instability and volatility of NRR also hinder economic progress (Auty, 2001), and governance issues such as corruption and mismanagement can exacerbate these impacts by negatively affecting economic growth (Robinson et al., 2006). Moreover, NRR, particularly from oil, gas, and coal, tend to reduce net savings in countries with weak institutional quality (IQ). Similarly, weak political institutions may hinder the effective of fiscal capacity of a country when substituting taxes with NRR revenues (Masi et al., 2024). IQ plays a critical role in determining the effects of NRR on the economy. It reflects the effectiveness of government control of corruption and adherence to the rule of law (Dreher & Schneider, 2010). High-quality institutions generally reduce transaction costs and uncertainties through transparent and consistent rules (Acemoglu et al., 2001), promoting economic growth by fostering market efficiency, controlling corruption and transaction costs (Murphy et al., 1991), and increasing transparency and fairness (La Porta et al., 1997; Andreula et al., 2009; Dai et al., 2015; Vijge et al., 2019).

Research Objective

This study delves into the interplay between IQ, NRR, and the shadow economy (SE). The latter encompasses all economic activities that are unregulated and unrecorded by the

government (Lippert & Walker, 1997). Known variously as the shadow, alternative, cash, hidden, invisible, black, secondary, underground, or undocumented economy, SE involves activities that evade documentation and taxation (Leonard, 1998; Losby et al., 2002; Wiegand, 1992).

Research Questions

Given the actual debate on the impact of NRR and IQ on SE, the present study focuses on the following research questions:

1. What is the role of IQ on SE?
2. How does NRR influence SE?
3. Does NRR differ in its impact on SE across country groups?
4. Considering the moderation of IQ, how does NRR affect SE?

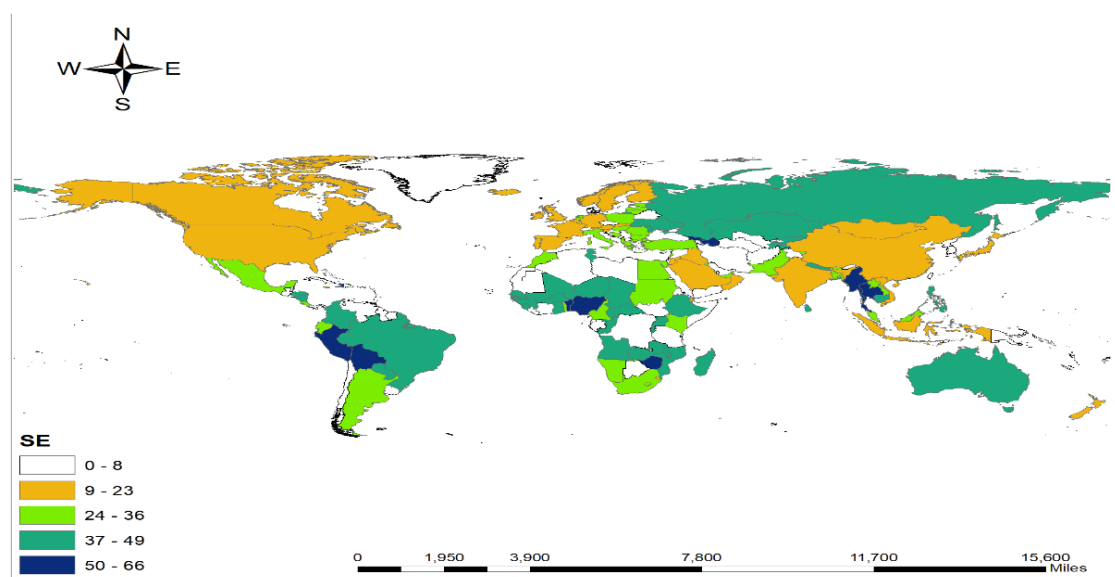
Despite a few studies examining the impact of NRR on SE, there is limited focus on the combined effects of NRR and IQ on SE across country groups at a global level such as high-income countries (HICs), upper-middle-income countries (UMICs), lower-middle-income countries (LMICs), and low-income countries (LICs). This is what the present study aims to do.

Map 1 presents the countries included in the study, alongside a map (Map 2) illustrating the percentage of SE activities across the sampled countries.



Map 1: List of Countries Used in the Study

Source: Created by the author.



Map 2: Country-wise SE

Source: Created by the author.

Research Method

Focusing on a global scale, this research aims to fill the literature gap using the Method of Moments Quantile Regression (MMQR), which offers advantages in handling individual effects and conditional heterogeneous covariance effects over other methodologies like Generalized Method of Moments (GMM), Bayesian Model Averaging (BMA), Autoregressive Distributed Lag Stationarity (ARDL) model, Dynamic Ordinary Least Squares (DOLS) model, and Fully Modified Ordinary Least Squares (FMOLS) used in prior studies (Baklouti & Boujelbene, 2020; S. Khan & Rehman, 2022; Nguyen, 2022; Pham Tran, 2022; Tran et al., 2022; Zhanabekov, 2022).

Natural Resources Rent, Circular Economy, And Environmental Sustainability

In the first part of the study, the thesis aims to investigate how natural resource rents (NRR) with moderation of institutional quality (IQ) determine the shadow economy (SE). In the second part of the study, it focuses on the nexus of NRR, circular economy (CE), and environmental sustainability (ENV). The ongoing economic development has led to significant environmental degradation, damaging biodiversity and contributing to climate change. Rapid production and linear economic growth often fail to provide sustainable environmental benefits (Zhao et al., 2023). This issue is a critical concern not only in

emerging countries but also in developed nations. While economic activities boost the economy, they must also protect biodiversity and environmental quality by reducing carbon dioxide (CO₂) emissions. Greenhouse gases, particularly CO₂ emissions, are considered one of the most dangerous threats to environmental health and climate change (Shukla et al., 2022). Natural resource rents (NRR) has a substantial role in increasing carbon emissions (Balsalobre-Lorente et al., 2021; Fan et al., 2022; J. Li et al., 2023). In this context, the current study investigates the impact of NRR on environmental sustainability (ENS). Additionally, it examines whether the integration of Circular Economy (CE) practices influences the relationship between NRR and ENS, providing insights into how these elements interact and impact sustainable development.

Research Objective

Despite visible actions and policies adopted to address environmental issues, extracting natural resources remains a primary cause of environmental pollution (Danish et al., 2019). Natural resource rents (NRR) plays a dual role: it is essential for economic growth and stability, yet its extraction poses significant environmental risks. The excessive use of energy resources exacerbates carbon emissions and the ecological footprint in pursuing economic growth (Hassan et al., 2019; Zhang et al., 2022). Economies prioritizing revenue maximization from natural resource extraction often face inefficiencies in governance, impeding sustainable industrialization and modernization (Auty, 2001; Isham et al., 2005). However, when revenues from natural resources are directed toward sustainable and renewable sectors, the outcomes can be notably different (Ullah et al., 2021). Thus, the approach to utilizing natural resources must incorporate a focus on enhancing environmental quality.

To address environmental challenges, the circular economy (CE) has emerged as an effective tool for ensuring environmental sustainability (ENS). British economists D. Pearce and R. K. Turner defined CE as a resource-recycling model for economic development (Tiossi et al., 2019). In Germany, the Waste Management Act of 1996 introduced the 3R principles of CE: "reduce, reuse, and recycle." Building on these principles, Potting et al. (2017) expanded the concept to a 9R-based CE, adding "Refuse, Rethink, Repair, Refurbish, Remanufacture, Repurpose, and Recover." The adoption of CE practices has positive effects on environmental quality across various sectors,

including agriculture (Han et al., 2006), industry (Ma et al., 2014), waste recycling (Guran, 2019), and forestry (Pakarinen et al., 2010). The CE improves environmental quality, economic freedom, and social justice for current and future generations (Kirchherr et al., 2017).

In the European Union (EU) countries, over 75% of greenhouse gas (GHG) emissions are attributed to consumption and fossil fuel-based energy production (Eurostat, 2022). Addressing these challenges has become a top priority, with EU member states adopting policies to reduce CO₂ emissions. However, achieving climate neutrality by 2050 remains a distant goal, emphasizing the need for intensified efforts highlighting the importance of this study's focus on the EU. The pragmatic sustainability model, rooted in altruism, provides clear pathways for balancing economic, social, and environmental goals (D'Adamo et al., 2024). This model assists EU countries in advancing their Sustainable Development Goals (SDGs). The United Nations (UN) introduced 17 Sustainable Development Goals (SDGs) in response to the complex challenges. Among these, SDG-12 focuses on enhancing environmental sustainability (ENS) by implementing a circular economy (CE) framework through sustainable production and consumption (Balsalobre-Lorente & Shah, 2024). By addressing carbon emissions and environmental issues, ENS tackles climate change, which will facilitate the achievement of SDG 13. Additionally, SDG-8, which focuses on "Decent work and Economic Growth," promotes the adoption of the cutting-age technology to maximize the usage of raw materials while minimizing their extraction (Dantas et al., 2021). In this context, CE practices play a significant role in advancing SDG 8 (Garcia-Saravia Ortiz-de-Montellano et al., 2023; Karamustafa et al., 2024; Schroeder et al., 2019), as well as contributing to the achievement of SDGs 12 and 13.

Research Importance

This study suggests three key policy areas for achieving sustainable development: (i) the efficient use of natural resources in green sectors, (ii) promoting sustainable production and consumption through circular economy (CE) practices, and (iii) reducing CO₂ emissions to achieve net-zero emissions and ensure environmental sustainability (ENS). The primary aim of this study is to identify practical pathways for advancing sustainable development (SD). While existing research has explored these concepts, it has not fully

addressed these areas' specific challenges and opportunities. This study focuses on these gaps, offering feasible and actionable pathways to ensure sustainable development, particularly in achieving environmental sustainability.

Research Findings

Our findings suggest that, in general, NRR exacerbates ENS in EU countries. However, the intervention of CE can mitigate the negative effects of NRR. Notably, NRR contributes positively to the enhancement of CE practices. To ensure sustainable development, the study demonstrates that CE significantly improves biocapacity (BIC) while simultaneously reducing the ecological footprint (EFP). In conclusion, the research highlights that CE practices, when applied collectively, improve overall ENS, providing solid evidence that CE is a crucial mechanism for advancing environmental sustainability.

Research Contributions

This study makes several significant contributions to existing literature. It is the first kind of study analyzing the dynamic between NRR, CE, and ENS. Secondly, unlike previous studies that primarily focused on carbon emissions (Wang et al., 2024), greenhouse gas emissions (Meys et al., 2020), or ecological footprints (Ullah et al., 2021; Hassan et al. (2019); Zhang et al., 2022), this study introduces new metrics for ENS. It provides comprehensive analysis by incorporating ecological footprint (EFP), biocapacity (BIC), and overall ENS. Thirdly, the study contributes to counterbalance of negative consequences of NRR by introducing CE.

Research Method

This research employs an advanced econometric technique- the Method of Moments Quantile Regression (MMQR)- to analyze distributional heterogeneity and provide empirical evidence by integrating fixed effects (Machado & Santos Silva, 2019). MMQR offers advantages over traditional methods, allowing for heterogeneous effects across various conditional quantiles. Additionally, in the presence of outliers, using conditional quantiles provides a robust approach to addressing these issues (Koenker, 2004). The study further supports its findings by applying other robust methods, including mean group estimation (MG), augmented mean group estimation (AMG), fully modified

ordinary least squares (FMOLS), and Canonical Cointegration Regression (CCR). This study suggests dual policy implications: a passive policy focused on CO₂ emissions targets, waste management, and recycling under CE practices and an active policy advocating for emissions reduction through the strategic use of natural resources. The insights provided herein aim to guide future research and policy formation, presenting robust strategies for integrating CE and NRR to achieve ENS. Subsequent sections of this study will cover the literature review, data and methodology, result analysis, and robustness of the results.

Shadow Economy and Political Stability

In the third part, the thesis addresses how shadow economy (SE) or shadow economy (SE) determines political stability (PS). Political stability is a fundamental prerequisite for sustainable economic development, promoting a predictable environment for investment, trade, and social progress (Aisen & Veiga, 2013). It enables governments to implement effective policies, pursue long-term development plans, maintain public order, and foster trust—all of which are essential for economic resilience and growth (Hurwitz, 1973). Moreover, PS is crucial for attracting both domestic and international investors, which is important for a nation's economic growth (Kim, H. (2010). However, the path to achieving and maintaining PS is complex, influenced by various economic factors, including the roles of FE, SE, and the strength of regulatory institutions. This raises an interesting question: how do these elements interact to shape PS?

The FE and SE, regulatory quality (RQ), and PS are interconnected in complex ways. The FE supports PS by generating government revenue essential for public services and maintaining social order. This revenue stream enhances state legitimacy and enables the provision of essential services, reinforcing social cohesion and economic predictability. (Daniels, 2004). Theoretical models, such as those proposed by Laffer (1971), suggest that an efficiently regulated FE can stabilize the macroeconomic environment, reducing susceptibility to external shocks and promoting long-term resilience, which contributes to PS. In contrast, the SE, while often providing essential services and employment opportunities, particularly in low-income regions, operates outside of state regulation, depriving government revenue and diminishing their capacity to enforce laws (Elgin, 2015). Thus, the SE can function as both a buffer for economic hardship and a challenge

to state authority, complicating efforts to achieve sustainable political stability (La Porta & Shleifer, 2008) and a higher trend in PS. Figure 1 explains the relationship between PS and SE.

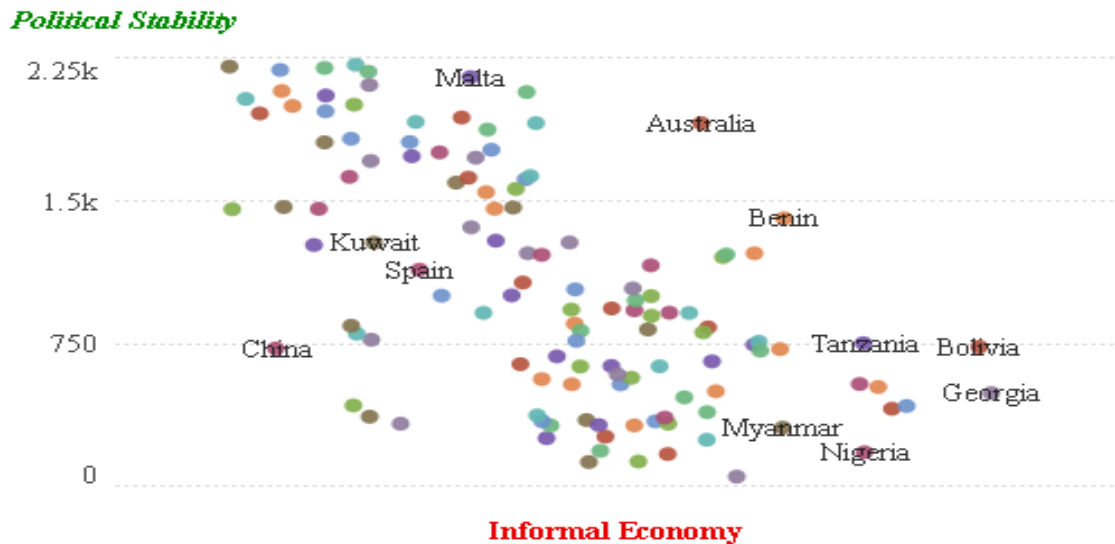


Figure 1: Nexus between SE (Informal Economy = Shadow Economy) and PS

Source: Created by the author.

Though PS is highly desirable for any nation, political instability persists in many countries today. While the FE influences PS by directly contributing to government revenues, the effects of the SE on PS are complex and context dependent. In many countries, informal employment constitutes a substantial share of the non-agricultural labor force, with estimates indicating it accounts for over half of employment in developing nation (Chen, M.A., 2012). While this sector can provide essential livelihood options for those excluded from the formal labor market, its growth may reveal weaknesses in state regulatory institutions, which, in turn, affect PS (Arvin-Rad et al., 2010). In countries with limited RQ, the SE often emerges in response to overly restrictive or poorly enforced regulations, undermining the legitimacy of formal institutions and weakening the government's ability to enforce laws consistently and maintain PS (Feige, 1990; Kloosterman et al., 1999). Additionally, government regulation, which serves to stabilize and direct economic activities, faces unique challenges when a significant share of economic activity occurs outside its purview. This interaction makes it essential to study the comprehensive effects of both FE and SE on political PS to discern their individual impacts and adopt targeted policies.

Research Findings

Using data spanning 1996 to 2018 for 124 countries, this study investigates the dynamic relationship between the FE, SE and PS, emphasizing heterogeneous effects across income groups. The findings reveal that a growing SE significantly undermines PS, particularly in high-income nations, where its impacts are consistently negative across all quantiles. In contrast, higher middle-income countries demonstrate a paradoxical positive effect of SE on PS at higher quantiles, suggesting a complex interplay where SE can support economic resilience under certain conditions. Conversely, low and lower-middle-income countries show minimal effects of SE on PS, reflecting varying institutional and economic structures. FE, driven by improved governance and efficiency, emerges as a stabilizing force, positively influencing PS across all contexts. RQ plays a moderating role, with robust frameworks significantly mitigating the adverse effects of SE on PS, particularly in high-income settings. However, the effects of RQ are less pronounced in low-income countries, underscoring the need for tailored policy interventions to strengthen institutional resilience.

Research Importance

While PS is crucial for reducing conflict and promoting sustainable development (Aisen & Veiga, 2013; Feng, 1997; Goldstone et al., 2010), there remains a potential research gap regarding how economic factors affect it. Substantial research has explored links between PS and economic factors such as the FE and SE, income inequality, tax evasion, and policy volatility (Ali, 2001; Fatás & Mihov, 2013; Henisz, 2004; Khan et al., 2023; Mutascu et al., 2012; Nel, 2003; Tiwari, 2013; Ugur et al., 2022). However, most of these studies focus on isolated effects, often examining specific aspects like the SE in certain regions or the impact of regulatory policies in high-income countries (Alesina & Perotti, 1996; Mazhar & Jafri, 2017). For instance, Mazhar and Jafri (2017) highlight the importance of the SE in influencing political dynamics, particularly in contexts where inflation and tax evasion are prevalent. Hammer (2019) argues that SE play a critical role in emerging markets, where formal regulation alone may be insufficient for stability. Similarly, Margolis (2010) suggests that PS depends on alignment between formal and shadow institutions, with larger 'gaps' between these sectors potentially heightening instability. Consequently, much of the existing literature lacks a comprehensive global

perspective that incorporates both shadow and formal economic activities across diverse income groups.

Research Objectives

To address these gaps, this paper aims to study three primary objectives. First, it investigates the global impact of FE and SE on PS, with a focus on their interaction with RQ. Second, it employs the innovative Method of Moments Quantile Regression (MMQR) approach to capture heterogeneous effects across income groups, offering a nuanced understanding beyond traditional methods. Third, it evaluates the moderating role of RQ in shaping the relationship between SE and PS, particularly across high, middle, and low-income countries. By achieving these objectives, this study seeks to provide actionable insights for policymakers, enabling them to design targeted strategies that enhance PS while fostering sustainable economic development.

Research Contributions

The findings of this study make significant contributions to the existing literature by providing a comprehensive global analysis of the impact of FE and SE on PS—a critical determinant of sustainable development. First, to the best of our knowledge, this study is among the first to integrate these dimensions and examine their global impact using the innovative Method of Moments Quantile Regression (MMQR) approach. Second, the analysis underscores the importance of policies that effectively manage both FE and SE activities to enhance PS without hindering economic growth. Third, the study's global scale ensures its implications are relevant across diverse regions, offering valuable guidance to international organizations and policymakers in balancing economic growth and PS across varied contexts. Fourth, the results emphasize the pivotal role of RQ as a moderating factor, particularly in mitigating the destabilizing effects of SE in high-income countries. Finally, by highlighting the dual roles of FE and SE alongside RQ, the study provides critical insights for designing balanced economic policies that address the unique contributions and challenges posed by each sector.

1. CHAPTER: THEORETICAL BACKGROUND

1.1. THE CONCEPTUAL FRAMEWORK OF NRR, IQ, AND SE

To understand the nexus of natural resources rent (NRR), institutional quality (IQ), and shadow economy (SE), the study presents the conceptual networks among them. The role of institutional quality (IQ) is fundamental to understanding economic development. North's (1990) new institutional economic theory highlights the significance of institutions in determining a country's economic trajectory. Higher institutional quality tends to suppress rent-seeking behavior and, in turn, contributes to increased income levels (Kandil, 2009; Kim Thi Tran et al., 2021; Nguyen et al., 2018; Saima Nawaz et al., 2023; Valeriani et al., 2011). Specifically, institutions that maintain the rule of law facilitate sustained economic growth (Butkiewicz & Yanikkaya, 2006). Moreover, effective governance enhances organizational efficiency and supports development (Sánchez et al., 2013). Conversely, weak institutions create space for rent-seeking, thereby undermining growth prospects. The quality of institutions also influences individuals' participation in the formal versus informal (shadow) economy. Institutional incentives and constraints affect these choices (Kırşanlı, 2024). Weak institutional frameworks may encourage informality, whereas strong institutions can reduce shadow economic engagement by adopting tax morale and enforcing legal norms (Dang et al., 2022; Torgler & Schneider, 2009).

Governance theory further argues that political and institutional embeddedness are essential for effective governance (Dellepiane, 2010). This perspective emphasizes institutional endogeneity and distributive characteristics that extend beyond property rights to encompass broader governance and developmental outcomes. Governance, in this context, plays a central role in the institutional framework, encompassing regulatory structures in both public and private sectors, as well as the coordination of networks and hierarchies (Mayntz, 2004). Thus, strong public administration and sound institutions are critical in reducing SE, while administrative weaknesses tend to exacerbate them (Bayar, 2016). Transaction cost theory, as introduced by Williamson (1981), explains how complex regulations and high taxation encourage individuals to avoid the formal economy, thereby encouraging SE. This theory suggests that burdensome regulations and high taxation incentivize economic actors to circumvent the formal sector. Shadow

practices, in this context, emerge as mechanisms to reduce transaction costs and improve operational efficiency. Excessive regulation, in particular, creates a ground for informality (Bezverkhyy, 2020), while weak institutions further aggravate informal activity (Schneider & Buehn, 2018). Thus, transaction cost theory elucidates the interplay between institutional quality, regulatory burden, and SE activity.

The relationship between natural resource rents (NRR) and informal economic activity can be understood through the concepts of the resource curse and resource blessing hypotheses. Sachs and Warner (1995) introduced the resource curse theory to explain why resource-abundant nations often fail to achieve sustained development. They argue that high levels of corruption, weak institutions, and resource mismanagement hinder development. A lack of accountability in government institutions promotes corruption, rent-seeking, and clientelism, leading to poor economic performance (Narh, 2025). Consequently, resource abundance tends to drive shadow economic activities. Similarly, Van der Ploeg (2011) contributes the concept of resource bonanza, arguing that resource windfalls can lead to currency appreciation, economic deindustrialization, weak rule of law, and governance failure. In some cases, natural resource sectors exacerbate inequality, promote corruption, and diminish social trust (Le Billon, 2014). In the absence of democratic governance and civil liberties, resource bonanzas may transform into resource curses (Bulte & Damania, 2008). Weak institutions rooted in rent-seeking behavior further encourage informality (Krueger, 1974; Wiens, 2014). The interaction between IQ and NRR can either strengthen or undermine economic outcomes, contingent on the nature of governance structures. Acemoglu and Robinson (2012) distinguish between inclusive and extractive institutions. Inclusive institutions promote equitable growth and participation, while extractive institutions concentrate power and wealth, thereby increasing informality and inequality (Korstanje, 2015).

In summary, theories such as the resource curse (Sachs & Warner, 1995), inclusive versus extractive institutions (Acemoglu & Robinson, 2012), governance theory (Dellepiane, 2010), and new institutional economic theory (North, 1990) provide a multidimensional framework to analyze how institutional quality and resource dependence influence the prevalence of the SE.

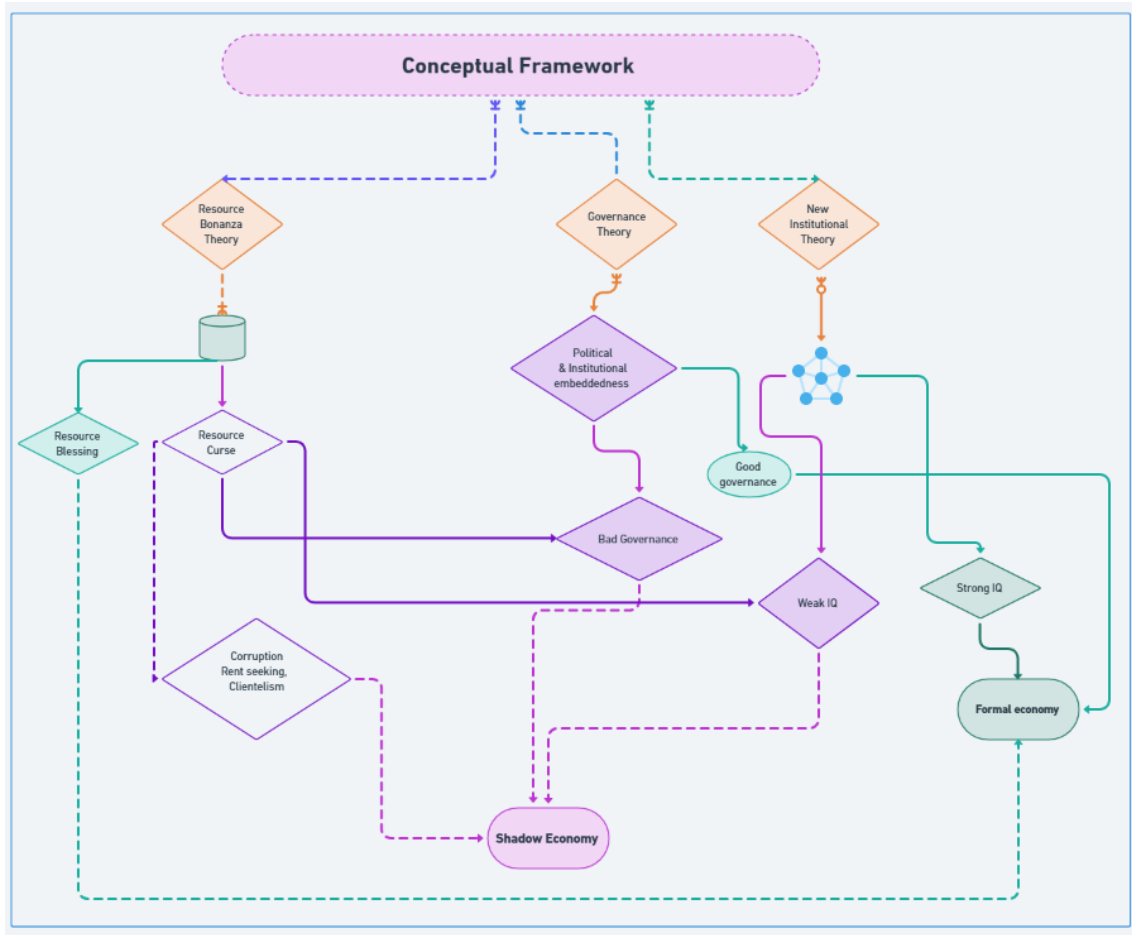


Figure 2: Conceptual Framework

Source: Created by the author.

1.2. The Conceptual Framework of NRR, CE, and ENV

Global warming and climate change are among today's most critical challenges. In response, the United Nations has introduced 17 Sustainable Development Goals (SDGs) (Hák et al., 2016). Among these, SDG-13 focuses on immediate actions to combat climate change and mitigate its impacts. Alarming, the agricultural sector and associated land use are responsible for significant greenhouse gas (GHG) emissions, estimated at 10-12 Gt CO₂e annually (Canavan et al., 2016; Dobermann, 2016; Smith et al., 2014). The food system must be redesigned to reduce GHG emissions to limit global warming to 1.5°C above pre-industrial levels (Wollenberg et al., 2016).

Achieving SDG-13 requires adopting sustainable production and consumption methods by creating innovative systems (Canavan et al., 2016; Dobermann, 2016). In response to this urgent need, the United Nations (UN), through SDG-12, has promoted sustainable

production and consumption patterns to ensure sustainable development (SD). The UN declared that 17 SDGs are significantly promoted by CE, degrowth, green growth, and SDG-related research (Belmonte-Ureña et al., 2021). The SD concept was first introduced in the Brundtland Report (1987), also known as "Our Common Future," and was formalized by the World Commission in 1987 (Gusmão Caiado et al., 2018). In this context, the Circular Economy (CE) has gained prominence, encompassing frameworks such as cradle-to-cradle (C2C), the sharing economy, and industrial symbiosis (McDonough & Braungart, 2002; Frenken, 2017; Chertow, 2000).

The C2C model emphasizes the interlinked objectives of economic prosperity, environmental protection, and human well-being (Toxopeus et al., 2015), transitioning from a "less bad" to a "more good" sustainability approach (Mohajan, 2021; Lovins, 2008). C2C creates an efficient, waste-free system (Lovins, 2008). The CE, designed based on the C2C (Braungart et al., 2007), is particularly effective for consumer goods (Korhonen et al., 2018). By accelerating the CE model, sustainability can be promoted by improving environmental conditions and reducing negative environmental impacts (Hou & Li, 2014). The CE involves the recovery, recycling, and reuse of resources (Kumar & Putnam, 2008), thus creating a pathway for sustainable development.

On the other hand, the "resource curse" theory (Ploeg, 2011), repression effect (Rezaei et al., 2015), and rentier effect (Isham et al., n.d.; Rutledge, 2017) investigate the impact of natural resources (NRR) on economic performance and environmental quality. According to the "resource curse" theory, countries rich in natural resources often experience poorer economic growth than those with fewer resources (Ploeg, 2011). Furthermore, abundant natural resources can impede modernization and encourage rent-seeking behaviors (Auty, 2002). Specifically, the rentier effect suggests that excessive rents from NRR can reduce the demand for taxation, leading to less accountable and weaker institutions (Ross, 2001). This dependency on NRR can also create patronage effects and increase corruption. Similarly, the repression effect indicates that governments may use NRR rents to suppress public desires and inhibit industrialization (Auty, 2001).

These limitations in resource-based economies can contribute to environmental pollution, with the extraction of NRR being a significant source (Danish et al., 2019). The higher revenues from NRR extraction may also divert investment from more sustainable sectors like the CE. Conversely, if NRR revenues are channeled into developing the circular

economy, it could enhance environmental sustainability. Figure 3 illustrates the conceptual framework, demonstrating how NRR and CE enhance ENS.

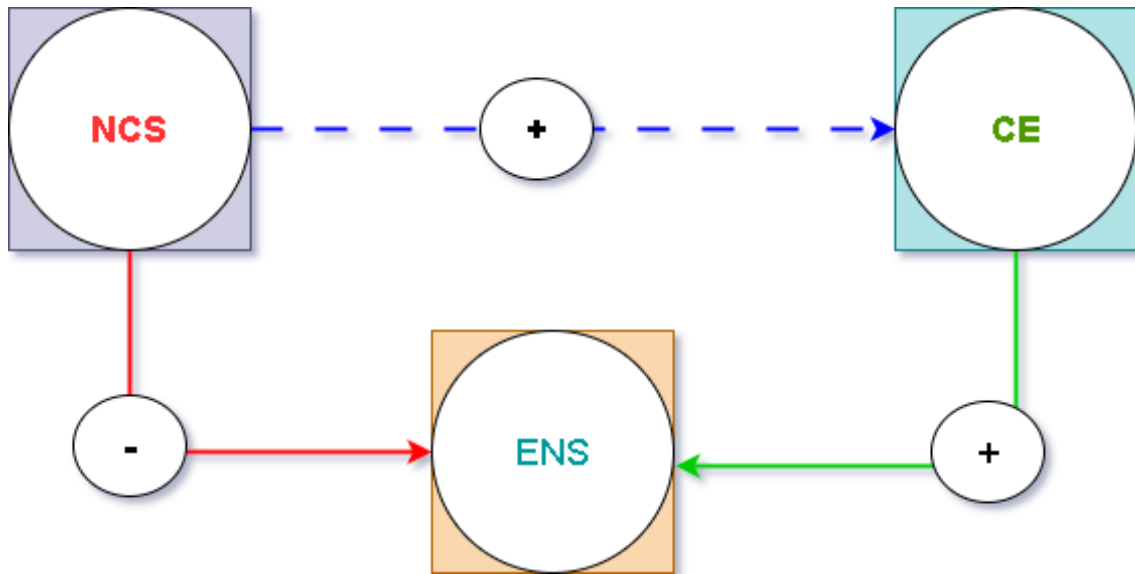


Figure 3: Conceptual Framework

Source: Created by the author.

1.3. Theoretical Framework of Political Stability and Shadow Economy

PS is critical to a nation's development, impacting economic growth, social cohesion, and international relations. Economic factors are widely recognized as influential determinants of PS. Economic development, income distribution, and employment opportunities play pivotal roles. Scholars, such as Barro (1996), argue that higher levels of economic development are associated with greater PS, as prosperous societies often experience lower levels of social unrest. Factors like income inequality and unemployment have also been identified as potential triggers for political instability (Alesina & Perotti, 1996). Due to this feature, foreign direct investment is especially vulnerable to the political climate in the locations where it is invested. Governments must provide a stable political environment to draw in and keep foreign money because overseas investors require it. According to Assi's (2023) extensive sample of emerging nations, foreign direct investment (FDI) promotes socio-political stability. In addition, institutions form the backbone of political systems, and their quality is a crucial determinant of stability. Strong institutions, characterized by effective governance, the rule of law, and checks and balances, contribute to political resilience (Kaufmann et al.,

2010). Research by Acemoglu and Robinson (2006) emphasizes the importance of inclusive institutions in fostering PS, as they provide a framework for fair representation and mitigate the risk of elite capture. Conversely, weak or corrupt institutions have been identified as precursors to political instability (North, 1990), highlighting the need for institutional reforms to ensure long-term stability.

Social factors, including demographics, ethnicity, and social cohesion, also significantly determine PS. Demographic dynamics, such as population growth and age distribution, can impact political systems (Goldstone, 2010). Ethnic and religious diversity may contribute to social harmony or exacerbate tensions, depending on how political institutions manage and accommodate diversity (Collier & Hoeffler, 2004). Social cohesion, as measured by factors like trust in institutions and civic engagement, has been linked to PS (Putnam, 1993), emphasizing the importance of improving a sense of community and shared values. However, the international context can shape a nation's PS through various channels. Examples of international context, external shocks, such as economic crises or conflicts, can have spillover effects on domestic PS (Haggard & Kaufman, 1995). International actors, including foreign governments, organizations, and multinational corporations, can influence political dynamics through diplomatic and economic channels (Dunning, 2004). Globalization and interconnectedness also contribute to the complexity of PS as nations become increasingly interdependent (Rodrik, 1997).

Cultural factors, encompassing values, beliefs, and norms, contribute to the stability of political systems. Huntington (1996) argues that the clash of civilizations can lead to political instability, particularly when political or economic factors exacerbate cultural differences. Cultural resilience, on the other hand, can contribute to stability by providing a shared foundation for societal cohesion and governance (Inglehart & Welzel, 2005). Previous studies have primarily focused on the influence of factors such as economic growth, migration, monetary policy, misallocation, corruption, institutions, and international trade on shaping PS, as illustrated in Figure 4.

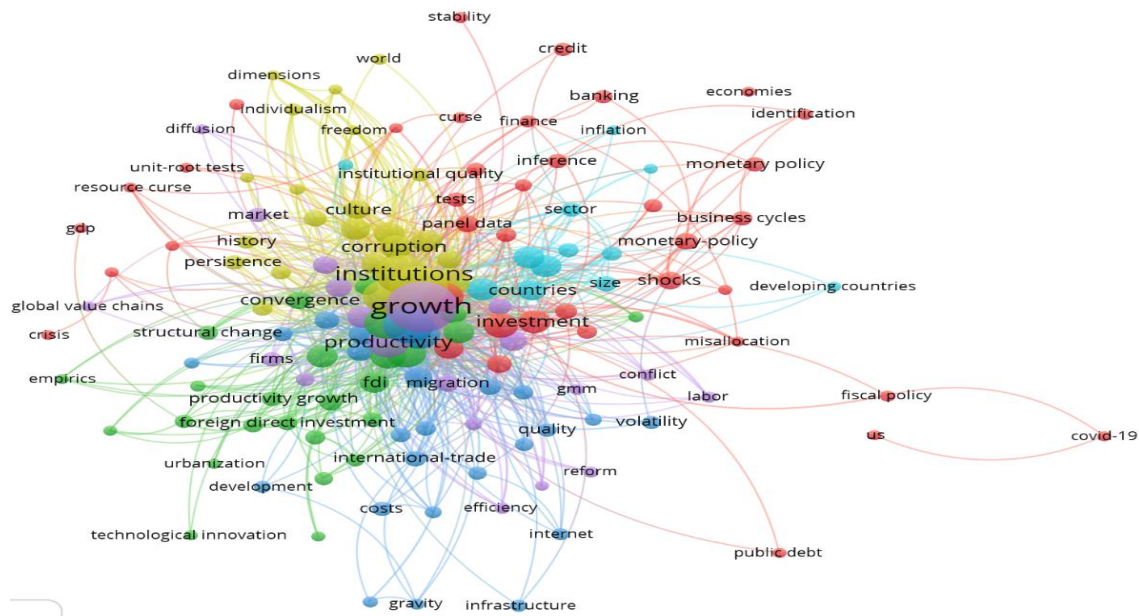


Figure 4: Networking of Political Stability

Source: Created by the author.

Understanding the determinants of the SE is crucial for assessing its impact on PS. Several studies highlight economic, social, and institutional factors influencing the size and scope of the SE. Economic variables, such as high tax burdens (Buehn, Dell'Anno, and Schneider 2018; Huynh and Nguyen 2020; Williams and Horodnic 2015; Mazhar and Méon 2017; Frey and Weck 1983; Schneider 1997), stringent regulations, and economic inequality, have been identified as catalysts for the growth of the SE (Johnson Et Al.1997, Rosser Jr et. Al. 2000, Schneider & Enste, 2000). Additionally, Xu et. al. (2018) find that country risk is a robust and significant determinant of the SE. Social factors, including trust in government institutions (Remeikiene and Gaspareniene. 2015) and cultural attitudes towards informal practices, also play a role (Williams & Schneider, 2016). Additionally, weak institutional frameworks (Bayar and Ozturk 2016; Canh, Schinckus, and Dinh Thanh 2021), corruption, and ineffective law enforcement contribute to the expansion of the SE (Dell'Anno, 2003).

2. CHAPTER: LITERATURE REVIEW

2.1. Natural Resources, Institutional Quality, and Shadow Economy

Identifying and measuring SE is challenging (Blackburn et al., 2012; Gauci & Rapa, 2020). The presence of SE disrupts and avoids tax collections and revenues (Saraçoğlu, 2020). Additionally, insufficient access to legal and administrative support for firms leads to tax evasion (Cobham, 2005).

The concept of institutions, introduced by North (1990), refers to the rules governing human interactions in society, encompassing both formal setups like rule of law, property rights, democracy, and fair judiciary processes, as well as informal settings like social customs, norms, and traditions. According to this theory, economic performance depends on institutional frameworks. As a consequence, better IQ improves economic performance by reducing uncertainty (Hallerberg & Wolff, 2006), transaction costs (Hoffman et al., 2016), and asymmetric information (Johnson et al., 1998; Boustanifar, 2014; Fosu, 2014). Addressing these issues encourages economic agents to operate within the formal economy to ensure governance and legal protection. In contrast, bureaucratic harassment, pervasive corruption, and poor legal frameworks reflect weak institutions, which, in turn, increase SE (Dreher & Schneider, 2010).

According to the literature, these ‘illegal’ practices are found in 69 countries (Friedman et al., 2000), whereas ad-hoc IQ improvements in 141 countries belonging to the Organization of Islamic Cooperation (OIC) and non-OIC countries have been shown to reduce SE (Khan & Rehman, 2022). A similar result is observed in 56 Asian countries (Zhanabekov, 2022; Dang et al., 2022). Overall, public monitoring and enforcement secure property rights (Quezada & Chan, 2024). Additionally, the mediation role of trade openness and GDP growth, alongside with high tax morale and better IQ, positively affects SE (Zhanabekov, 2022). Finally, political and fiscal decentralization have different impacts on SE: while the former tends to increase SE, the latter does not appear to have a significant impact (Buehn et al., 2013).

2.1.1. Shadow Economy and Natural Resource Rents

The abundance of natural resources can trigger the ‘voracity effect’ due to poor institutions exploited by dominant stakeholders (Tornell et al., 1999; Strulik, 2012).

Additionally, the exploitation of natural resources causes poor management in other economic sectors, leading to the ‘Dutch Disease’ which hampers economic development with negative consequences (Ajide & Ridwan, 2023). Corruption and mismanagement create unrest in the non-resource sector labour markets. Moreover, the ‘Dutch Disease’ can lead to currency appreciation and result in deindustrialization, driving the economy into the informal sector (Dell’Anno and Solomon, 2008). Additionally, Natural Resource Rent (NRR) may lead to uneven spillover effects of technological advancement between the manufacturing and service sectors across poor and rich countries (Reisinezhad, 2024). In African countries, rents from natural gas, oil, and coal validates the ‘Dutch Disease’ and show that increased rent correlates with a rise in SE in the long run between 1991 and 2015 (Ajide & Ridwan, 2023). Also, an uneven distribution of NRR induces income inequality, leading to a larger SE in 75 high and middle-income countries using data from 1990 to 2016 (Alvarado et al., 2021; Kpognon, 2022a), even NRR dependency induces undernourishment in developing countries (Njangang et al., 2024).

The debate over whether NRR is a blessing or a curse for the economy remains ongoing. NRR can have positive or negative effects on the economy depending on the institutional structure and resource management (Stijns, 2005). The exploitation of natural resources before 1990 damaged economic growth as it substituted manufacturing inputs. However, between 1990 and 2010, NRR was among the factors driving economic growth (Gerelmaa & Kotani, 2016). Financial development is also considered an additional factor determining an impact of NRR on economic growth. The study by Erdoğan et al. (2020) highlights that a threshold of 45% of financial development would have minimal indirect effect on a country’s growth. Furthermore, when coupled with better security, intellectual management, and technology, NRR would significantly drive the growth of a country (Hussain et al., 2022; Hye & Siddiqui, 2010; Topcu et al., 2020; Hassan et al., 2019). Similar conclusions are also recently found for China and US (Singh et al., 2023).

2.1.2. Shadow Economy and Unemployment

Addressing the relationship between SE and Unm is a complex issue for many countries. Recent studies have focused on this intricate economic relationship, revealing that Unm has a substantial impact on SE (Bajada & Schneider, 2009; Dobre & Adriana, 2009; Abdalaziz et al., 2020; Abada et al., 2021; Saafi et al., 2015; Sahnoun & Abdennadher,

2019; TRAN, 2021). Existing research shows that factors such as limited working hours, unemployment, high taxes, and self-employment contribute to the shift from the formal economy to SE. Enste's (2003) research and similar studies point out that when working hours are reduced or early retirements is operated, workers have more time to engage in informal sectors. Similarly, self-employment increases underground activities, as it opens avenues to avoid indirect taxes with the collaboration of customers, a practice easier for individuals than for corporate or large-scale firms (Bordignon & Zanardi, 1997).

Other studies find a bidirectional relationship between SE and Unm particularly in countries such as Turkey, Qatar, Bahrain, Jordan, Lebanon, Sweden and Finland (Abdlaziz et al., 2020), whereas the work by Saafi et al. (2015) finds no particular relationship between the observed covariates. In the context of the US and Italy, only unidirectional causality is found (Boeri & Garibaldi, 2002; Dell'Anno & Solomon, 2008; Davidescu & Dobre, 2012).

2.2. Natural Resources, Circular Economy, and Environmental Sustainability

2.2.1. Natural Resources & Environmental Sustainability

The relationship between natural resource rent (NRR) and environmental quality has been extensively examined across various country groups and different dimensions, revealing divergent findings characterized as either a "resource curse" or "resource blessing." Recent empirical investigations suggest that while NRR is not inherently detrimental to environmental quality, its excessive exploitation poses significant environmental risks (Yu et al., 2016; Sadiq et al., 2023; Zhao et al., 2023). The environmental impact of NRR appears to be contingent upon its usage, particularly in the context of industrialization and sector-specific allocation (Cherniwchan, 2012).

In developing countries, studies by Hassan et al. (2019) and Zhang et al. (2022) demonstrate that NRR-driven industrialization in unsustainable sectors significantly contributes to increased carbon emissions and ecological footprints. The unsustainable extraction and consumption of NRR have reached unprecedented levels in these nations, exacerbating environmental degradation (Ahmad et al., 2021). Notably, this phenomenon is not confined to developing economies; even among the top 15 green-energy economies, excessive NRR extraction has enhanced ecological footprints (Ullah et al., 2021).

Similarly, research on EU-16 countries reveals that NRR mismanagement deteriorates environmental quality over the long term (Bekun et al., 2019).

Conversely, some studies challenge the "resource curse" narrative, suggesting that NRR can facilitate environmental improvement by adopting cleaner energy sources, such as natural gas (Balsalobre-Lorente et al., 2018). This environmental enhancement effect is attributed to technological diffusion, capital flows, and globalization (Yang et al., 2021), findings corroborated by Tufail et al. (2021) and Pata & Ertugrul (2023).

Though the findings are not unique, the results depend on place, institutions, time dimensions, and development stage. For example, in Russia, while NRR improved the environmental quality, the same time NRR in South Africa enhanced carbon emission; on the other hand, no impact of NRR on carbon emission is found in the case of Brazil, China, and India (Danish et al., 2019). Similarly, Luo et al. (2023)'s investigation in low, middle, and high-income countries concluded the heterogeneous impact of NRR. High-income countries need more environmental policies to improve the alternatives to fossil-fueled energy; however, low- and middle-income countries should focus on environmentally-friendly economic growth with aforesaid policies. In addition, the study on 82 countries concluded that NRR reduced carbon emissions in lower quantiles, nevertheless increasing it in medium and upper quantiles (Altinoz & Dogan, 2021).

It is worth noting that despite plenty of studies, existing literature has limited scopes to measure environmental quality. The current study will fill the gaps by introducing innovative indicators to environmental sustainability issues. Thus, an inclusive and comprehensive indicator will give a further understanding of the nexus between environmental sustainability and NRR. Inconclusive findings in the previous literature might be raised depending on other third factors overlooked in previous studies. The study also introduces CE's impact on environmental sustainability in this context.

2.2.2. Circular Economy & Environmental Sustainability

A few but growing number of studies have focused on investigating the nexus between CE and environmental issues. CE presents a design of a closed-loop from the extraction of NRR to the regenerative transformation from waste (Agrawal et al., 2021; Park et al., 2010; Wang et al., 2024). Li & Wang (2015) find that CE, applying the closed loop, enhances resource efficiency, which lowers the repeated consumption of raw materials.

As a result, it can improve environmental quality by reducing carbon emissions. When CE policies are introduced, industrial sectors show improvement in environmental quality through resource efficiency (Qu et al., 2022).

Similarly, recycling rates reduced carbon emissions, though there were significant differences within EU countries (Bayar et al., 2021). In the long run, CE initiatives contributed to lower CO₂ emissions in 15 EU countries (Mongol et al., 2022). The positive impact of CE on the reduction of carbon emissions is identified in Switzerland (Magazzino et al., 2020), in India, and in China (Wang et al., 2019). The benefit of CE is not only limited to the environment but also brings major economic benefits, such as job creation and GDP growth in European countries (European, 2024). In addition, recycling plastic, paper waste, and steel bring the environmental benefits and advantages in energy sectors (Cudjoe et al., 2021). To accelerate CE practices, biomethane through incorporation of efficient management of green energy and waste contributes in sustainable development (D'Adamo et al., 2021).

However, a few studies concluded that CE has no significant effect on carbon emissions. The countries depending on mining and NRR did not find CE benefits due to Nigeria and China's energy intensity reduction (G. Li et al., 2020). Additionally, recycling technology in chemical industries did not lower fossil fuel consumption or greenhouse gas emissions (Meys et al., 2020). Moreover, recycling steel, paper, and plastic in China damaged the environmental quality (Cudjoe et al. (2021). Another study in EU countries did not find any significant interaction among recycling rate, renewable, and carbon emission (Bayar et al. (2021). On the other hand, Within Italy, the northern part of Italy has made significant progress in CE practices in comparison to the southern part of Italy (D'Adamo, Gastaldi, et al., 2021).

Empirical studies failed to reach any conclusive result, while few studies concluded that CE contributes to reducing carbon emissions or improving environmental quality (Wang et al., 2024). others could not find any effect. Short data spans are a common challenge to CE and causality linkages. In addition, implementing CE is a challenging task with regional variations and behavioral dynamics (Bassi et al., 2021). The regional development process depends on coordination between or among stakeholders, institutional quality, and regenerated process of resources (Veyssière et al., 2022). To overcome these shortcomings, the study uses the extended range of data from 2005 to

2021 and validates the nexus in multiple dimensions. Existing literature focuses on carbon emissions (Bayar et al. (2021), greenhouse gas emissions (Meys et al., 2020), and ecological footprint (Ullah et al., 2021; Hassan et al. (2019); Zhang et al., 2022). However, the current study focuses on ENS in the view of biocapacity and ecological footprint, which captures a better understanding of environmental quality. The literature gap will be filled by extensive and multi-dimensional study, including new concepts of environmental sustainability.

2.3. Shadow Economy and Political Stability

The mechanisms through which the SE affects PS are intricate and interconnected. One primary mechanism is the erosion of state revenues through tax evasion and SE activities, which can undermine the government's capacity to deliver public goods and services (Dreher & Schneider, 2010). This fiscal strain may lead to a deterioration of public infrastructure, social services, and overall governance, negatively impacting PS. Moreover, the SE can foster corruption and undermine the rule of law, further compromising the effectiveness of political institutions (Buehn & Schneider, 2012). The resulting disappointment with the government can fuel social unrest, protests, and even political instability.

Empirical studies provide valuable insights into the relationship between the SE and PS. For instance, research by Medina & Schneider (2018) reveals that higher levels of SE activities are associated with increased political instability in Latin American countries. In his study, Dutta (2020) demonstrates that the presence of a SE contributes to PS through the facilitation of economic growth and the mitigation of inflation. Conversely, in some Eastern European nations, the SE has been found to act as a coping mechanism during times of economic downturn, potentially contributing to PS in specific contexts (Feld & Schneider, 2010). These regional variations underscore the need for a nuanced understanding of the SE's impact on PS, considering the unique socio-economic and political contexts of different regions.

2.4. Empirical Literature: Formal Economy and Political Stability

Good governance, characterized by transparency, accountability, effectiveness, and rule of law, is widely acknowledged as a critical determinant of a nation's PS. Good

governance contributes to PS through various mechanisms. Transparent and accountable governance fosters citizens' trust in institutions, reducing the likelihood of social unrest and political turmoil (Treisman, 2007). Effective governance ensures the fair distribution of resources, reducing socioeconomic disparities that often fuel political instability (Knack & Kropf, 2003). Additionally, the rule of law and strong institutions enhance the predictability and consistency of political processes, creating an environment conducive to PS (Helmke & Levitsky, 2004).

Empirical studies consistently support the positive correlation between good governance and PS. For instance, research by Mauro (1995) and Keefer and Knack (1997) found that countries with higher levels of corruption and weak governance structures were more prone to political instability. Conversely, nations with robust governance indicators, such as the Control of Corruption Index and Rule of Law Index, tend to exhibit greater PS (World Bank, 2019). Cross-country analyses reinforce these findings, emphasizing the universal applicability of the relationship between good governance and PS (Bertelsmann Stiftung, 2021).

2.4.1. Research Gap

In literature, PS has been studied from multiple perspectives, with a focus on both economic and social determinants. Economic factors such as economic development (Barro, 1996), income inequality, and unemployment (Alesina & Perotti, 1996), as well as the relationship between foreign direct investment (FDI) and PS (Assi, 2023), have been widely examined. On the social side, factors like population growth, age distribution (Goldstone, 2010), ethnic and religious diversity (Collier & Hoeffler, 2004), and trust in institutions and civic engagement (Putnam, 1993) have also been investigated. Despite the extensive research in this particular area, there is a notable gap in studies examining the relationship between PS and SE. This study aims to address that gap by exploring the links between the SE, FE, and PS on a global scale, contributing new insights to the existing body of literature. Figure 5 illustrates the networks of the SE, highlighting that most studies focus on economic factors such as economic growth, innovation, corruption, culture, inflation, and tax evasion. The figure also identifies a significant gap in literature, with few studies exploring the relationship between PS and SE.

3. CHAPTER: DATA, METHODOLOGY AND ANALYSIS

3.1. Data: Natural Resources, Institutional Quality, & Shadow Economy

Table 1 presents data description and sources over the period 1996-2018. The panel consists of 124 countries grouped into HICs, HMICs, LMICs, LICs. The World Bank Atlas method classifies the country groups based on their gross national income (GNI) (World Bank Country and Lending Groups, 2023) The study focuses on SE as dependent variable and data are inferred according to the work by Elgin et al. (2021) The Multiple Indicators Multiple Causes (MIMIC) method is used to compute SE as percentage of official GDP. NRR includes the composite of oil, natural gas, coal, mineral, and forest rents. The country-wise NRR and SE nexus is depicted in Figure 6 and Table 2, in which LICs and LMICs show higher levels of SE within the global sample.

Abbreviation	Variable	Description	Sources
SE	Shadow economy	Informal output (% of official GDP)	WDI ¹
IQ	Institutional Quality	An index composed of control of corruption, government effectiveness, political stability, regulatory quality, rule of law, and voice of accountability	WGI ²
NRR	Natural resource rents	Total rents from oil, natural gas, coal, mineral, and forest rents.	WDI
Urb	Urbanization	Urban population (% of total population)	WDI
Unm	Unemployment	Unemployment, total (% of total labour force)	WDI
FDI	Foreign direct investment	Foreign direct investment, net inflows (% of GDP)	WDI

Table 1: Data Description and Sources

Source: Created by the author.

¹ <https://databank.worldbank.org/source/world-development-indicators>

² <https://www.worldbank.org/en/publication/worldwide-governance-indicators>

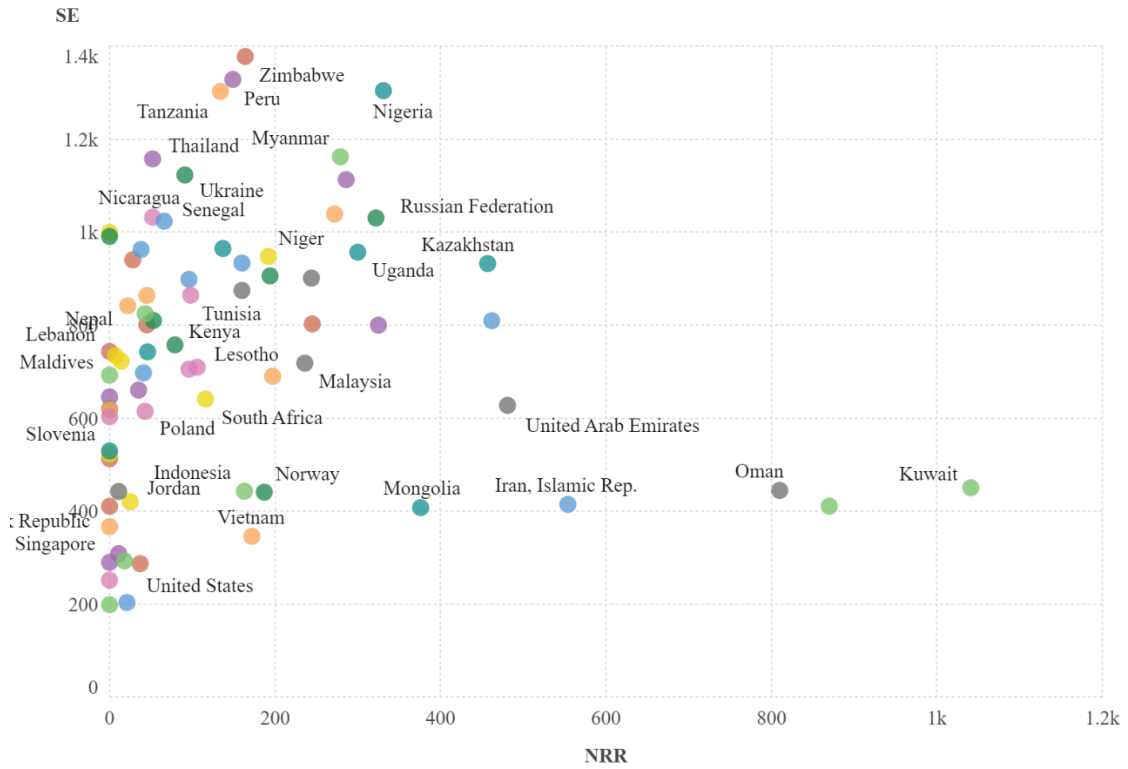


Figure 6: Country-Wise SE & NRR Nexus

Source: Created by the author.

Country	SE	Country	SE	Country	SE	Country	SE
Albania	34.51	Denmark	18.07	Kyrgyz Republic	39.05	Papua New Guinea	35.19
Algeria	32.64	Ecuador	33.42	Lao PDR	30.00	Paraguay	37.55
Angola	45.45	Egypt, Arab Rep.	34.55	Latvia	28.70	Peru	57.75
Argentina	24.69	Estonia	31.05	Lebanon	32.31	Philippines	40.88
Australia	44.35	Ethiopia	37.09	Lesotho	30.84	Poland	26.72
Austria	9.86	Finland	18.19	Lithuania	31.41	Portugal	22.74
Azerbaijan	56.34	France	15.40	Madagascar	41.94	Romania	32.28
Bahamas, The	28.17	Gambia, The	46.25	Malawi	39.38	Russian Federation	44.79
Bahrain	19.37	Georgia	66.30	Malaysia	31.22	Rwanda	38.02
Bangladesh	35.66	Germany	15.84	Maldives	30.11	Saudi Arabia	17.85
Belarus	46.00	Ghana	40.55	Mali	40.59	Senegal	44.49
Belgium	22.44	Greece	28.80	Malta	26.87	Sierra Leone	45.16
Benin	50.62	Guinea	39.28	Mauritania	34.77	Singapore	12.60
Bhutan	28.46	Guinea-Bissau	38.24	Mauritius	22.29	Slovak Republic	17.84
Bolivia	65.40	Haiti	58.78	Mexico	30.66	Slovenia	26.21
Botswana	31.84	Honduras	48.70	Moldova	43.44	South Africa	27.87
Brazil	39.29	Hungary	24.54	Mongolia	17.72	Spain	23.02
Brunei Darussalam	31.13	Iceland	15.84	Morocco	35.21	Sri Lanka	43.07
Bulgaria	34.38	India	21.59	Mozambique	39.18	Sweden	19.23
Burkina Faso	40.31	Indonesia	19.25	Myanmar	50.52	Switzerland	8.64
Burundi	39.59	Iran, Islamic Rep.	18.02	Namibia	30.31	Tajikistan	41.85
Cambodia	48.36	Ireland	15.93	Nepal	36.59	Tanzania	56.62
Cameroon	32.28	Italy	28.06	Netherlands	13.42	Thailand	50.32
Canada	15.90	Jamaica	34.80	New Zealand	12.47	Togo	34.89
Central African Republic	41.81	Japan	10.93	Nicaragua	44.87	Tunisia	37.57
Chad	44.77	Jordan	18.27	Niger	41.20	Turkiye	31.93
China	12.15	Kazakhstan	40.53	Nigeria	56.70	Uganda	41.59
Colombia	36.71	Kenya	32.93	Norway	19.16	Ukraine	48.82
Congo, Dem. Rep.	47.04	Korea, Rep.	26.93	Oman	19.33	United Arab Emirates	27.28
Costa Rica	25.79	Kuwait	19.58	Pakistan	35.84	United Kingdom	12.74
Vietnam	15.03	Zambia	48.38	United States	8.85	Zimbabwe	59.90

Table 2: List of Country with size of SE

Source: Created by the author.

IQ is represented by an index composed of control of corruption, government effectiveness, political stability, regulatory quality, rule of law, and voice of accountability, obtained through principal component analysis. FDI refers to the net inflow of foreign investment as a percentage of GDP; whereas Unm indicates the share of the labour force interested in employment but unable to find jobs. Urb shows the

population living in urban areas. In this study, FDI, Unm, and Urb are considered as control variables.

Table 3 depict the descriptive statistics of the sample. The total panel presents 2,852 observations. The skewness and kurtosis tests (joint $\chi^2(2)=133.67$ p-value=0.00) in Table 4 and the Shapiro-Wilk test in Table 5 indicate that the assumption of normality is rejected within conventional ranges of confidence intervals (C.I.).

Finally, Table 6 shows the Pearson pair-wise correlation matrix across variables. In particular, only IQ and Urb are both negatively and strongly correlated to SE. For the remaining co-variates, an almost non-existent correlation value is found.

Variable	Obs	Mean	Std. Dev.	Min	Max
SE	1012	26.77	12.33	8.06	60.6
IQ	1012	0	2.29	-4.37	3.84
NRR	1012	.65	1.08	0	7.44
FDI	1012	3.45	6.88	-40.09	86.48
Une	1012	7.54	4.42	.25	29.77
Urb	1012	66.70	19.19	18.20	91.87

Table 3: Descriptive Statistics

Source: Created by the author.

Joint test				
Variable	Pr(Skewness)	Pr(Kurtosis)	adj_chi2(2)	Prob>chi2
residuals	.00	.00	133.67	.00

Table 4: Skewness/Kurtosis Tests for Normality

Source: Created by the author.

Variable	W	V	z	Prob>z
SE	.99	24.70	8.26	.00
IQ	.95	81.30	11.33	.00
NRR	.73	445.10	15.71	.00
Urb	.97	43.99	9.75	.00
Unm	.90	163.07	13.12	.00
FDI	.21	1295.23	18.46	.00

Table 5: Shapiro Wilk Test for Inormality.

Source: Created by the author.

Variables	SE	IQ	NRR	Urb	Unm	FDI
SE	1.00					
IQ	-0.68	1.00				
NRR	0.12	-0.39	1.00			
Urb	-0.49	0.65	-0.08	1.00		
Unm	-0.06	0.16	-0.23	0.18	1.00	
FDI	-0.04	0.10	-0.04	0.12	-0.01	1.00

Table 6: Pearson Pair-Wise Correlation Matrix

Source: Created by the author.

3.2. Data: Natural Resources, Circular Economy, and Environmental Sustainability

This study uses data from 2005 to 2021 collected from various sources. The rationality behind the timeframe selection is that the European Union has taken the circular economy (CE) initiatives through the thematic strategy on the prevention and recycling of waste since 2005 (European Commission, 2005). During this time, the EU economy shifted from traditional to sustainable approaches by CE practices (He et al., 2013). The countries' details are listed in table 7.

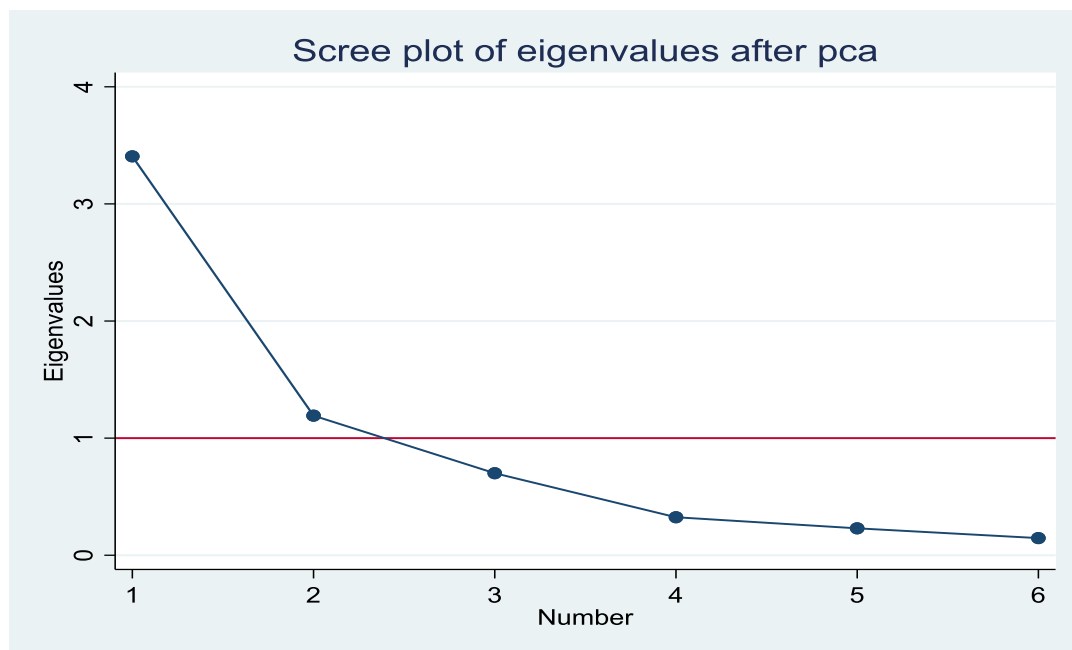
Austria	Denmark	Estonia
Finland	France	Germany
Greece	Hungary	Ireland
Italy	Lithuania	Luxembourg
Netherlands	Norway	Poland
Portugal	Slovenia	Spain
Sweden		

Table 7: List of Countries

Source: Created by the author.

Most of the selected countries adopted the EU Circular Economy Package, which is aligned with the EU Green Deal (European Commission, 2020). In addition, circular economy data is rarely available. Only these countries maintain high-standard CE data, including environmental sustainability indicators (OECD, 2020). Circular economy (CE) data is collected from Eurostat.

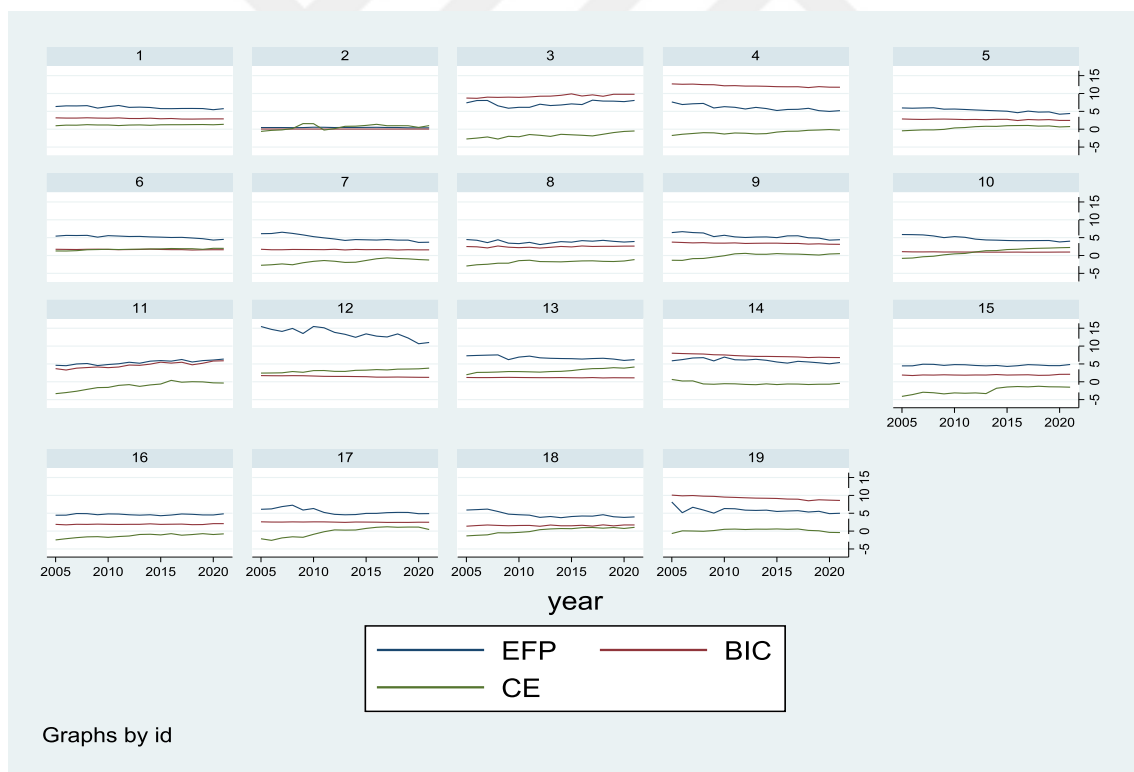
The principal component analysis is applied to create the CE index. It comprises indicators under three principal themes: global sustainability resilience, production & consumption, and waste management. Material import dependency is a factor of CE under "Global Sustainability & Resilience," revealing what percentage of raw material depends on import. Thus, the higher the import dependency, the lower the percentage of domestic extraction of natural resources. Furthermore, under the theme of "production and consumption," three indicators- resource productivity, generation of packaging waste, and plastic packaging waste- are parts of CE. Resource productivity accounts for the total domestic products over domestic material consumption. In an economy, how much domestic materials are consumed for domestic production is revealed by resource productivity. There are two indicators for packaging waste. While the generation of packaging waste shows the materials used to cover the product from beginning to end, the generation of plastic packing waste considers only plastic waste. Both of them measure the waste per capita. In addition, recycling both from packaging and municipal waste works under the "waste management" theme. Packaging waste recycling is crucial for CE, aiming to capture 70% of total packing waste recycling by 2030. Recycling of municipal waste measures household waste, calculating 10% of total waste in the EU. Graph 1 explains the variation among CE indicators.



Graphic 1: CE Index Variations

Source: Created by the author.

Environmental sustainability (ENS), a dependent variable, is constructed using the ratio of biocapacity (BIC) to ecological footprint (EFP), both obtained from the Global Footprint Network. EFP captures resources and land used for economic activities and waste disposal, whether in land or water (Rees, 2000). The EFP accounts for the human effect on the earth (Moffatt, 2000). The indicator reflects comprehensive, unambiguous, clear concepts. However, biocapacity accounts for our planet's renewable capacity and quantifies the ecosystem's regenerative rate (Global Footprint Network, 2023; York University, 2005). The EFP and BIC reveal an extensive and better understanding of environmental quality over traditional factors (Rees, 2000), while CO2 or greenhouse gas emissions measures emissions only from burning fossil fuels and producing cement (Global Footprint Network, 2020). The data definitions are presented in Table 8 in detail. Therefore, for environmental sustainability, the ecological footprint and biocapacity suits better than other traditional factors. Graph 2 depicts the dynamics among EFP, BIC, and CE.



Note: Country IDs: - 1= Austria; 2= Denmark, 3= Estonia; 4= Finland, 5= France; 6= Germany; 7=Greece;; 8= Hungary; 9= Ireland;; 10= Italy; 11= Lithuania; 12= Luxembourg; 13= Netherlands; 14= Norway; 15= Poland; 16= Portugal; 17= Slovenia; 18= Spain, 19= Sweden.

Graphic 2: The Dynamics of EFP, BIC, and CE

Source: Created by the author.

Abbreviation	Variables	Sources
ENS	The ratio of biocapacity and ecological footprint ¹	Authors Calculation
NRR	Total Natural Resource Rents % of GDP	WDI
CE	The circular economy is composed of an index of Resource Productivity, Generation of packaging waste per capita, generation of plastic packaging waste per capita, Recycling rate of municipal waste, Recycling rate of packaging waste by type of packaging, Material import dependency by using Principal Component Analysis	Eurostat ¹
Inf	Inflation, consumer prices (annual %)	WDI
DCP	Domestic credit to private sector (% of GDP)	WDI
GCF	Gross capital formation (% of GDP)	WDI
RSP	Resource Productivity	Eurostat
CPI	Consumer price index (2010 = 100)	WDI
EMS	Employment in services (% of total employment) (modeled ILO estimate)	WDI
EXP	Exports of goods and services (% of GDP)	WDI
GDP	GDP growth (annual %)	WDI
GET	Government Effectiveness: Percentile Rank	WGI
BIC	Biocapacity per capita	Footprint Network ²
EFP	Ecological footprint per capita	Footprint Network
GFC	General government final consumption expenditure (% of GDP)	WDI
MVA	Manufacturing, value added (annual % growth)	WDI
REC	Renewable energy consumption (% of total final energy consumption)	WDI

Note: WDI= World Development Indicators; ¹<https://ec.europa.eu/eurostat/web/circular-economy/database>; ²<https://data.footprintnetwork.org/#/abouttheData>

Table 8: Data Definitions

Source: Created by the author.

The descriptive statistics are summarized in Table 9, providing an overview of the dataset's characteristics. No anomalies were detected, with each variable comprising 323 observations. CE has the lowest mean among the variables, while RSP exhibits the smallest standard deviation at 1.05. It is noteworthy that MVA has the lowest minimum value, whereas EXP shows the highest maximum value. Furthermore, tests for skewness, kurtosis, and a joint normality assessment confirm that most variables do not exhibit a normal distribution. These data dynamics give an understanding of the nature of the data, which is crucial to determining appropriate econometric techniques to take into account the non-normality issue.

Variable	Obs	Mean	Std. Dev.	Min	Max	Pr	Pr	Joint test for Normality	
						(skewness)	(kurtosis)	Adj	P-value
BIC	323	3.639	3.283	0.044	12.694	0	0.049	50.99	0
EFP	323	5.569	2.392	0.385	15.491	0	0	91.99	0
ENV	323	0.645	0.527	0.087	2.362	0	0.003	55.04	0
CPI	323	104.257	9.045	76.915	132.113	0.181	0.2	3.45	0.178
EMS	323	70.94	7.646	53.373	89.479	0.406	0.063	4.17	0.124
EXP	323	59.617	36.278	18.982	213.223	0	0	110.85	0
GFC	323	72.878	9.616	36.54	93.281	0	0	52.37	0
GDP	323	1.752	3.956	-14.839	24.475	0.092	0	37.87	0
GET	323	85.304	11.174	58.571	100	0.001	0	52.3	0
GCF	323	22.481	4.8	11.892	54.775	0.001	0	99.48	0
Inf	323	1.826	1.682	-4.448	10.926	0	0	65.05	0
MVA	323	2.11	8.607	-23.214	85.323	0	0	171.08	0
REC	323	22.081	14.552	1.9	61.4	0	0.315	32.79	0
NRC	323	0.9	1.909	0.005	12.618	0	0	203.13	0
RSP	323	1.912	1.05	0.498	4.768	0	0.007	19.87	0
DCP	323	95.585	36.965	27.116	201.259	0.002	0.583	8.82	0.012
CE	323	0	1.679	-4.085	4.139	0.074	0.074	6.26	0.044

Table 9: Descriptive Statistics

Source: Created by the author.

The correlation matrix is presented in Table 10. The analysis illustrates the strength and direction of relationships between variables. For example, BIC positively correlates with environmental factors, whereas EFP exhibits an inverse relationship consistent with the environmental sustainability matrix. Similarly, CE and REC strongly align with sustainable development measures, underscoring the significance of these variables in managing natural resources for sustainable development. These findings justify the importance of integrating natural resource management within the sustainable development framework.

Variables	ENS	CE	REC	GFC	GDP	MVA	NRR
ENS	1.000						
CE	-0.340	1.000					
REC	0.693	-0.120	1.000				
GFC	-0.031	-0.443	-0.019	1.000			
GDP	0.018	-0.036	-0.045	-0.339	1.000		
MVA	-0.011	-0.016	-0.030	-0.217	0.799	1.000	
NRR	0.291	-0.189	0.534	-0.208	0.033	0.021	1.000

Table 10: Correlation Matrix

Source: Created by the author.

3.3. Data: Political stability & Shadow Economy

This study utilizes panel data for 124 countries from 1996 to 2018, sourced primarily from the World Development Indicators (WDI) and Worldwide Governance Indicators (WGI). The dataset includes 27 higher middle-income, 17 low-income, 37 lower-middle-income, and 36 high-income countries. Map 3 depicts the selected countries in the study, presented in the world map.



Map 3: Selected Countries in the Study

Source: Created by the author.

The selection of variables in this study is supported in theoretical and empirical foundations from existing literature. The key variables used in this study are political stability (PS), regulatory quality (RQ), shadow economy (SE), and formal economy (FE) where PS is the dependent variable. The unemployed labor force (ULF) and Inflation (IGA) are control variables. In the context, PS is influenced by institutional quality, particularly RQ, as it directly impacts the effectiveness of governance and private sector development, thereby reducing the likelihood of instability (Ahmad et al., 2003). The SE, as captured through lagged estimates, has been shown to undermine institutional strength, exacerbate unemployment, and reduce trust in formal governance systems, leading to political instability (Schneider & Enste, 2000). RQ, meanwhile, plays a dual role: it supports stable

policy environments that discourage SE activities and strengthens political institutions (Djankov et al., 2002). Macroeconomic indicators like inflation and unemployment are widely recognized as drivers of political instability, with economic shocks leading to public discontent and potential political unrest (Alesina et al., 1996). GDP per capita growth is included to capture the economic context influence on governance stability, consistent with prior findings that economic prosperity reduces political volatility (Lipset, 1959). The interaction term between the SE and RQ is employed to explore their joint effect, hypothesizing that strong regulatory frameworks can mitigate the adverse effects of SE on PS. In the study, PS is a dependent variable, while SE and FE are dependent variables. RQ is a moderating factor, including control variables- unemployment (ULF), inflation (IGA). The variables employed in this analysis, alongside their descriptions and sources, are detailed in Table 11.

Abbreviation	Variable	Description	Source
PS	Political Stability	Percentile rank measuring perceptions of the likelihood of political instability and/or politically motivated violence, adjusted for temporal and compositional changes.	WGI
SE	Shadow economy (lag of Shadow Economy)	MIMIC model-based estimates of shadow output as a percentage of official GDP.	WDI
RQ	Regulatory Quality	Percentile rank capturing perceptions of a government's ability to formulate and implement sound policies and regulations that promote private sector development.	WGI
ULF	Unemployed labor force	Percentage of the total labor force that is unemployed but actively seeking work.	WDI
IGA	Inflation as per annual GDP deflator	Annual growth rate of the GDP implicit deflator, reflecting overall price changes in the economy.	WDI
FE	Formal Economy is proxy of GDP per Capita Growth	Annual percentage growth rate of GDP per capita, based on constant local currency, representing the economic output per individual.	WDI

Note: WGI = World Governance Indicators; WDI = the World Development Indicators.

Table 11: Data Definition

Source: Created by the author.

Understanding the data nature is important to identify the proper models. So, the descriptive statistics are reported in Table 12, which reveals no anomalies in the data. Across the variables, the observations are identical. Among the variables, FE belongs to

the lowest value, while IGA shows the highest value. The data is not normally distributed because of skewness and kurtosis. To address this issue, the study applies to the MMQR method.

Variable	Obs	Mean	Std. Dev.	Min	Max	Pr(skewness)	Pr(kurtosis)
PS	2852	46.505	28.417	0	100	0	0
SE	2852	32.958	12.9	8.065	68.913	0	0
RQ	2852	51.628	27.772	0	100	0	0
ULF	2852	7.003	4.874	0.14	29.77	0	0
IGA	2852	11.73	106.771	-27.049	4800.532	0	0
FE	2852	3.987	4.115	-36.392	34.5	0	0

Table 12: Descriptive Statistics

Source: Created by the author.

The pairwise correlation matrix identifies the direction of variables, which is reported in Table 13. Among the variables, IE and PS are negatively associated; however, RQ and PS have substantial positive correlation. The SE may deteriorate PS, while regulations, particularly RQ, contribute to ensure PS. On the other hand, ULF is negatively related to IE.

Variables	(PS)	(IE)	(RQ)	(ULF)	(IGA)	(FE)
PS	1					
SE	-0.580*	1				
	0					
RQ	0.761*	-0.619*	1			
	0	0				
ULF	0.077*	-0.060*	0.146*	1		
	0	-0.001	0			
IGA	-0.077*	0.065*	-0.092*	-0.012	1	
	0	-0.001	0	-0.507		
FE	-0.120*	0.110*	-0.173*	-0.132*	-0.006	1
	0	0	0	0	-0.741	

*** p<0.01, ** p<0.05, * p<0.1

Table 13: Pairwise Correlations

Source: Created by the author.

4. CHAPTER: METHODOLOGY: INFERENCE ANALYSIS

4.1. Cross-sectional Dependence Test

To check the dependence and correlation between entities and individual units, the cross-sectional dependence (CSD) test is used in panel data models (Pesaran, 2021). The test indicates the model fit. When CSD is present, the pooled panel regression leads to biased and inefficient coefficient estimates. The test statistics is explained in the following notations (Pesaran, 2004):

$$CD = \left[\frac{TN(N-1)}{2} \right]^{1/2} \bar{\rho} \quad 1$$

Here:

$$\bar{\rho} = \left(\frac{2}{N(N-1)} \right) \sum_{i=1}^{N-1} \sum_{j=i+1}^N \rho_{ij} \quad 2$$

where, N refers to the size of the cross sections, and T is sample size. The pair-wise cross-sectional correlation coefficients for the residuals ρ_{ij} are estimated by using the Augmented Dickey–Fuller (ADF) regression.

4.2. Panel Unit Root Test

First-generation unit root tests are used to determine the stationarity of variables, assuming no cross-sectional dependence (CSD) in panels. However, this assumption often does not hold in real-world scenarios, where economic shocks can occur simultaneously and affect multiple entities. The presence of CSD can result in underestimated standard errors, rendering the first-generation unit root tests unreliable. To address this issue, second-generation unit root tests, such as the Cross-sectionally Augmented Dickey-Fuller (CADF) (Pesaran, 2007) and Cross-sectional Im, Pesaran, and Shin (CIPS) (Im et al., 2003) tests are applied as follows:

$$CIPS = \frac{1}{N} \sum_{i=1}^N t_j(N, T) = \frac{\sum_{i=1}^N CADF_i}{N} \quad 3$$

$$\Delta Y_{it} = \varphi_i + \beta_i \bar{Y}_{t-1} + \sum_{j=1}^p \beta_{ij} \bar{Y}_{t-1} + \sum_{j=1}^p \alpha_{ij} \Delta Y_{i,t-1} + \epsilon_{it} \quad 4$$

where, $t_j(N, T)$ represents CADF statistics and $\bar{Y}_{t-1}$ and $\Delta Y_{i,t-1}$ is respectively the lag of each series and the first difference when CSD is present.

4.3. Panel Cointegration Test

Panel cointegration tests are widely used to identify long-run associations between variables in panel data (Pedroni, 2004). These tests are effective tools for addressing unit roots, cross-sectional dependence, and structural breaks in panel data (Pedroni, 2004). Additionally, Pedroni (2004) discusses the characteristics of pooled time series tests and their application to the purchasing power parity hypothesis. Westerlund (2007) introduced error correction tests, offering low size distortions and high power compared to other popular residual-based tests. Our study applies both the Pedroni and Westerlund tests, which provide robust and unbiased results even in the presence of CSD (Kapetanios et al., 2011). The Westerlund test explains the cointegration through the following:

$$\begin{aligned} G_a &= \frac{1}{n} \sum_{i=1}^n \frac{\beta}{SE(\beta)} \\ G_t &= \frac{1}{n} \sum_{i=1}^n \frac{T\beta}{\beta(1)} \\ P_t &= \frac{\beta}{SE(\beta)} \\ P_a &= T\beta \end{aligned} \tag{5}$$

where, G_a and G_t are used to investigate cointegration within each cross-section and represent group mean statistics, while P_t and P_a refer to the panel mean statistics and are used to assess cointegration for panel data. Specifically, G_t tests for cointegration in the presence of a unit root in the error terms and identifies the null hypothesis of no cointegration for at least one unit within the entire panel. Conversely, P_t evaluates whether none of the cross-sections are cointegrated under the null hypothesis. Moreover, G_a reflects that at least one unit does not reach an equilibrium point after experiencing an economic shock, while P_a addresses that the entire panel fails to achieve equilibrium following a short-term deviation.

4.4. Method of Moments Quantile Regression (MMQR)

4.4.1. MMQR for Natural Resources, Institutional Quality, & Shadow Economy

The MMQR is a sophisticated and novel method introduced by Machado and Silva (2019) to understand the estimation of conditional means. It offers significant advantages over pooled regression, particularly in handling individual effects and accounting for conditional heterogeneous covariance effects. The MMQR also allows for the consideration of unobserved heterogeneity and its covariate effects. This method is capable of estimating appropriate models even when dealing with non-linear relationships while simultaneously addressing issues of heterogeneity and endogeneity. Our study employs the following approach:

$$\begin{aligned}
 SE_{it}(\rho/\alpha, u_{it}, x_{it}) \\
 = \alpha_0 + \alpha_{1\rho} IQ_{it} + \alpha_{2\rho} NRR_{it} + \alpha_{3\rho} UR_{it} + \alpha_{4\rho} UN_{it} \\
 + \alpha_{5\rho} FDI_{it} + u_{it}
 \end{aligned} \tag{6}$$

where, ρ represents the quantiles ranging from zero to one, corresponding to ρ th conditional quantile $(\rho/\alpha, u_{it}, x_{it})$; whereas, in eq. (16) below, IQ contributes to the model as a moderating factor in terms of IQ_NRR :

$$\begin{aligned}
 SE_{it}(\rho/\alpha, u_{it}, x_{it}) \\
 = \alpha_0 + \alpha_{1\rho} IQ_{it} + \alpha_{2\rho} NRR_{it} + \alpha_{3\rho} IQ_NRR_{it} \\
 + \alpha_{4\rho} UR_{it} + \alpha_{5\rho} UN_{it} + \alpha_{6\rho} FDI_{it} + u_{it}
 \end{aligned} \tag{7}$$

4.4.2. MMQR: Natural Resources, Circular Economy, & Environmental Sustainability

Functions:

$$ENS_{it} = f(NRR_{it}, Inf_{it} DCP_{it}, GCF_{it}, RSP_{it}) \tag{8}$$

$$CE_{it} = f(NRR_{it}, CPI_{it}, GET_{it}, EGS_{it}, EMS_{it}, GDP_{it}) \tag{9}$$

$$BIC_{it} = f(CE_{it}, GFC_{it}, GDP_{it}, GET_{it}, MCA_{it}) \tag{10}$$

$$EFP_{it} = f(CE_{it}, GFC_{it}, GDP_{it}, GET_{it}, MCA_{it}) \tag{11}$$

$$ENS_{it} = f(CE_{it}, REC_{it}, GFC_{it}, GDP_{it}, MCA_{it}) \tag{12}$$

$$ENS_{it} = f(NRC_CE_{it}, REC_{it}, GFC_{it}, GDP_{it}, MCA_{it}) \tag{13}$$

The variables are explained in Table 1. In these equations, the subscript "i" refers to cross-sectional units, such as the individual European countries in this study. The subscript "t" denotes the time span from 2005 to 2021.

Models:

$$ENS_{it} = \delta_{0i} + \theta_1 NRR_{it} + \theta_2 Inf_{it} + \theta_3 DCP_{it} + \theta_4 GCF_{it} + \theta_5 RSP_{it} + \varepsilon_{it} \quad 14$$

$$CE_{it} = \delta_{0i} + \theta_1 NRR_{it} + \theta_2 CPI_{it} + \theta_3 EMS_{it} + \theta_4 GDP_{it} + \theta_5 RSP_{it} + \varepsilon_{it} \quad 15$$

$$BIC_{it} = \delta_{0i} + \theta_1 CE_{it} + \theta_2 GFC_{it} + \theta_3 GET_{it} + \theta_4 GDP_{it} + \theta_5 MCA_{it} + \varepsilon_{it} \quad 16$$

$$EFP_{it} = \delta_{0i} + \theta_1 CE_{it} + \theta_2 GFC_{it} + \theta_3 GET_{it} + \theta_4 GDP_{it} + \theta_5 MCA_{it} + \varepsilon_{it} \quad 17$$

$$ENS_{it} = \delta_{0i} + \theta_1 CE_{it} + \theta_2 REC_{it} + \theta_3 GFC_{it} + \theta_4 GDP_{it} + \theta_5 MCA_{it} + \varepsilon_{it} \quad 18$$

$$ENS_{it} = \delta_{0i} + \theta_1 NRC_CE_{it} + \theta_2 REC_{it} + \theta_3 GFC_{it} + \theta_4 GDP_{it} + \theta_5 MCA_{it} + \varepsilon_{it} \quad 19$$

In the aforementioned models, δ represents the intercept term, while θ_i ($i = 1-5$) denotes the coefficients of the independent variables across the models. Additionally, ε_{it} accounts for the unobserved factors not included in the model.

4.4.3. MMQR: Political Stability & Shadow Economy

Functions:

$$PS = f(Lag_SE, RQ, ULF, IGA) \quad 20$$

$$PS = f(GDP, RQ, ULF, IGA) \quad 21$$

Models:

$$PS_{it} = \alpha + \beta_1 Lag_SE_{it} + \beta_2 RQ_{it} + \beta_3 (Lag_IE \times RQ)_{it} + \beta_4 ULF_{it} + \beta_5 IGA_{it} + \varepsilon_{it} \quad 22$$

$$PS_{it} = \alpha + \beta_1 FE_{it} + \beta_2 RQ_{it} + \beta_3 ULF_{it} + \beta_4 IGA_{it} + \varepsilon_{it} \quad 23$$

Where α represents the intercept term, β_i denotes the coefficients of the independent variables, ε_{it} is the error term capturing unobserved heterogeneity, i indicates the cross-sectional unit (country), and t represents the time period.

5. CHAPTER: RESULTS OF PRE-ESTIMATION TECHNIQUES

5.1. Natural Resources, Institutional Quality, and Shadow Economy

Table 14 shows the estimated results of the CSD test. The reported values reject the null hypothesis within conventional C.I., thus indicating the presence of CSD in the data. However, IQ and Unm display mixed results, with CSD present in some country groups. The results of the unit root tests are presented in Tables 15-17, covering different country groups. The study employs CIPS and CADF tests, both at level and first difference, with and without a trend. Across country groups, most variables at level suggest that lag values influence future data points, indicating non-stationary data. However, at first difference, stationarity is present. Given that data are integrated of order I(1), the study applies several cointegration tests to identify long-run relationships, as reported in Table 18. The Westerlund (2007) test shows significant cointegration for HICs, LMICs, and all countries at 5% significance level. Additionally, the Modified Phillips-Perron t-test, the Phillips-Perron and Augmented Dickey-Fuller t-tests highlight the existence of long-run cointegrated relationships within specific groups.

Variables	All countries		HICs		HIMCs		LMICs		LICs	
	CSD-test	p-value	CSD-test	p-value	CSD-test	p-value	CSD-test	p-value	CSD-test	p-value
SE	167.49	.00	45.41	.00	58.98	.00	74.87	.00	13.58	.00
IQ	1.10	.19	0.13	.90	1.49	.14	4.61	.00	.46	.64
NRR	77.29	.00	37.18	.00	24.92	.00	24.85	.00	12.47	.00
IQ_NRR	1.29	.20	27.43	.00	3.99	.00	16.98	.00	5.98	.00
Urb	261.38	.00	62.13	.00	63.32	.00	81.73	.00	51.55	.00
Unm	7.14	.00	19.64	.00	5.01	.00	1.24	.21	-.67	.51
FDI	31.11	.00	17.12	.00	7.26	.00	9.54	.00	7.85	.00

Table 14: Cross-Sectional Dependence Test

Source: Created by the author.

Variables	All countries				HICs			
	CIPS	CIPS	CADF	CADF	CIPS	CIPS	CADF	CADF
	(I0) trend	(I1) trend	(I0)	(I1)	(I0) trend	(I1) trend	(I0)	(I1)
SE	-2.18	-3.95***	1.57	-2.02***	-2.05	-3.28***	-2.11	-2.71***
IQ	-2.48	-4.14***	-1.40	-2.07	-2.67	-4.56***	-2.18	-3.22***
NRR	-2.86	-4.18***	-2.84***	-3.28***	-2.54	-4.20***	-2.13	-3.55***
IQ_NRR	-2.75***	-4.19 ***	-2.99***	-3.50 ***	-2.69	-4.50***	-2.18	-3.59***
Urb	-1.37	-2.88***	-1.94	-2.75	-2.42	-2.55*	-1.87	-2.66***
Unm	-2.05	-3.80***	-1.57	-2.16	-2.58	-3.66***	-2.56**	-2.61***
FDI	-5.30 ***	-5.47***	-1.91**	-2.87	-3.71***	-5.45***	-2.43	-2.72***

Notes: *, **, *** indicates statistically significant estimates within 90, 95 and 99% C.I. respectively.

Table 15: Panel Unit Root Test Results

Source: Created by the author.

Variables	HMICs				LMICs			
	CIPS	CIPS	CADF	CADF	CIPS	CIPS	CADF	CADF
	(I0) trend	(I1) trend	(I0)	(I1)	(I0) trend	(I1) trend	(I0)	(I1)
SE	-2.07	-3.92***	-2.18	-3.182***	-2.38	-4.10***	-1.84	-3.29***
IQ	-2.52	-3.99***	-2.21	-2.71	-2.38	-4.14***	-2.17	-3.20***
NRR	-2.59*	-4.40***	-2.34	-3.58***	-2.62*	-4.15***	-2.37	-3.22***
IQ_NRR	-2.20	-4.67***	-2.02	-3.37***	-2.22	-4.13***	-2.13	-2.93***
Urb	-1.68	-2.89***	-2.05	-2.36	-1.42	-2.66**	-1.64	-2.51*
Unm	-2.40	-3.67***	-2.56	-2.84***	-1.82	-4.09***	-1.51	-3.20***
FDI	-3.57	-5.24***	-2.80	-2.87***	-3.35***	-5.37***	-2.32	-3.75***

Notes: *, **, *** indicates statistically significant estimates within 90, 95 and 99% C.I. respectively.

Table 16: Panel Unit Root Test for HMICs and LMICs

Source: Created by the author.

	CIPS	CIPS	CADF	CADF
	(I0) trend	(I1) trend	(I0)	(I1)
SE	-2.8	-4.57***	-2.89***	-3.62***
IQ	-2.3	-3.78***	-2.50	-2.83***
NRR	-2.3	-4.11***	-1.60	-2.99***
IQ_NRR ³	-2.0	-3.97***	-1.70	-2.87***
Urb	-1.0	-2.29***	-.80	-2.70
Unm	-2.1	-3.37***	-1.60	-3.05***
FDI	-3.0	-5.03***	-3.80	-1.82***

Notes: *, **, *** indicates statistically significant estimates within 90, 95 and 99% C.I. respectively.

Table 17: Panel Unit Root Test for LICs

Source: Created by the author.

Test	All countries		HICs		HMICS		LMICs		LICs	
	Stat.	p-value	Stat	p-value	Stat.	p-value	Stat.	p-value	Stat.	p-value
Westerlund (2007)	2.14	.02	2.85	.00	-0.99	.16	2.12	.02	-0.38	.35
Westerlund_trend (2007)	4.31	.00	3.65	.00	1.11	.13	3.49	.00	.57	.28
Modified Phillips–Perron t	12.63	.00	7.91	.00	5.40	.00	7.24	.00	3.70	.00
Phillips–Perron t	-3.07	.00	1.33	.09	-4.21	.00	-1.74	.04	-2.66	.00
Augmented Dickey–Fuller t	-3.84	.00	1.47	.07	-4.90	.00	-2.62	.00	-2.80	.00

Table 18: Cointegration Test.

Source: Created by the author.

5.2. Natural Resources, Circular Economy, and Environmental Sustainability

The results of the Cross-Sectional Dependence (CSD) test are presented in Table 19. In this test, the null hypothesis assumes no dependence within countries, while the alternative hypothesis confirms the presence of cross-sectional dependency. The test results indicate the presence of CSD in the data, implying that ENS, CE, REC, GFC, GDP, and MVA are all associated with cross-sectional dependence.

³ NRR with the moderation of IQ.

Variables	CD-test	p-value
ENS	24.04	0.00
CE	31.21	0.00
REC	44.38	0.00
GFC	20.97	0.00
GDP	38.37	0.00
MVA	30.72	0.00

Table 19: Cross-Section Dependence (CSD) Test

Source: Created by the author.

Given the presence of cross-sectional dependence (CSD) in the dataset, the study employs second-generation unit root tests, such as the Cross-Sectionally Augmented Dickey-Fuller (CADF) and the Cross-Sectionally Augmented IPS (CIPS) tests. The results, presented in Table 20, indicate that most variables exhibit non-stationarity at levels, failing to the rejection of the null hypothesis of non-stationarity. However, after applying first-difference transformations, the findings confirm that most variables achieve stationarity at the I(1) level, which ensures the robustness of subsequent econometric analyses by addressing issues related to data stationarity.

	CIPS		CADF	
Variables	Level	Difference	Level	Difference
BIC	-1.81	-5.28***	-2.00	-3.64***
EFP	-2.40**	-4.52***	-1.92	-2.60***
ENS	-2.93***	-4.98***	-2.08	-2.68***
CPI	-1.31	-2.35**	-1.71	-2.09
EMS	-2.00	-2.95***	-2.39**	-2.57***
EXP	-1.016	-2.69***	-1.30	-2.25***
GFC	-1.88	-3.63***	-1.81	-2.78***
GDP	-2.80***	-4.32***	-2.19**	-2.91***
GET	-2.11	-4.65***	-1.64	-2.83***
GCF	-2.03	-3.16***	-2.26**	-3.42***
Inf	-2.50***	-4.09***	-2.32	-2.88***
MVA	-3.04***	-4.83***	-2.41	-3.14***
REC	-2.07	-3.87***	-2.16	-3.00***
NRR	-2.33**	-3.18***	-2.69**	-3.34***
RSP	-1.93	-3.87***	-2.34	-2.87***
DCP	-1.28	-2.59***	-2.22	-2.72**
CE	-2.07	-4.34***	-1.71	-2.79**
NRR CE	-2.00	-3.25***	-2.66	-2.93**

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

Table 20: Results of CIPS and CADF

Source: Created by the author.

The cointegration analysis indicates a long-run relationship among the variables. The cointegration tests, developed by Westerlund (2007), are presented in Table 21. Four test statistics exist: Gt, Ga, Pt, and Pa. Each represents cointegration tests from different perspectives. Gt, Ga, and Pa do not show significant evidence of cointegration, while Pt statistic provides significant evidence of cointegration, rejecting the null hypothesis.

Statistic	T Statistics	P-value
Gt	-2.520	0.718
Ga	-3.702	1.000
Pt	-16.976	0.000
Pa	-4.968	1.000

Table 21: Westerlund Cointegration Test

Source: Created by the author.

5.3. Political Stability & Shadow Economy

The cross-sectional dependence (CSD) test reports in Table 22. Due to global trade, commerce, and the exchange of information and technology, countries demonstrate interdependence. In most cases, the null hypothesis of no cross-sectional dependence is rejected, indicating that the variables under consideration are indeed correlated across countries. This suggests that the dynamics in one country are closely linked to those in others, highlighting the interconnectedness in the global economic and technological advancements.

Variables	CD-test	P-value
PS	17.62	00
SE	167.49	00
RQ	0.429	0.66
ULF	7.14	00
IGA	54.19	00
FE	60.335	00

Table 22: Cross-Section Dependence Test

Source: Created by the author.

In the presence of cross-sectional dependence (CSD), first-generation unit root tests are inadequate as they assume no such dependence between countries. To address this, the study employs second-generation unit root tests, specifically the Cross-Sectionally

Augmented Dickey-Fuller (CADF) and Cross-Sectionally Augmented IPS (CIPS) tests. The results, presented in Table 23, indicate that the variables are non-stationary at the level, but become stationary after taking the first difference. This confirms that the data shows a unit root at the level, but is stationary after differencing, accounting for the CSD across the countries.

Variables	CIPS		CADF	
	Level	Difference	Level	Difference
PS	-2.249***	-4.561***	-2.329	-3.357***
SE	-1.970	-3.861***	-2.250	-3.111***
RQ	-1.961	-4.408***	-2.110	-3.182***
ULF	-1.350	-3.471***	-2.269	-2.922***
IGA	-3.983***	-5.654***	-3.054***	-4.303***
FE	-3.401***	-5.454***	-2.942***	-4.379***
Note: *** at 1% level of significance, ** at 5% level of significance, * at 10% level of significance.				

Table 23: Results of CIPS and CADF

Source: Authors

After identifying the unit root and cross-sectional dependence (CSD), the study proceeds to apply the cointegration tests developed by Westerlund (2007) and Pedroni (1999, 2004) to examine the long-term relationship between the variables. The results of these tests, presented in Table 24, confirm that the variables are cointegrated, indicating a stable long-run relationship. This finding highlights the existence of a significant equilibrium relationship between the variables, suggesting that they move together over time despite short-term fluctuations.

Test	T Statistics	P value
Westerlund (2007)	4.735	0.000
Westerlund_trend (2007)	4.680	0.000
Modified Phillips–Perron t	9.6304	0.000
Phillips–Perron t	-2.374	0.000
Augmented Dickey-Fuller t	-2.425	0.000

Table 24: Cointegration Test

Source: Created by the author.

6. CHAPTER: RESULT & DISCUSSION

6.1. Result of Natural Resources, Institutional Quality, and Shadow economy

The estimated results in Table 25-29, indicate that IQ has a significant negative effect on SE. This suggests that an improvement in IQ contributes to a reduction in shadow economic activities across all country groups. Additionally, IQ presents a robust negative impact on both LICs and HICs across all quantiles. However, for LMICs, IQ significantly influences SE only in lower quantiles, while for HMICs, IQ substantially reduces SE in lower and middle quantiles. This demonstrates that better IQ encourages participation in the formal economy by securing property rights and establishing competitive, rule-based market structures. Additionally, strong institutions help control corruption and reduce tax evasion, ultimately decreasing the size of SE. These findings are consistent with previous studies by Dang et al. (2022), Huynh et al. (2020), and Khan & Rehman (2022).

Also, NRR yields an insightful result, showing that NRR generally helps reducing SE across various country groups, except for LICs. NRR significantly reduces SE in all countries, as well as in HMICs and HICs. For LMICs, NRR has a substantial negative impact only in upper quantiles. Generally, HICs and HMICs have strong IQ, technology-based infrastructures, and good governance, which facilitate the efficient management of NRR.

Number of observations (2,852)					Pseudo R ² (from 0.254 to 0.257)				
SE	Q _{0.10}	Q _{0.20}	Q _{0.30}	Q _{0.40}	Q _{0.50}	Q _{0.60}	Q _{0.70}	Q _{0.80}	Q _{0.90}
IQ	-0.12***	-0.117***	-0.114***	-0.112***	-0.109***	-0.107***	-0.104***	-0.102***	-0.099***
	(.017)	(.015)	(.013)	(.012)	(.012)	(.013)	(.014)	(.015)	(.017)
NRR	-0.014*	-0.021***	-0.027***	-0.034***	-0.04***	-0.047***	-0.053***	-0.058***	-0.066***
	(.008)	(.007)	(.006)	(.006)	(.006)	(.006)	(.006)	(.007)	(.008)
IQ_NRR ¹	-0.025***	-0.028***	-0.031***	-0.034***	-0.036***	-0.039***	-0.042***	-0.044***	-0.047***
	(.009)	(.008)	(.007)	(.007)	(.006)	(.007)	(.007)	(.008)	(.009)
Urb	-0.304***	-0.299***	-0.296***	-0.292***	-0.288***	-0.284***	-0.28***	-0.276***	-0.272***
	(.016)	(.015)	(.013)	(.012)	(.012)	(.013)	(.013)	(.015)	(.017)
Unm	0.076***	0.077***	0.077***	0.078***	0.079***	0.08***	0.08***	0.081***	0.082***
	(.006)	(.005)	(.005)	(.004)	(.004)	(.004)	(.005)	(.005)	(.006)
FDI	0.004***	0.003**	0.003**	0.002*	0.001	0.001	0.0001	-0.001	-0.001
	(.002)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.002)

Notes: *, **, *** indicates statistically significant estimates within 90, 95 and 99% C.I. respectively. Values in parenthesis refers to standard errors. ¹NRR with the moderation of IQ.

Table 25: MMQR Result for All Countries

Source: Created by the author.

Number of observations (920) Number of groups (124)					Pseudo R ² (from 0.173 to 0.288) Wald chi ² (141.95) & Prob > chi ² (0.00)				
	Q _{0.10}	Q _{0.20}	Q _{0.30}	Q _{0.40}	Q _{0.50}	Q _{0.60}	Q _{0.70}	Q _{0.80}	Q _{0.90}
IQ	-.103***	-.109***	-.114***	-.12***	-.127***	-.133***	-.138***	-.144***	-.152***
	(.023)	(.021)	(.02)	(.019)	(.02)	(.021)	(.023)	(.026)	(.031)
NRR	-.043**	-.05***	-.057***	-.065***	-.074***	-.082***	-.089***	-.098***	-.109***
	(.017)	(.016)	(.015)	(.014)	(.015)	(.016)	(.017)	(.019)	(.023)
IQ_NRR ¹	-.032***	-.031***	-.029***	-.027***	-.025***	-.024**	-.022**	-.02*	-.018
	(.011)	(.01)	(.009)	(.009)	(.009)	(.01)	(.011)	(.012)	(.014)
Urb	-.159***	-.152***	-.146***	-.138***	-.129***	-.122***	-.115***	-.107***	-.097***
	(.023)	(.021)	(.02)	(.019)	(.02)	(.021)	(.023)	(.026)	(.03)
Unm	.091***	.091***	.091***	.091***	.091***	.092***	.092***	.092***	.092***
	(.008)	(.007)	(.006)	(.006)	(.006)	(.007)	(.008)	(.009)	(.01)
FDI	.011***	.008***	.006**	.004	.001	-.001	-.003	-.006	-.009**
	(.004)	(.003)	(.003)	(.003)	(.003)	(.003)	(.004)	(.004)	(.005)

Notes: *** 1% level of significance, **5% level of significance, *1% level of significance; values in parenthesis refers to standard errors. ¹NRR with the moderation of IQ.

Table 26: MMQR Estimated Results for HICs

Source: Created by the author.

Number of observations (644)					Pseudo R ² (from 0.102 to 0.071)				
SE	Q _{0.10}	Q _{0.20}	Q _{0.30}	Q _{0.40}	Q _{0.50}	Q _{0.60}	Q _{0.70}	Q _{0.80}	Q _{0.90}
IQ	-.078	-.071	-.064	-.058	-.052	-.044	-.037	-.033*	-.025
	(.322)	(.272)	(.22)	(.18)	(.135)	(.074)	(.03)	(.017)	(.061)
NRR	-.07	-.076	-.082	-.088	-.093	-.101	-.107***	-.111***	-.118**
	(.308)	(.26)	(.211)	(.172)	(.129)	(.071)	(.028)	(.016)	(.059)
IQ_NRR ¹	-.065	-.07	-.076	-.08	-.084	-.091	-.095***	-.099***	-.104
	(.346)	(.292)	(.237)	(.193)	(.145)	(.08)	(.032)	(.018)	(.066)
Urb	-.216	-.217	-.218	-.219	-.219*	-.221***	-.221***	-.222***	-.223***
	(.314)	(.265)	(.215)	(.176)	(.132)	(.072)	(.029)	(.016)	(.06)
Unm	.14	.144	.147	.149	.152	.156***	.159***	.161***	.165***
	(.255)	(.215)	(.174)	(.142)	(.107)	(.059)	(.024)	(.013)	(.048)
FDI	.023	.021	.019	.017	.015	.013	.011	.009**	.007
	(.084)	(.071)	(.058)	(.047)	(.035)	(.019)	(.008)	(.004)	(.016)

Notes: *** 1% level of significance, **5% level of significance, *1% level of significance; values in parenthesis refer to standard errors. 1NRR with the moderation of IQ.

Table 27: MMQR Estimated Results for HMICs

Source: Created by the author.

Number of observations (920)					Pseudo R ² (from 0.155 to 0.22)				
SE	Q _{0.10}	Q _{0.20}	Q _{0.30}	Q _{0.40}	Q _{0.50}	Q _{0.60}	Q _{0.70}	Q _{0.80}	Q _{0.90}
IQ	-.044**	-.036**	-.03**	-.024*	-.018	-.012	-.005	0	.008
	(.017)	(.015)	(.014)	(.013)	(.013)	(.014)	(.015)	(.016)	(.019)
NRR	.005	-.001	-.007	-.012	-.017	-.022**	-.028**	-.032**	-.039***
	(.014)	(.012)	(.011)	(.011)	(.011)	(.011)	(.012)	(.013)	(.015)
IQ_NRR ¹	-.01	-.016	-.022	-.027**	-.031**	-.036***	-.042***	-.046***	-.053***
	(.017)	(.015)	(.014)	(.014)	(.013)	(.014)	(.015)	(.016)	(.019)
Urb	-.298***	-.296***	-.294***	-.292***	-.29***	-.288***	-.286***	-.284***	-.281***
	(.025)	(.022)	(.02)	(.019)	(.019)	(.02)	(.021)	(.023)	(.027)
Unm	.09***	.087***	.085***	.082***	.08***	.078***	.076***	.074***	.071***
	(.015)	(.013)	(.012)	(.012)	(.012)	(.012)	(.013)	(.014)	(.016)
FDI	-.006	-.005	-.004	-.003	-.002	-.001	0	.001	.003
	(.005)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.005)	(.005)

Notes: *** 1% level of significance, **5% level of significance, *1% level of significance; values in parenthesis refers to standard errors. 1NRR with the moderation of IQ.

Table 28: MMQR Estimated Results for LMICs

Source: Created by the author.

Number of observations (391)					Pseudo R ² (from 0.115 to 0.316)				
SE	Q _{0.10}	Q _{0.20}	Q _{0.30}	Q _{0.40}	Q _{0.50}	Q _{0.60}	Q _{0.70}	Q _{0.80}	Q _{0.90}
IQ	-.455***	-.459***	-.462***	-.464***	-.466***	-.468***	-.47***	-.473***	-.475***
	(.176)	(.135)	(.113)	(.091)	(.074)	(.062)	(.053)	(.055)	(.067)
NRR	.618*	.504*	.44**	.372**	.313**	.261**	.205*	.123	.059
	(.346)	(.266)	(.223)	(.18)	(.147)	(.122)	(.107)	(.109)	(.134)
IQ_NRR ¹	.799*	.664*	.589*	.509**	.44**	.379**	.313**	.217	.141
	(.471)	(.361)	(.303)	(.245)	(.199)	(.166)	(.144)	(.149)	(.182)
Urb	-.744***	-.743***	-.742***	-.742***	-.741***	-.74***	-.74***	-.739***	-.738***
	(.267)	(.205)	(.172)	(.138)	(.113)	(.094)	(.081)	(.084)	(.102)
Unm	-.397	-.33*	-.293*	-.254*	-.22**	-.189**	-.157**	-.11	-.072
	(.26)	(.199)	(.167)	(.135)	(.11)	(.092)	(.08)	(.082)	(.1)
FDI	-.035	-.024	-.018	-.012	-.007	-.002	.003	.01	.016
	(.086)	(.066)	(.055)	(.045)	(.036)	(.03)	(.026)	(.027)	(.033)
Notes: *** 1% level of significance, **5% level of significance, *1% level of significance; values in parenthesis refers to standard errors. ¹ NRR with the moderation of IQ.									

Table 29: MMQR Result for LICs

Source: Authors' own elaborations.

Strong institutional structures also help minimising the mismanagement of revenues from natural resources and prevent corruption. As a result, in HICs and HMICs, NRR is beneficial to the economy (Hussain et al., 2009), thus helping reducing SE. This argument is supported by Singh et al. (2023). Furthermore, theoretical predictions suggest that NRR, when coupled with high IQ, promotes formal economic development (Fagbemi & Kotey, 2022), thereby diminishing SE. Although NRR in LMICs does not consistently affect SE, it is significant only in higher quantiles. In contrast, NRR in LICs shows a positive relationship with SE, indicating that NRR significantly increases SE. This occurs because the investment and expenditure required for natural resource extraction diminish opportunities for the formal economy, causing more labour and firms to shift to the shadow sector (Kpogonon, 2022a). Additionally, Gerelmaa and Kotani (2016) and Ploeg (2011) found that NRR can either hinder or help economic development depending on the country. In LICs, NRR can hinder economic development due to weak IQ and poor resource management.

The control variables produce estimated results consistent with economic theory. Urb plays a substantial role in reducing SE across all countries and groups. The transition from rural to urban areas increases government oversight and the regulation of economic activities (Mora & Saunoris, 2022), which in turn reduces SE. On the other hand, Unm

shows a significant positive impact on SE in all country groups (Medina & Schneider, 2018; Remeikiene & Gaspareniene, 2021; Zhanabekov, 2022), except for LICs. In these latter group of countries, the relationship between Unm and SE may be influenced by the complementary relationship between corruption and SE (Riaz & Hayat, 2022), which might explain why Unm could potentially decrease SE in these countries. Finally, FDI shows a negative impact on SE, but exhibits sporadic significance across different quantiles and country groups.

6.2. Result of Natural Resources, Circular Economy, & Environmental Sustainability

6.2.1. Nexus NRR and ENS

The study initially examines the influence of natural resource rent (NRR) on environmental sustainability (ENS). Applying the Method of Moments Quantile Regression (MMQR), the results presented in Table 30 reveal that NRR has a significant negative impact on ENS, particularly in the middle and upper quantiles. The higher quantiles of ENS refer to better environmental quality. The findings certify that excessive use of NRR threatens environmental quality. Hence, excessive reliance on NRR negatively impacts environmental quality. The extraction of natural resources possibly leads to inefficient institutions (Acemoglu et al., 2001), provoking rent-seeking attitudes and conflict within societies (Hodler, 2006). The poor institutional quality enhances corruption, undermining waste management. It also increases environmental pollution (Karim et al., 2022). The dependence on natural resources intensifies their extraction, leading to ecological loss and a decline in biocapacity, which undermines the sustainable development process by deteriorating environmental quality (Cai et al., 2023; Downey et al., 2010; Nguyen et al., 2023). These findings underscore the critical need for sustainable practices to mitigate the adverse effects of NRR on ENS. Transitioning to alternative sustainable investments can reduce excessive reliance on NRR, thereby improving ENS outcomes. However, NRR does not have a significant negative effect on lower quantiles up to the 40th percentile, which suggests that, to some extent, the use of NRR does not necessarily harm environmental quality.

NRR on environmental quality varies significantly across different regions. In South Asia, for example, excessive reliance on NRR contributes to environmental degradation,

particularly through increased carbon emissions (Y. Li et al., 2022). Similarly, reducing dependence on natural resources has improved environmental quality in China, primarily due to strengthened environmental policies (J. Li et al., 2023). Additionally, in Sub-Saharan Africa, the negative effects of NRR on the environment are exacerbated by poor institutional quality, leading to higher carbon emissions (Befeke et al., 2023; Kwakwa, 2025). A study of 16 EU countries concluded that, in general, NRR has a long-term negative effect on the environment by increasing CO₂ emissions (Bekun et al., 2019). However, in countries such as Germany, France, Italy, Spain, and the United Kingdom, NRR has had a more positive impact on environmental quality, largely due to stronger institutional frameworks (Balsalobre-Lorente et al., 2018). In BRICS countries, the effects of NRR on carbon emissions are more heterogeneous: while it has helped reduce CO₂ emissions in Russia, it has increased emissions in South Africa (Danish et al., 2019). Additionally, the analysis incorporates control variables, including inflation (Inf), gross capital formation (GCF), and domestic credit to the private sector (DCP). Inflation emerges as a significant deterrent to investments in ENS by increasing economic uncertainty, undermining sustainable initiatives' long-term feasibility (Rahman et al., 2024). Conversely, DCP allocated to sustainable sectors enhances ENS by promoting resource efficiency, whereas investments in unsustainable sectors detract from it. Furthermore, resource productivity (RSP) positively contributes to ENS by optimizing the use of resources and minimizing waste. These findings highlight the subtle dynamics between economic variables and ENS.

ENS	Location	Scale	Q _{0.10}	Q _{0.20}	Q _{0.30}	Q _{0.40}	Q _{0.50}	Q _{0.60}	Q _{0.70}	Q _{0.80}	Q _{0.90}
NRR	-.011*	-.004	-.005	-.007	-.008	-.009	-.01*	-.012*	-.013**	-.015*	-.018*
	(.006)	(.004)	(0.008)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.008)	(0.01)
Inf	-.008**	-.0004	-.008*	-.008**	-.008**	-.008**	-.008**	-.008**	-.009**	-.009**	-.009
	(.003)	(.002)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.006)
DCP	.0004*	-.0001	.001**	.001**	.001**	.0005**	.0004**	.0004*	.0003	.0003	.0001
	(.0002)	(.0002)	(0.0003)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0003)	(0.0003)	(0.0004)
GCF	-.004***	.001	-.006***	-.005***	-.005***	-.004***	-.004***	-.004***	-.003**	-.003	-.002
	(.001)	(.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
RSP	.06***	.004	.054***	.056***	.057***	.058***	.06***	.061***	.063***	.065***	.069***
	(.011)	(.008)	(0.015)	(0.012)	(0.012)	(0.011)	(0.011)	(0.012)	(0.013)	(0.015)	(0.02)

Notes: Standard errors are in parentheses,
*** p<0.01, ** p<0.05, * p<0.1

Table 30: MMQR Results: NRR on ENS

Source: Created by the author.

6.2.2. Robustness: FMOLS Model

To further explore the nexus between natural resource rent (NRR) and environmental sustainability (ENS), the study employs the Fully Modified Ordinary Least Squares (FMOLS) method, which validates the earlier findings. The FMOLS results (Table 31) confirm that NRR negatively impacts ENS, indicating that increased extraction of natural capital significantly deteriorates environmental quality in the long run. These findings reinforce the critical need for sustainable practices to mitigate the adverse environmental effects of excessive reliance on NRR.

	ENS
NRR	-0.012* (0.007)
Inf	-0.008** (0.003)
DCP	0.0002 (0.0003)
GFC	-0.004** 0.001
RSP	0.057** (0.02)

Notes: T statistics in parentheses, Critical value (T-5): 4.03, 2.57, 2.01 at 1%, 5%, 10% significance level successively. *** p<0.01, ** p<0.05, * p<0.10

Table 31: FMOLS Results- NRR on ENS

Source: Created by the author.

6.2.3. Nexus CE and NRR

The second model examines the influence of natural resource rent (NRR) on circular economy (CE). The empirical findings presented in Table 32 demonstrate that NRR significantly enhances CE practices, particularly in upper quantiles. The relationship between NRR and CE practices exhibits a dual nature: NRR can either catalyze or impede CE development, contingent upon the prudence of natural capital investment and management strategies. CE ensures that materials within an economy are subject to continuous reuse, recycling, and recovery cycles rather than being discarded after a single use (Ghisellini et al., 2016). NRR in European Union countries facilitates a renewable and recyclable raw-material loop, thereby establishing channels for sustainable

production and consumption patterns (Bianchi & Cordella, 2023). Moreover, the strategic integration of NRR through resource-efficient and sustainable approaches accelerates the adoption of enhanced CE practices.

For instance, effective NRR management promotes the sustainable utilization of renewable resources, such as minerals, across multiple life cycles. This process inherently supports waste reduction initiatives and minimizes raw material consumption. Consequently, NRR creates a viable pathway for systematically developing and implementing CE practices.

CE	Location	Scale	Q _{0.10}	Q _{0.20}	Q _{0.30}	Q _{0.40}	Q _{0.50}	Q _{0.60}	Q _{0.70}	Q _{0.80}	Q _{0.90}
NRR	.062	.07**	-.048	-.016	.01	.032	.057	.084	.117**	.14**	.168**
	(.053)	(.03)	(.068)	(.06)	(.056)	(.054)	(.053)	(.055)	(.06)	(.064)	(.072)
CPI	.017***	.0002	.017***	.017***	.017***	.017***	.017***	.017***	.018***	.018***	.018***
	(.004)	(.002)	(.005)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.005)
EMS	.141***	-.002	.145***	.144***	.143***	.142***	.141***	.14***	.139***	.138***	.137***
	(.013)	(.007)	(.017)	(.015)	(.014)	(.013)	(.013)	(.014)	(.015)	(.016)	(.018)
EXP	.011***	-.0005	.012**	.012***	.012***	.011***	.011***	.011***	.011***	.011**	.011**
	(.004)	(.002)	(.005)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.005)
GDP	.003	.001	.002	.002	.002	.003	.003	.003	.004	.004	.005
	(.007)	(.004)	(.008)	(.007)	(.007)	(.007)	(.006)	(.007)	(.007)	(.008)	(.009)

Notes: Standard errors are in parentheses

*** p<.01, ** p<.05, * p<.1

Table 32: MMQR Result- NRR on CE

Source: Created by the author.

6.2.4. Robustness

The nexus is further validated by including additional control variables. In Table 33, the study introduces a new control variable alongside the existing ones. The results confirm that NRR has a significant positive impact on enhancing CE practices. To strengthen the analysis, the study also applies the Fully Modified Ordinary Least Squares (FMOLS) method (Table 34) to examine the relationship between NRR and CE using the same set of control variables. The findings from FMOLS consistently indicate that NRR significantly contributes to the development and advancement of CE practices, reinforcing the robustness of the nexus.

CE	Location	Scale	Q _{0.10}	Q _{0.20}	Q _{0.30}	Q _{0.40}	Q _{0.50}	Q _{0.60}	Q _{0.70}	Q _{0.80}	Q _{0.90}
NRR	.056	.062**	-.039	-.014	.007	.03	.055	.082	.104*	.125**	.151**
	(.052)	(.029)	(.067)	(.061)	(.057)	(.053)	(.052)	(.054)	(.056)	(.061)	(.068)
GET	.02**	.006	.011	.013	.015	.017*	.02**	.022**	.024**	.026**	.029**
	(.009)	(.005)	(.012)	(.011)	(.01)	(.01)	(.01)	(.01)	(.01)	(.011)	(.012)
CPI	.018***	-.0003	.018***	.018***	.018***	.018***	.018***	.018***	.017***	.017***	.017***
	(.004)	(.002)	(.005)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.005)
EMS	.137***	-.003	.142***	.141***	.14***	.138***	.137***	.136***	.135***	.134***	.132***
	(.014)	(.008)	(.018)	(.016)	(.015)	(.014)	(.014)	(.014)	(.015)	(.016)	(.018)
EXP	.012***	.0003	.011**	.011***	.012***	.012***	.012***	.012***	.012***	.012***	.012**
	(.004)	(.002)	(.005)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.005)
GDP	.002	.001	-.0001	.0004	.001	.001	.002	.003	.003	.004	.004
	(.006)	(.004)	(.008)	(.007)	(.007)	(.007)	(.006)	(.007)	(.007)	(.007)	(.008)

Notes: Standard errors are in parentheses

*** p<.01, ** p<.05, * p<.1

Table 33: MMQR Result: NRR on CE

Source: Created by the author.

	CE
NRR	0.078*
	(0.044)
GET	0.027**
	(0.010)
CPI	0.018***
	(0.003)
EMS	0.135***
	(0.013)
EXP	0.012***
	(0.003)
GDP	0.003
	(0.006)

Notes: Standard error in parentheses

Critical value (T-5): 4.03, 2.57, 2.01 at 1%, 5%, 10% significance level successively.

*** p<0.01, ** p<0.05, * p<0.10

Table 34: FMOLS Result- NRR on CE

Source: Created by the author.

6.2.5. Nexus CE and BIC

The Circular Economy (CE) significantly contributes to biocapacity (BIC) enhancement through three primary mechanisms: efficient resource utilization, waste minimization, and waste regeneration systems (Ghisellini et al., 2016). Through the implementation of the 3R principles—Reduce, Reuse, and Recycle—CE practices effectively diminish the

demand for fresh raw materials (Liu et al., 2017). Additionally, regenerative activities associated with CE improve land-use efficiency and facilitate ecosystem restoration (Breure et al., 2018), enhancing biocapacity by improving a healthier and cleaner environment, as reported in Table 35.

Furthermore, government effectiveness (GET) substantially impacts BIC across all quantiles, underscoring its importance in supporting sustainable practices. However, government expenditure (GFC) negatively affects BIC in the middle and upper quantiles, highlighting potential inefficiencies or unsustainable practices in capital investments that may hinder environmental sustainability efforts.

BIC	Location	Scale	Q _{0.10}	Q _{0.20}	Q _{0.30}	Q _{0.40}	Q _{0.50}	Q _{0.60}	Q _{0.70}	Q _{0.80}	Q _{0.90}
CE	.049**	-.023*	.082***	.076***	.067***	.055**	.048**	.04*	.031	.023	.011
	(.023)	(.013)	(.029)	(.027)	(.025)	(.024)	(.023)	(.024)	(.026)	(.028)	(.032)
GFC	-.014**	-.01**	.0002	-.003	-.006	-.011	-.014**	-.018**	-.021***	-.025***	-.03***
	(.007)	(.004)	(.009)	(.008)	(.008)	(.007)	(.007)	(.007)	(.008)	(.008)	(.009)
GDP	-.004	-.0001	-.004	-.004	-.004	-.004	-.004	-.004	-.004	-.004	-.004
	(.008)	(.004)	(.01)	(.009)	(.009)	(.008)	(.008)	(.008)	(.009)	(.01)	(.011)
GET	.026***	.0002	.026***	.026***	.026***	.026***	.026***	.026***	.026***	.026***	.027***
	(.006)	(.003)	(.008)	(.007)	(.007)	(.006)	(.006)	(.006)	(.007)	(.007)	(.009)
MVA	-.003	.0002	-.004	-.003	-.003	-.003	-.003	-.003	-.003	-.003	-.003
	(.004)	(.002)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.005)

Notes: Standard errors are in parentheses

*** p<.01, ** p<.05, * p<.1

Table 35: MMQR Result: CE on BIC

Source: Created by the author.

6.2.6. Robustness CE and BIC

FMOLS results further confirm that the circular economy (CE) significantly contributes to biocapacity (BIC) enhancement. In this model, the control variables align closely with the findings from the Method of Moments Quantile Regression (MMQR), reinforcing the robustness of the analysis (Table 36). These consistent results validate and strengthen the argument that CE is a critical pathway for improving BIC and promoting overall environmental quality.

	BIC
CE	0.049** (0.025)
GFC	-0.017** (0.005)
GDP	-0.004 (0.008)
GET	0.03*** (0.006)
MVA	-0.005 (0.003)

Notes: T statistics in parentheses

Critical value (T-5): 4.03, 2.57, 2.01 at 1%, 5%, 10% significance level successively.

*** p<0.01, ** p<0.05, * p<0.10

Table 36: FMOLS Result- CE on BIC

Source: Created by the author.

6.2.7. Nexus CE and EFP

This model examines the role of the Circular Economy (CE) in enhancing environmental sustainability through the reduction of Ecological Footprint (EFP). The empirical findings demonstrate that CE substantially contributes to EFP reduction, as shown in Table 37. By promoting sustainable production and consumption, CE practices improve waste management and optimize resource efficiency (Geissdoerfer et al., 2017). Through integrating sustainability objectives and mitigating environmental impacts, CE significantly reduces EFP (Bianchi & Cordella, 2023) while concurrently facilitating biocapacity (BIC) development.

EFP	Location	Scale	Q _{0.10}	Q _{0.20}	Q _{0.30}	Q _{0.40}	Q _{0.50}	Q _{0.60}	Q _{0.70}	Q _{0.80}	Q _{0.90}
CE	-.421*** (.049)	-.087*** (.029)	-.275*** (.069)	-.325*** (.06)	-.359*** (.054)	-.396*** (.051)	-.425*** (.05)	-.453*** (.051)	-.481*** (.053)	-.517*** (.058)	-.557*** (.066)
GFC	-.016 (.013)	-.012* (.008)	.005 (.018)	-.003 (.016)	-.007 (.014)	-.013 (.013)	-.017 (.013)	-.021 (.013)	-.025* (.014)	-.03** (.015)	-.036** (.017)
GDP	.06*** (.017)	.014 (.01)	.036 (.024)	.044** (.02)	.05*** (.019)	.056*** (.017)	.06*** (.017)	.065*** (.017)	.069*** (.018)	.075*** (.02)	.082*** (.023)
GET	.058*** (.013)	.006 (.007)	.048*** (.018)	.052*** (.015)	.054*** (.014)	.056*** (.013)	.058*** (.013)	.06*** (.013)	.062*** (.014)	.064*** (.015)	.067*** (.017)
MVA	-.021*** (.008)	-.006 (.005)	-.012 (.011)	-.015 (.01)	-.017** (.009)	-.02** (.008)	-.022*** (.008)	-.023*** (.008)	-.025*** (.009)	-.028*** (.009)	-.03*** (.011)

Notes: Standard errors are in parentheses

*** p<.01, ** p<.05, * p<.1

Table 37: MMQR Result- CE on EFP

Source: Created by the author.

6.2.8. Robustness FMOLS: CE and EFP

To ensure robustness, the study applies Fully Modified Ordinary Least Squares (FMOLS) as part of cross-validation in Table 38, further supporting the argument that the circular economy (CE) significantly reduces the ecological footprint (EFP). The model keeps the same set of control variables, which exhibit consistency with the findings from MMQR. This alignment strengthens the validity of the results and underscores the critical role of CE in promoting environmental sustainability.

	EFP
CE	-0.448*** (0.071)
GFC	-0.020 (0.015)
GDP	0.07*** (0.019)
GET	0.077*** (0.018)
MVA	-0.03*** (0.008)

Notes: Standard error in parentheses

Critical value (T-5): 4.03, 2.57, 2.01 at 1%, 5%, 10% significance level successively.

*** p<0.01, ** p<0.05, * p<0.10

Table 38: FMOLS Result- CE on EFP

Source: Created by the author.

6.2.9. Nexus CE and ENS

Having examined the impact of the circular economy (CE) on the Ecological Footprint (EFP) and Biocapacity (BIC), this study further investigates CE's influence on Environmental Sustainability (ENS). The findings demonstrate that CE practices significantly contribute to ENS improvement, with a powerful positive relationship observed across lower to middle quantiles (Table 39). CE operates through regenerative and closed-loop systems, enabling economic activities while minimizing resource consumption. This systematic approach reduces natural resources extraction (Bianchi & Cordella, 2023), preserving the ecosystem and promoting ENS. Furthermore, CE practices reduce dependence on fossil fuels, a major contributor to environmental degradation (Mutezo & Mulopo, 2021; Pintilie, 2021; Zhang, 2024). CE significantly improves environmental quality by minimizing fossil fuel consumption, reinforcing its

pivotal role in enhancing ENS. Additionally, renewable energy consumption (REC), as an integral component of CE, demonstrates a positive relationship with ENS across all quantiles, further underscoring CE's comprehensive contribution to sustainable development.

ENS	Location	Scale	Q _{0.10}	Q _{0.20}	Q _{0.30}	Q _{0.40}	Q _{0.50}	Q _{0.60}	Q _{0.70}	Q _{0.80}	Q _{0.90}
CE	.017**	-.002	.02**	.019***	.019***	.018***	.017***	.016**	.016*	.015	.014
	(.007)	(.005)	(.008)	(.007)	(.007)	(.007)	(.007)	(.008)	(.008)	(.009)	(.011)
REC	.006***	-.001	.007***	.006***	.006***	.006***	.006***	.005***	.005**	.005**	.004
	(.002)	(.001)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.003)
GFC	.002	-.002*	.006***	.005**	.004**	.003*	.003	.002	.001	0	-.001
	(.002)	(.001)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)	(.003)
GDP	-.006***	-.001	-.004	-.004**	-.005**	-.005***	-.005***	-.006***	-.006**	-.007**	-.007**
	(.002)	(.001)	(.003)	(.002)	(.002)	(.002)	(.002)	(.002)	(.003)	(.003)	(.003)
MVC	.001	.0004	.0002	.0004	.001	.001	.001	.001	.001	.001	.002
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.002)

Notes: Standard errors are in parentheses

*** p<.01, ** p<.05, * p<.1

Table 39: MMQR Result: CE on ENS

Source: Created by the author.

6.2.10. Robustness FMOLS and CCR

The study employs Fully Modified Ordinary Least Squares (FMOLS) and Canonical Cointegration Regression (CCR) to validate the results further in Table 40. The findings are consistent with the Method of Moments Quantile Regression (MMQR) outcomes, as reported in Table 39. These results confirm that the circular economy (CE) significantly enhances environmental sustainability (ENS) in the short and long term. The robustness of the findings is further ensured by applying multiple techniques.

ENS	FMOLS	CCR
CE	0.01*** [7.39]	0.01*** [5.87]
REC	0.01*** [70.69]	0.01*** [48.85]
GFC	0.01*** [125.03]	0.01*** [101.48]
GDP	-0.00*** [-11.32]	-0.00*** [-4.73]
MVA	-0.00*** [-7.16]	0.00*** [-4.62]

Notes: T statistics in parentheses

Critical value (T-5): 4.03, 2.57, 2.01 at 1%, 5%, 10% significance level successively.

*** p<0.01, ** p<0.05, * p<0.10

Table 40: FMOLS & CCR Result

Source: Created by the author.

	ENS	ENS	ENS	ENS	ENS
CE	.024* (.014)	.014** (.006)	.042** (.018)	.042** (.018)	.033** (.016)
REC		.008*** (.002)	.005** (.002)	.005** (.002)	.005*** (.002)
GFC			.005 (.005)	.001 (.005)	-.003 (.004)
GDP				-.002 (.001)	-.006** (.003)
MVA					.002** (.001)

Notes: Standard errors are in parentheses

*** p<.01, ** p<.05, * p<.1

Table 41: Augmented Mean Group Estimation (AMG)

Source: Created by the author.

	ENS	ENS	ENS	ENS	ENS
CE	.047*** (.016)	.008 (.006)	.03* (.016)	.03** (.014)	.028** (.014)
REC		.008*** (.002)	.007*** (.002)	.006*** (.002)	.006*** (.002)
GFC			.007* (.004)	.0001 (.003)	-.002 (.003)
GDP				-.005*** (.002)	-.006** (.002)
MVA					.0001 (.001)

Notes: Standard errors are in parentheses

*** p<.01, ** p<.05, * p<.1

Table 42: Mean Group Estimation (MG)

Source: Created by the author.

Specifically, the study incorporates mean group estimation (with and without augmentation, as shown in Tables 41 and 42) to reinforce the reliability of the results. Additionally, the analysis cross-checks the impact of CE on ENS by gradually introducing additional control variables. Across all methods and specifications, the results consistently demonstrate that CE has a substantial and positive influence on ENS, highlighting its critical role in promoting environmental sustainability over the long term. This study conducts comprehensive research to identify pathways toward sustainable development, focusing on the complex relationship between natural resource rent (NRR) and environmental outcomes. While NRR has traditionally been viewed as an engine of linear economic development, our findings reveal its paradoxical role in ENS. The analysis demonstrates that NRR extraction adversely affects ENS through two primary mechanisms: first, through biodiversity loss resulting from resource extraction, which compromises ecosystem and overall environmental quality, and second, through the acceleration of fossil fuel consumption.

The excessive exploitation of NRR depletes natural resources and contributes to environmental degradation. This study examines the mitigating potential of circular economy (CE) practices to address these challenges. Our findings indicate that when revenue from NRR is integrated into CE sectors, it creates a positive feedback loop that enhances environmental sustainability. Specifically, the results demonstrate a positive correlation between NRR investment and the development of CE practices.

The study examines CE's dual impact on biocapacity (BIC) and ecological footprint (EFP) to evaluate the pathway toward sustainable development. The empirical results confirm that CE has a significant positive effect on BIC enhancement and EFP reduction. Furthermore, our analysis of CE's influence on overall ENS reveals its substantial role in securing ENS improvements.

6.3. Result of Political Stability and Shadow Economy

Table 43 summarizes the results examining the impact of lag_SE, RQ, and their interaction term (SE*RQ) on PS. The results show that the lag_SE consistently exhibits a negative effect on PS, with the impact being stronger at lower quantiles, highlighting how SE activities destabilize politically vulnerable environment consistent with the findings (Baklouti & Boujelbene, 2010; Kim & Moon, 2022), which emphasizes the

detrimental effects of SE on institutional integrity and governmental authority. These results further support (Mazurenko et al., 2023) who underscore the persistence of SE in politically unstable regions and the importance of institutional frameworks in mitigating their effects.

Decentralization of government may improve openness and efficiency, potentially reducing the SE (Goel & Saunoris, 2014). In politically uncertain environments, the effectiveness of decentralization diminishes, enabling the SE to endure, hence highlighting the importance of strong institutions in regulating SE activities (Berdiev et al., 2018). In contrast, RQ positively influences PS across all quantiles, although its significance diminishes at higher quantiles. This indicates that robust regulatory frameworks are particularly effective in less stable environments. Effective governance, as demonstrated by higher RQ, pursuing adherence to the rule of law and strengthens public trust, ultimately promoting PS and economic growth (Ofoeda et al., 2022). These findings are consistent with (Ajide et al., 2020) who highlight the critical role of governance quality in enhancing economic performance and institutional accountability. The interaction term (SE*RQ) reveals a positive and significant moderating effect on PS, with its influence growing stronger at higher quantiles. This result suggests that improvements in RQ can mitigate the destabilizing effects of SE, particularly in more politically stable contexts. These findings align with previous studies, including (Abaidoo & Agyapong, 2021; Assidi et al., 2024). (Tran Pham, 2023) which emphasizes the role of RQ in countering the negative impacts of SE. Additionally, ULF consistently undermines PS across all quantiles, with its destabilizing effect becoming more pronounced in PS environments. In contrast, IGA negatively affects PS at lower quantiles but shows a diminishing influence at higher quantiles. These results underscore the need to address labor market challenges and maintain price stability to support PS effectively. Additionally, ULF consistently undermines PS across all quantiles, with its destabilizing effect becoming more pronounced in PS environments. In contrast, IGA negatively affects PS at lower quantiles but shows a diminishing influence at higher quantiles. These results underscore the need to address labor market challenges and maintain price stability to support PS effectively.

	(Q _{0.1})	(Q _{0.2})	(Q _{0.3})	(Q _{0.4})	(Q _{0.5})	(Q _{0.6})	(Q _{0.7})	(Q _{0.8})	(Q _{0.9})
	PS	PS	PS	PS	PS	PS	PS	PS	PS
lag_SE	-1.02**	-.92**	-.83**	-.76**	-.67**	-.57*	-.48	-.36	-.22
	(.40)	(.36)	(.34)	(.33)	(.33)	(.34)	(.36)	(.41)	(.48)
RQ	.24***	.21***	.19***	.17***	.14**	.12*	.10	.07	.03
	(.08)	(.07)	(.06)	(.06)	(.06)	(.06)	(.07)	(.08)	(.09)
SE*RQ	.002	.003*	.003 **	.003***	.004***	.01***	.01***	.01***	.01***
	(.001)	(.002)	(.002)	(.001)	(.001))	(.001)	(.001)	(.002)	(.002)
ULF	-.42***	-.45***	-.47***	-.48***	-.5***	-.52***	-.54***	-.57***	-.6***
	(.1)	(.09)	(.09)	(.09)	(.08)	(.09)	(.09)	(.11)	(.12)
IGA	-.01*	-.01*	-.01	-.01	-.004	-.003	-.002	-.001	.001
	(.004)	(.004)	(.004)	(.004)	(.003)	(.004)	(.004)	(.005)	(.01)

Notes: Standard errors are in parentheses

*** p<.01, ** p<.05, * p<.1

Table 43: MMQR Global Results- SE Impact

Source: Created by the author.

6.3.1. Country Group-wise IE Impact

The SE analysis in Table 44 across different country groups reveals distinct patterns in its influence on economic outcomes. In high-income countries, SE consistently shows a significant and negative effect across all quantiles, signifying that SE acts as a constraint regardless of economic conditions consistent with (Dung & Thanh, 2021). Conversely, In higher middle-income countries, the effect of SE shifts from negligible in lower quantiles to positive and significant in higher quantiles. This transition mentions that, under specific economic constraints, SE can start to enhance economic resilience. During periods of economic prosperity, the SE demonstrates its adaptability by evolving to offer vital services, hence supporting economic stability in transitional phases (Abdul Rani et al., 2024). This corresponds with the findings of Salinas et al. (2021), who observe that informal activities can alleviate economic recessions in middle-income nations, indicating the resilience and adaptability of the SE in these scenarios. In low-income and lower-middle-income countries, the SE is negative but diminishes in magnitude across quantiles, eventually approaching neutrality. This trend implies that while SE initially constrains economic performance, its impact weakens in higher quantiles, reflecting the dual role of informality in providing economic resilience while limiting growth as

institutions struggle to integrate these activities into the formal sector (Blackburn et al., 2012).

In high-income nations, RQ demonstrates an increasingly pronounced negative impact over quantiles, indicating that enhancements in RQ progressively alleviate detrimental economic consequences. The importance of RQ in these circumstances corresponds with the idea that efficient regulatory frameworks enhance economic efficiency and growth by mitigating uncertainty and encouraging compliance (Dar & Amirkhalkhali, 2012; Rahman et al., 2021). However, in higher middle-income countries, the effects of RQ seem to be slightly favorable, becoming significant at higher quantiles. This indicates that during economic strain, the advantages of regulatory enhancements become more evident, likely owing to increased expectations for compliance and efficiency in difficult economic conditions (Nawaz et al., 2023). These findings align with existing literature suggesting that RQ might enhance economic performance, especially in contexts where institutional frameworks are challenged (Olayungbo & Adediran, 2017). Low-income nations exhibit a lagged transition from negligible to favorable effects of RQ at higher quantiles. This underscores the growing significance of regulation in environments with fragile institutional frameworks, where initial regulatory initiatives may offer minimal advantages but gain relevance when economic circumstances change (Bansal, 2014). Additionally, in lower middle-income nations, RQ frequently has substantial positive impacts. This finding indicates that the establishment of solid regulatory frameworks is essential for these nations' development to promote sustainable economic growth and improve overall institutional quality (Chiang et al., 2022).

The relationship between the SE and RQ demonstrates variable moderation effects depending on income levels. In high-income nations, the SE_RQ regularly demonstrates a slight positive correlation. This suggests that improved RQ can slightly mitigate the negative effects of the SE across all quantiles. Studies indicate that nations with strong regulatory frameworks typically incur reduced capital costs and enhanced market efficiency, potentially leading to superior economic results even in a SE (Nagaraj & Zhang, 2019). Moreover, the RQ in these countries frequently aligns with robust institutional frameworks that enhance compliance and enforcement, thus alleviating the impacts of the SE (Ondoa & Seabrook, 2020). In contrast, in higher middle-income nations, the SE_RQ effect is predominantly minimal, with only marginal positive effects

noted. This indicates that the current economic conditions and regulatory frameworks may need more robustness to regulate the SE significantly. Research suggests that although RQ can enhance economic growth, its efficacy frequently depends on the overarching institutional framework and the particular obstacles encountered by these economies (Gani, 2011). Consequently, the restricted moderation shown in these nations may indicate a confluence of regulatory inadequacies and the intricacies associated with overseeing SE activities, highlighting the urgent need for stronger frameworks. In low-income nations, the moderating effect of RQ transitions from marginally positive to negative at higher quantiles. This situation indicates considerable issues where enhanced RQ may ironically undermine its intended advantages in the presence of a Vast SE. Research indicates that in certain situations, the regulatory framework may be submerged by the magnitude of informal activity, resulting in poor enforcement and unforeseen repercussions (Assche et al., 2018). Lower middle-income countries demonstrate a comparable pattern, with a detrimental SE_RQ effect commencing from the fourth quantile and exacerbating at elevated quantiles. This underscores the complex dynamics of regulating the SE, indicating that RQ alone may be inadequate to successfully mitigate the informal sector's effects without extensive policy assistance and capacity enhancement (Giralt et al., 2017).

	(Q _{0.1})	(Q _{0.2})	(Q _{0.3})	(Q _{0.4})	(Q _{0.5})	(Q _{0.6})	(Q _{0.7})	(Q _{0.8})	(Q _{0.9})
	PS	PS	PS	PS	PS	PS	PS	PS	PS
High income Countries									
lag_SE	-2.77*** (1.05)	-2.77*** (.89)	-2.77*** (.82)	-2.77*** (.78)	-2.77*** (.75)	-2.77*** (.75)	-2.77*** (.8)	-2.78*** (.87)	-2.78*** (.98)
RQ	-.31** (.16)	-.41*** (.14)	-.46*** (.13)	-.52*** (.12)	-.58*** (.11)	-.64*** (.12)	-.71*** (.12)	-.77*** (.13)	-.84*** (.15)
SE_RQ	.02*** (.01)	.02*** (.01)	.02*** (.01)	.02*** (.01)	.02*** (.01)	.03*** (.01)	.03*** (.01)	.03*** (.01)	.03*** (.01)
ULF	-.68*** (.21)	-.77*** (.18)	-.82*** (.16)	-.86*** (.15)	-.92*** (.15)	-.97*** (.15)	-1.03*** (.16)	-1.09*** (.17)	-1.15*** (.19)
IGA	.09* (.05)	.09* (.05)	.09** (.04)	.09** (.04)	.09** (.04)	.09** (.04)	.09** (.04)	.09** (.04)	.09* (.05)
Higher middle-income countries									
lag_SE	-.28 (2.9)	.1 (2.48)	.37 (2.19)	.67 (1.89)	.97 (1.61)	1.4 (1.27)	1.83* (1.09)	2.27** (1.13)	2.87* (1.51)
RQ	.28 (.42)	.29 (.36)	.3 (.32)	.31 (.28)	.32 (.23)	.34* (.18)	.35** (.16)	.37** (.16)	.39* (.22)
SE_RQ	.001	.001	.002	.002	.002	.002	.003	.003	.003

	(.01)	(.01)	(.01)	(.01)	(0)	(0)	(0)	(0)	(0)
ULF	-.43	-.43	-.43	-.44	-.44	-.44	-.44*	-.45*	-.45
	(.65)	(.55)	(.49)	(.42)	(.36)	(.28)	(.24)	(.25)	(.33)
IGA	.01	.01	.01	.01	.01	.005	.002	-.0001	-.003
	(.01)	(.01)	(.01)	(.01)	(.01)	(.005)	(.005)	(.005)	(.01)
Lower Middle-Income countries									
lag_SE	-.78	-.71	-.62	-.55	-.47	-.39	-.29	-.17	-.04
	(.59)	(.54)	(.51)	(.5)	(.51)	(.54)	(.61)	(.7)	(.83)
RQ	.49***	.5***	.52***	.53***	.55***	.56***	.59***	.61***	.63***
	(.15)	(.14)	(.13)	(.13)	(.13)	(.14)	(.16)	(.18)	(.21)
SE_RQ	-.004	-.004	-.005*	-.01**	-.01**	-.01**	-.01**	-.01*	-.01*
	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.003)	(.004)
ULF	-.61***	-.61***	-.61***	-.62***	-.62***	-.62***	-.62***	-.63***	-.63***
	(.14)	(.13)	(.12)	(.12)	(.12)	(.13)	(.14)	(.16)	(.2)
IGA	-.05***	-.05***	-.06***	-.06***	-.06***	-.06***	-.06***	-.06***	-.06***
	(.01)	(.01)	(.01)	(.01)	(.01)	(.01)	(.01)	(.01)	(.02)
Low Income Countries									
lag_SE	-1.58	-1.43	-1.25	-1.06	-.89	-.74	-.61	-.48	-.32
	(1.21)	(1.06)	(.93)	(.88)	(.94)	(1.05)	(1.2)	(1.36)	(1.57)
RQ	-.18	.04	.32	.61	.88	1.11	1.32	1.52	1.77
	(1.09)	(.95)	(.83)	(.8)	(.85)	(.95)	(1.08)	(1.22)	(1.41)
SE_RQ	.02	.02	.01	0	-.01	-.02	-.02	-.03	-.04
	(.03)	(.02)	(.02)	(.02)	(.02)	(.02)	(.03)	(.03)	(.04)
ULF	.46	.83	1.28	1.76	2.19*	2.56*	2.91*	3.24*	3.63*
	(1.67)	(1.46)	(1.28)	(1.22)	(1.3)	(1.45)	(1.65)	(1.86)	(2.16)
IGA	0.001	.0004	.0001	.0001	.0003	-.001	-.001	-.001	-.001
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)

Notes: Standard errors are in parentheses

*** p<.01, ** p<.05, * p<.1

Table 44: MMQR Country Group-Wise Results

Source: Created by the author.

6.3.2. FE Impact: All Countries

In table 45, a significant positive link exists between FE and PS in all the countries with low PS at lower quantiles. Economic expansion may promote stability in these regions. As FE increases, the formal sector will likely improve governance, reduce social unrest, and fortify institutions, thus improving enhanced PS. This discovery corresponds with prior studies highlighting economic conditions' significance in stabilizing politically unstable places (Firmansyah et al., 2023; Khan & Bhatti, 2022; Nawaz et al., 2021). In moderate PS i.e., middle quantiles, the intensity of FE impact on PS diminishes in significance. This observation suggests that RQ and institutional strength may be more

pivotal in fostering PS. The literature corroborates this idea, suggesting that with enhanced PS, the correlation between economic growth and stability may diminish as established institutions and governance frameworks become more stringent (Bernal-Verdugo et al., 2013; Elbargathi, 2019; Mandal, 2022). In high stability at higher quantiles, the correlation between FE and PS further weakens, presumably due to strong institutional frameworks that inherently sustain stable political settings (Javed et al., 2018; Uddin et al., 2017).

In low-PS regions at lower quantiles, RQ has a strong positive impact which signifies that effective governance and regulatory frameworks are essential for adopting stability (Baklouti & Boujelbène, 2020). ULF and IGA, however, negatively affect stability, as high unemployment exacerbates social discontent and inflation undermines economic conditions, both contributing to political instability. In moderate-PS regions, RQ continues to play a positive role, but the impact of ULF and IGA is somewhat diluted by other stabilizing factors. In high-PS regions, RQ's effect weakens, as institutional strength is already established, while the influence of ULF and IGA diminishes due to effective economic management and political cohesion. Thus, RQ is critical for stability, especially in fragile political contexts while ULF and IGA consistently pose risks to stability across all levels, albeit with diminishing returns in a more stable environment.

	(Q _{0.1})	(Q _{0.2})	(Q _{0.3})	(Q _{0.4})	(Q _{0.5})	(Q _{0.6})	(Q _{0.7})	(Q _{0.8})	(Q _{0.9})
	PS	PS	PS	PS	PS	PS	PS	PS	PS
FE	.28***	.24***	.2***	.17***	.14***	.1**	.06	.02	-.03
	(.06)	(.06)	(.05)	(.05)	(.05)	(.05)	(.06)	(.06)	(.07)
RQ	.32***	.32***	.31***	.31***	.3***	.3***	.29***	.29***	.28***
	(.03)	(.03)	(.03)	(.03)	(.03)	(.03)	(.03)	(.03)	(.04)
ULF	-.34***	-.35***	-.36***	-.37***	-.38***	-.4***	-.41***	-.42***	-.44***
	(.1)	(.09)	(.08)	(.08)	(.08)	(.08)	(.09)	(.1)	(.12)
IGA	-.002	-.003*	-.003**	-.004**	-.004***	-.004***	-.004***	-.004**	-.004**
	(.002)	(.001)	(.001)	(.002)	(.002)	(.002)	(.002)	(.002)	(.002)

Notes: Standard errors are in parentheses

*** p<.01, ** p<.05, * p<.1

Table 45: MMQR Global Analysis – FE Impact

Source: Created by the author.

6.3.3. Region-based FE Impact

In table 46, the study also investigates the FE impact on PS in different country regions. In high-income nations, the nexus between FE and PS is frequently shown to be positive, signifying that enhancements in economic performance correspond with improvements in PS. This association is substantiated by the research of Acemoğlu and Robinson (2010), highlighting the significance of strong institutions and efficient governance structures in promoting economic growth and PS. It also indicates that economic advancement can foster greater PS, as increasing earnings may diminish socio-political instability and citizen displeasure. However, RQ has a negligible impact at lower quantiles, but its effect can become evidently detrimental at higher quantiles. It indicates that excessively rigid or intricate regulatory frameworks may hinder economic adaptability and innovation, ultimately undermining PS in developed nations (Dzihny et al., 2023). ULF continually acts as a destabilizing force, with its adverse impact becoming increasingly evident across quantiles. Research by Ismailov et al. (2016), indicates that increased ULF intensifies economic difficulties, complicating political processes. Higher ULF rates frequently correlate with lower PS, intensifying social tensions and discontent. Although typically regarded as a detrimental economic indicator, IGA exhibits a link with PS in high-income nations. Research indicates a relationship between reduced political instability and more stable inflation rates in developed nations, suggesting that economic stability may enhance overall PS (Telatar et al., 2010).

In the higher-middle-income nations, initially, FE positively influences PS, suggesting that economic expansion may yield short-term stabilizing effects in the underdeveloped sectors of these economies. However, as income levels rise, the initial positive impact diminishes and eventually turns negative. This shift indicates that while economic growth may initially promote PS, governance inefficiencies and the unequal distribution of economic gains can reduce the long-term stabilizing capacity of FE as economies develop (Touitou, 2021; Zhuang et al., 2010). The trend between RQ and PS underscores the growing importance of regulatory reforms and governance enhancements as nations move towards higher prosperity and industrialization. ULF consistently displays a substantial adverse effect on PS across different income levels. This underscores the destabilizing impact of ULF, especially in upper-middle-income nations, where high ULF rates are likely to exacerbate social divisions and undermine political

unity. The results correspond with existing literature, which repeatedly recognizes high ULF as a significant catalyst for socio-political instability in emerging and middle-income settings (Effiong et al., 2022; Hatmaja & Fuddin, 2023). The decreasing role of IGA in higher-middle-income nations may indicate these economies' improved ability to withstand inflationary shocks through more effective monetary and fiscal policy. As economies advance, the focus shifts to other macroeconomic factors that can more strongly uphold PS (Chu et al., 2018).

In lower income nations, a strong positive association is discovered in the early stages of development in the first quantile, indicating that economic expansion fosters PS. However, this favorable impact progressively diminishes and becomes negative, underscoring that economic growth alone is inadequate for guaranteeing long-term PS, especially amid structural deficiencies and governance inefficiencies. (Aden Dirir, 2023; Nguyen et al., 2018; Osabiyi et al., 2019). RQ consistently demonstrates a favorable effect on PS across all quantiles. This emphasizes the notion that enhancements in governance are crucial for sustaining stability in lower-middle-income economies (Fathia, 2021; Sasikirono et al., 2023). ULF constitutes a substantial destabilizing element in lower-middle-income nations. The findings highlight the urgency of tackling labor market issues since elevated ULF rates intensify economic instability and incite social unrest, thereby jeopardizing PS (Salman & Alvi, 2023). IGA has a modest but persistent adverse impact on PS, indicative of the overarching economic volatility prevalent in lower-middle-income nations. These nations frequently encounter inflationary pressures compromising economic predictability, leading to instability (Devadas & Pennings, 2018; Mehrara et al., 2015). The inverse correlation between IGA and PS signifies the necessity of sustaining economic stability to promote a favorable atmosphere for political order.

In lower middle-income countries, the analysis reveals that the influence of FE on PS is not uniform across different levels of PS. In less stable political environments characterized by lower quantiles, FE positively impacts PS, revealing that economic growth can serve as a stabilizing force. However, as PS increases (higher quantiles), the effect of FE on PS diminishes and may even become negative. This phenomenon can be attributed to the emergence of governance inefficiencies, structural challenges, and rising income inequality, which can undermine the stabilizing effects of economic growth in more mature economies. This finding aligns with existing literature that emphasizes the

limitations of economic growth in maintaining political order, particularly in advanced economies (Firmansyah et al., 2023). RQ consistently demonstrates a positive and reinforcing effect on PS across all quantiles. This signifies the critical role of governance and institutional quality in fostering long-term stability. As nations progress from lower to higher income levels and PS, the significance of effective regulatory frameworks becomes increasingly evident. Institutions that uphold the rule of law, transparency, and efficient governance are essential for promoting PS, especially in advanced economies (Samedova et al., 2022). The analysis also highlights that ULF has a consistently negative impact on PS across all quantiles. High ULF rates can lead to economic marginalization and social unrest, particularly in middle and lower-income countries, thus emphasizing the necessity of strong labor market policies to enhance stability. This observation is supported by broader literature that identifies ULF as a significant driver of political instability in developing and transitional economies (Dimovski et al., 2023). Lastly, high inflation negatively affects PS at lower quantiles by eroding public confidence in governmental economic management, exacerbating social tensions. Conversely, in more PS and economically mature nations (higher quantiles), the effect of inflation becomes statistically insignificant. This suggests that advanced economies are better equipped to manage inflationary pressures through effective monetary and fiscal policies, making PS less sensitive to inflation than less developed nations (Kiley, 2021).

PS	(Q _{0.1})	(Q _{0.2})	(Q _{0.3})	(Q _{0.4})	(Q _{0.5})	(Q _{0.6})	(Q _{0.7})	(Q _{0.8})	(Q _{0.9})
High Income Countries									
FE	.34***	.34***	.34***	.34***	.34***	.34***	.34***	.34***	.34***
	(.11)	(.09)	(.08)	(.08)	(.08)	(.08)	(.08)	(.09)	(.1)
RQ	.004	-.03	-.05	-.08	-.1	-.12**	-.15**	-.17**	-.21**
	(.09)	(.07)	(.07)	(.06)	(.06)	(.06)	(.07)	(.07)	(.08)
ULF	-.37**	-.41***	-.44***	-.47***	-.49***	-.52***	-.54***	-.57***	-.61***
	(.18)	(.16)	(.14)	(.14)	(.13)	(.13)	(.14)	(.15)	(.17)
IGA	.1*	.1**	.1**	.1**	.1**	.1**	.1**	.1**	.1*
	(.05)	(.04)	(.04)	(.04)	(.04)	(.04)	(.04)	(.04)	(.05)
Higher Middle-Income Countries									
FE	.18*	.12	.08	.04	-.02	-.09	-.16	-.23*	-.31**
	(.11)	(.1)	(.09)	(.09)	(.09)	(.1)	(.12)	(.13)	(.15)
RQ	.33***	.35***	.36***	.37***	.39***	.41***	.44***	.46***	.48***
	(.05)	(.04)	(.04)	(.04)	(.04)	(.04)	(.05)	(.06)	(.07)
ULF	-.37**	-.38**	-.38***	-.38***	-.39***	-.39**	-.4**	-.41**	-.41*
	(.17)	(.15)	(.15)	(.14)	(.15)	(.16)	(.18)	(.2)	(.24)
IGA	.02***	.01***	.01***	.01**	.01	.001	-.002	-.01	-.01

	(.004)	(.004)	(.004)	(.004)	(.004)	(.004)	(.005)	(.01)	(.01)
Lower Middle-Income Countries									
FE	.33***	.28***	.24**	.2**	.16	.12	.07	.01	-.06
	(.12)	(.1)	(.1)	(.1)	(.1)	(.11)	(.12)	(.13)	(.16)
RQ	.33***	.33***	.33***	.33***	.34***	.34***	.34***	.34***	.35***
	(.06)	(.05)	(.05)	(.05)	(.05)	(.05)	(.06)	(.07)	(.08)
ULF	-.64***	-.64***	-.65***	-.65***	-.66***	-.67***	-.67***	-.68***	-.69***
	(.14)	(.13)	(.12)	(.12)	(.12)	(.13)	(.15)	(.16)	(.2)
IGA	-.004**	-.004**	-.005**	-.01***	-.01***	-.01***	-.01**	-.01**	-.01**
	(.002)	(.002)	(.002)	(.003)	(.003)	(.003)	(.002)	(.003)	(.003)
Low Income Countries									
FE	.34*	.29*	.24	.18	.13	.09	.04	.001	-.06
	(.2)	(.17)	(.15)	(.15)	(.15)	(.17)	(.19)	(.21)	(.25)
RQ	.63***	.59***	.55***	.5***	.45***	.42***	.38***	.35**	.30*
	(.14)	(.12)	(.11)	(.1)	(.11)	(.12)	(.13)	(.15)	(.17)
ULF	.53	.98	1.39	1.9*	2.37**	2.71**	3.13**	3.43**	3.91**
	(1.41)	(1.22)	(1.1)	(1.05)	(1.1)	(1.19)	(1.36)	(1.5)	(1.76)
IGA	.001	.001	.001	.0005	-.0002	-.0001	-.0005	-.001	-.001
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
Notes: Standard errors are in parentheses *** p<.01, ** p<.05, * p<.1									

Table 46: MMQR Results From Different Regions

Source: Created by the author.

7. CHAPTER: POLICY IMPLICATIONS

The findings provide valuable insights for policy formulation. The study shows that IQ plays a pivotal role in contributing to economic development while reducing SE across countries. Strong institutions enhance economic stability by securing property rights, enforcing contracts, and upholding the rule of law. Therefore, policymakers should focus on improving institutional frameworks, especially in LMICs and HICs, where the negative impact of poor institutional quality on SE is most significant. Governments should prioritise strengthening legal frameworks to protect property rights and enforce contracts, which can positively affect some incentives forms against informal economic activities (Choi & Woo, 2020; Nistotskaya & Cingolani, 2016). In addition, anti-corruption measures, such as increasing transparency in public administration and imposing stricter penalties for corrupted practices, are essential. Reducing corruption diminishes SE by ensuring fair market competition and equal economic opportunities (Zhu & Chang, 2019; Bauhr & Charron, 2018). Regulatory reforms are also necessary as they simplify business registration processes, reduce bureaucratic hurdles, and lower compliance costs. Streamlined regulations encourage businesses to formalize and decrease their reliance on informal practices (Dau et al., 2022).

The study highlights the dual impact of natural resource rents on SE. In HICs and HMICs, effective management of NRR reduces SE due to strong institutional frameworks that prevent corruption and mismanagement. Conversely, in LICs, NRR tends to increase SE, reflecting weak institutional structures and poor governance. Countries with significant natural resources should establish sovereign wealth funds (SWFs) to manage resource revenues transparently and sustainably. SWFs can help stabilize the economy, reduce volatility from commodity price fluctuations, and ensure that resource wealth benefits future generations (Bauer, 2018; Koning & Albertus, 2019). LICs should also enhance governance in natural resource sectors by ensuring transparency in resource extraction contracts, implementing robust monitoring systems, and encouraging community participation in resource management decisions (Cust & Poelhekke, 2022; Venables, 2016). Also, reducing dependence on natural resources requires investing in economic diversification. This can involve promoting sectors such as manufacturing, services, and technology, which can provide alternative employment opportunities and reduce the appeal of SE across development trajectories (Gollin et al., 2021).

Additionally, our findings reveal that *Urb* significantly reduces *SE* by increasing government oversight and regulation of economic activities. As urban areas expand, there is greater potential for formal economic activities due to better infrastructure, higher education levels, and improved access to financial services. Governments should invest in developing urban infrastructure, including transportation, communication, and utility services. Improved infrastructure enhances economic productivity and incentivizes businesses to operate formally (Ouyang et al., 2020; Frick & Rodríguez-Pose, 2019). Urban policies should also be inclusive by providing affordable housing, healthcare, and education to reduce urban poverty and prevent the growth of informal settlements. Inclusive policies help integrate marginalized communities into the formal economy (Simon, 2021; Satterthwaite, 2020). In addition, strengthening local governance in urban areas can improve service delivery, enhance accountability, and reduce corruption, thereby encouraging formal economic activities (Slack & Côté, 2022).

The study also shows that *Unm* significantly impacts *SE*, particularly in LMICs. High unemployment rates push individuals into the informal sector as a survival strategy. Reducing *Unm* through targeted interventions can help decrease *SE*. Reforms that promote labour market flexibility, including employment protection legislation and encouraging part-time and temporary work, can help reduce informal employment (World Bank, 2020). Governments should also invest in vocational training programs to equip the workforce with skills relevant to the formal economy. Education and training can improve employability and reduce reliance on informal jobs (OECD, 2021). In addition, SMEs are often a major source of employment. Policies that support SME development, such as access to credit, business development services, and market access, can reduce unemployment and, as a consequence, *SE* (Beck & Maimbo, 2020).

In terms of *FDI*, our main findings show that this co-variate has a negative relationship with *SE*, its impact is inconsistent across different quantiles and country groups. To harness *FDI*'s full potential in reducing *SE*, countries need to create conducive environments that attract sustainable and inclusive investments. Creating a stable macroeconomic environment, reducing political risks, and enhancing business activities are essential for attracting *FDI*. A better investment climate can increase formal economic activities and provide positive effects on *SE* (Anderson & Maul, 2019; Beal & Sandhu, 2022). Governments should promote *FDI* in sectors offering sustainable and inclusive

growth, such as renewable energy, healthcare, and education. Investments in these sectors can generate formal employment, thus reducing for informal economy practices (Dechezleprêtre et al., 2019; Guerriero & Rüede, 2022). Multinational companies should also consider to adopt Corporate Social Responsibility (CSR) practices that promote fair labour standards, environmental sustainability, and community engagement. Such practices can help integrate informal workers into the formal economy (Doh et al., 2020). Finally, a particular focus on LICs should be addressed. The study reveals that LICs face unique challenges in managing SE due to weaker IQ, poor governance, and high levels of corruption. Policymakers in LICs need tailored strategies to address these challenges. LICs should prioritize anti-corruption efforts by implementing transparent public financial management systems, strengthening anti-corruption agencies, and promoting civic engagement and accountability (Khan et al., 2021; Mahbubani, 2020). Investments in building institutional capacity appear also crucial. This includes training civil servants, improving public administration, and fostering a culture of integrity and professionalism in government institutions (Bersch et al., 2019). Additionally, policies that promote inclusive growth for this group of countries can also be considered, such as social safety nets, targeted poverty alleviation programs, and inclusive education, can reduce reliance on the informal economy and foster economic stability (Piketty, 2020). To effectively reduce SE, a holistic policy framework addressing the roots that are the cause of informal economic activities is essential. This framework should be based on a thorough understanding of the socio-economic, political, and institutional factors driving SE in different country contexts. This can be carried out by governments by conducting comprehensive diagnoses of SE including its size, causes, and consequences, such to determine targeted policy interventions and addressing specific drivers of SE (Medina & Schneider, 2022). A multi-stakeholder approaches can also contribute to reduce SE in LICs. Favouring collaboration among various stakeholders, including government agencies, the private sector, civil society, and international organizations can enhance policy coherence, promote synergies, and leverage resources (Ansell et al., 2021). Finally, effective monitoring and evaluation mechanisms should also be established to assess the impact of policy interventions on SE. These mechanisms can provide valuable feedback for refining policies and ensuring their effectiveness on SE (Chen et al., 2019).

CONCLUSION

The study provided in-depth research to understand the linkages between IQ, NRR, and SE since the majority of prior research was limited in scope in the first paper. Therefore, the first article filled a critical gap in the literature. First, previous studies focused on single country case or macro groups such as Europe or US; in contrast, the present study focused on country groups at global level as defined by the World Bank classification of countries according to the GNI indicator and used updated data up to 2018; third, the actual research used an MMQR model which offered advantages in handling individual effects and conditional heterogeneous covariance effects over other inferential methods used in prior studies. The findings reveal that IQ has a significant negative effect on SE, indicating that an increase in IQ contributes to the reduction of informal economic activities across all country groups. Notably, IQ demonstrates a robust negative impact on LICs and HICs across all quantiles, while it significantly influences SE only in the lower quantiles for LMICs and in both lower and middle quantiles for HMICs. This highlights the critical role of IQ in fostering economic development. Additionally, the study finds that NRR generally reduces SE, particularly in HICs, HMICs, and LMICs. Conversely, NRR in LICs is found to increase SE, as the investment and expenditure required for the extraction of natural resources tend to crowd out opportunities for the formal economy. This leads to more labour and firms operating within the SE, consistent with the findings of Kpognon (2022a).

Furthermore, the study examines the interaction between NRR and IQ. The results show that NRR, when moderated by IQ, has a significant negative influence on SE for all countries and most country groups, except for LICs. In LICs, NRR, even with the moderation of IQ, significantly increases SE due to poor economic and political institutions (Barbier, 2019). In these contexts, NRR appears to exacerbate the ‘Dutch Disease’ or ‘resource curse’ phenomena, where weak institutions fail to control corruption, leading to the mismanagement of resources. This latter produces economic inefficiencies and incentivizes informal economic activities, further expanding SE. These findings align with the studies of Tornell et al. (1999), and Strulik (2012), and are supported by the work of Ajide & Ridwan (2023).

While the study offers extensive insights, it acknowledges certain limitations. The findings are constrained by the duration of the data, which limits the generalizability of

the results across different time periods and countries. Moreover, the study focuses on only 124 countries, which may not represent the global situation comprehensively. Future research could overcome these shortcomings by considering a broader range of institutional factors, including investment freedom, business freedom, and fiscal and monetary policy indicators.

In the second article, the debate surrounding environmental sustainability (ENS), natural resource rent (NRR), and the circular economy (CE) is crucial in both developed and developing countries. The study contributes to the theoretical and empirical understanding of how integrating NRR within CE practices can enhance ENS, using EU countries from 2005 to 2021. This research, for the first time, examines the complex dynamic between these factors to achieve sustainable development. Under the theme of SDG 12, the research highlights that while NRR extraction can degrade ENS, incorporating CE practices significantly mitigates these effects. Using advanced econometric methods such as the Method of Moments Quantile Regression (MMQR), supported by robust techniques like MG, AMG, FMOLS, and CCR, the findings underscore a framework built on three policy pillars. The study recommends that policymakers adopt active regulatory measures, green incentives, and stringent standards to bridge the linear economy and sustainable development gap. EU member states should prioritize international policy diffusion and the dissemination of CE practices, encouraging institutional collaboration and knowledge exchange. This approach will further pursue sustainable consumption and production, driving sustainable development forward. As the findings demonstrate, CE best practices are a crucial driver for ENS, supported by technology diffusion and stable partnerships for exchanging raw materials and by-products. The EU could facilitate dialogue between the business and academic sectors to strengthen these networks. To counter the "resource curse," economic diversification is essential, with the implementation of CE practices being a key strategy. Revenue generated from NRR should be transparently managed and invested in sustainable sectors, supported by robust governance and legal frameworks to ensure accountability. For optimal outcomes, stakeholders must engage with international partners for better resource management and policy alignment. Governments should develop policies that combine both monetary and fiscal incentives. Monetary policy can create a supportive financial infrastructure for green investments, while targeted tax

incentives can drive the adoption of CE practices. While this study offers significant insights, it acknowledges limitations related to data constraints and a focus on EU countries. In addition, the study assumes all EU countries are homogenous. The environmental policies and institutional frameworks are not distinctive across EU countries. Each country has its own policies and priorities. However, these variations are not considered in the study. Future research should extend this analysis to other contexts to develop a more critical understanding of the CE-ENS relationship. A global study can provide a better understanding of CE and ENS nexus. Additionally, subsequent studies could explore the economic impacts of climate shocks and identify tools to mitigate these adverse effects as economies adopt environmentally sustainable practices.

The third article investigates the impact of the SE on PS across 124 countries from 1996 to 2018, applying the Method of Moments Quantile Regression (MMQR) to analyze the relationships between these variables. The findings indicate that a growing SE significantly undermines PS, while the expansion of the FE positively influences PS. The emergence of SE is largely attributed to weak institutional frameworks and poor governance, with government inefficiency exacerbating the inability to control SE activities. In contrast, FE, characterized by improved governance and higher efficiency, increases to stabilize political systems. The study underscores that as SE increases, PS decreases, emphasizing the detrimental effects of SE on PS. However, the impact of SE on PS varies by income group. High-income countries show a clear negative relationship between SE and PS, while higher-middle-income countries (HMICs) show a paradoxical positive effect of SE on PS, suggesting that these nations may require more governmental support and institutional flexibility to manage their economic activities. Low and lower-middle-income countries, on the other hand, do not demonstrate significant effects of SE on PS. These findings highlight the critical relationship between SE and PS across different economic contexts. This research makes a significant contribution to literature by exploring the global nexus between SE, FE, and PS, with a focus on income-based country groupings. The study offers key policy insights for enhancing PS. Specifically, it recommends strengthening government integrity and transparency, which would build public trust and facilitate the reduction of informal sector activities. Furthermore, the study advocates a balanced approach to taxation, encouraging moderate tax and tariff policies while promoting stricter non-tariff regulations to reduce SE practices. Public

awareness campaigns should also be prioritized to discourage participation in the SE. While this study provides valuable insights, it has some limitations. Future research would benefit from larger datasets, which could offer more robust and varied results. Additionally, future studies should explore the impact of tariffs and non-tariff barriers on PS and the reduction of SE. Given the limited scope of the current analysis, further research could incorporate additional indicators of PS and SE, offering a more comprehensive understanding of these complex dynamics. The third article investigates the impact of the SE on PS across 124 countries from 1996 to 2018, applying the Method of Moments Quantile Regression (MMQR) to analyze the relationships between these variables. The findings indicate that a growing SE significantly undermines PS, while the expansion of the FE positively influences PS. The emergence of SE is largely attributed to weak institutional frameworks and poor governance, with government inefficiency exacerbating the inability to control SE activities. In contrast, FE, characterized by improved governance and higher efficiency, increases to stabilize political systems. The study underscores that as SE increases, PS decreases, emphasizing the detrimental effects of SE on PS.

However, the impact of SE on PS varies by income group. High-income countries show a clear negative relationship between SE and PS, while higher-middle-income countries (HMICs) show a paradoxical positive effect of SE on PS, suggesting that these nations may require more governmental support and institutional flexibility to manage their economic activities. Low and lower-middle-income countries, on the other hand, do not demonstrate significant effects of SE on PS. These findings highlight the critical relationship between SE and PS across different economic contexts. This research makes a significant contribution to literature by exploring the global nexus between SE, FE, and PS, with a focus on income-based country groupings. The study offers key policy insights for enhancing PS. Specifically, it recommends strengthening government integrity and transparency, which would build public trust and facilitate the reduction of informal sector activities. Furthermore, the study advocates a balanced approach to taxation, encouraging moderate tax and tariff policies while promoting stricter non-tariff regulations to reduce SE practices. Public awareness campaigns should also be prioritized to discourage participation in the SE. While this study provides valuable insights, it has some limitations. Future research would benefit from larger datasets, which could offer more

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