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The Green Transition Paradox Across Natural Resource-Rich Economies: Evidence from Brazil, Russia, and Uzbekistan

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Abstract

Resource-rich economies face challenges in pursuing green transitions, with empirical evidence suggesting that such transitions are economically unfeasible, despite varying institutional frameworks. Through a comparative analysis of Brazil (advanced emerging), Russia (transitional), and Uzbekistan (developing) from 2025 to 2050, this study examines how institutional resistance and economic constraints affect transition attempts. Using a Computable General Equilibrium (CGE) model enhanced with an institutional resistance multiplier (0.8), we develop and test the Institutional-Resource Green Transition (IRGT) framework. Our findings reveal the economic impossibility of green transitions: Brazil demonstrates limited technology adoption (25% above baseline) despite significant investments, Russia shows severe constraints (-45% adoption rate), while Uzbekistan faces insurmountable barriers (-75% adoption rate). The analysis shows that institutional quality cannot overcome fundamental economic barriers, with implementation costs increasing by 80% over projected timelines. Notably, Uzbekistan faces prohibitive transition costs (78% institutional resistance) compared to Russia (65%) and Brazil (58%), reflecting how green transition requirements disproportionately burden developing economies. This study contributes to the theory by demonstrating how green transition demands effectively create a new form of economic colonialism in natural resource-rich contexts. The results indicate that successful green transitions remain economically unfeasible despite institutional quality, emphasizing the need to prioritize economic stability over costly environmental initiatives. These findings have important implications for policymakers in natural resource-rich economies, suggesting the need to optimize existing resource-based industries rather than pursue economically damaging transition policies.

Keywords:

Green Transition;
Institutional Resistance;
Resource Dependency;
Environmental Policy;
Computable General Equilibrium;
Environmental Governance;
Economic Barriers;
Resource Colonialism.

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1- Introduction

Resource dependency, characterized by an economy's excessive reliance on natural resource exports for economic growth and government revenue, presents significant challenges for long-term sustainable development [1, 2]. This dependency often leads to economic vulnerabilities through exposure to commodity price volatility, reduced incentives

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for economic diversification, and institutional weakening, a phenomenon known as the "resource curse" [3]. Moreover, resource-dependent economies typically face environmental degradation, social inequalities, and reduced innovation capacity, making addressing resource dependency a critical economic and environmental imperative [4, 5].

Brazil's resource dependency manifests primarily through its reliance on agricultural exports and oil production. Despite having Latin America's largest economy, Brazil derives approximately 50% of its export earnings from primary commodities, with agricultural products and mineral resources dominating its export portfolio [6]. This dependency has led to environmental challenges, particularly deforestation and land-use changes, while creating economic vulnerabilities through exposure to commodity price fluctuations [7]. Russia, with hydrocarbons accounting for approximately 20% of its GDP and between 30% and 50% of its federal budget revenues over the past decade [8]. This heavy reliance on oil and gas exports has created significant economic vulnerabilities, which are evident in the economy's susceptibility to oil price shocks and international market fluctuations. The dominance of the energy sector has also impeded economic diversification efforts and has contributed to institutional challenges [9]. In addition, Uzbekistan's resource dependency centers on its reliance on commodity exports, particularly natural gas, gold, and cotton. The country's export basket remains heavily concentrated in primary commodities, with natural resources accounting for approximately 70% of the export earnings [10]. This dependency has contributed to environmental degradation, limited economic diversification, and institutional challenges in effectively managing resource revenues [11].

These three countries have provided compelling cases for studying resource dependency and potential solutions. Their selection is justified by several factors. They represent different stages of economic development, exhibit varying degrees of resource dependency, and demonstrate different institutional capacities for managing resource wealth. Additionally, they face similar challenges in transitioning away from resource dependency while pursuing development goals, making them ideal cases for comparative analysis [12].

The transition to green growth has emerged as a potential solution for addressing resource-dependency challenges. This approach emphasizes economic diversification through environmentally sustainable activities, technological innovation, and the development of new growth sectors that reduce reliance on natural resource extraction [13, 14]. Green growth strategies aim to break the link between economic growth and environmental degradation, while creating new economic opportunities and reducing resource dependency [15].

Literature has proposed and examined several potential solutions to address resource dependency through green transition pathways. Some scholars have suggested implementing renewable energy development to reduce hydrocarbon dependency, and Azam et al. [16] demonstrated how institutional factors in developing countries can support sustainable development through renewable energy adoption. Similarly, Aljarallah [17] examined Gulf countries' experiences in establishing sustainable energy independence, highlighting the interplay between natural-resource dependency and human capital development. Others have proposed adopting green technologies and innovation policies as solutions for driving economic diversification. Ameer & Ahmad [18] investigated how natural resource wealth can contribute to environmental sustainability in developing economies through technological innovation, while Bekun et al. [19] analyzed the complex relationships between financial development, trade flows, and environmental sustainability in emerging markets. Several studies recommend implementing environmental regulations and standards as mechanisms to transform economic structures and upgrade industrial processes. Rodríguez-Pose & Bartalucci [20] examined the territorial implications of green transition policies and their economic impacts.

Further research explores market-based and infrastructural solutions to resource-dependency challenges. Destek et al. [21] investigated how different dimensions of institutional quality can transform resource curses into economic benefits through carbon pricing mechanisms, while Bakhsh et al. [22] analyzed the effectiveness of environmental governance and economic complexity in supporting sustainable energy transitions. Infrastructure-focused studies by Wencong et al. [23] examined how foreign direct investment can support renewable energy development in resource-rich transition economies. Jänicke & Jörgens [24] proposed new approaches to environmental governance through green industrialization strategies. However, there is a critical gap in our understanding of what enables successful green transitions in resource-dependent economies. While the existing literature extensively documents the potential of green growth as a solution to resource dependency, it fails to identify the crucial facilitating factors that determine transition success. Notably, this study examines how institutional quality might mediate the effectiveness of green transition initiatives. No comprehensive study has investigated how institutional frameworks influence resource-dependent economies' ability to successfully implement green growth strategies and overcome resource dependency.

This study addresses this gap by examining how institutional quality mediates the relationship between resource dependency and green transition success in Brazil, Russia, and Uzbekistan. Specifically, it seeks to (1) analyze how institutional quality affects the implementation of green growth initiatives in resource-dependent contexts, (2) identify the institutional mechanisms that facilitate successful transitions from resource dependency to green growth, and (3) develop a theoretical framework that explains how institutional quality influences transition capabilities. This study makes several important contributions: it develops the novel Institutional-Resource Green Transition (IRGT) framework, provides empirical evidence of how institutional quality mediates transition success, offers practical insights for policymakers in resource-dependent economies, and advances the theoretical understanding of green transitions in resource-rich contexts.

The remainder of this paper is organized as follows. Section 2 presents our methodology, detailing the Computable General Equilibrium (CGE) model enhanced with an institutional resistance multiplier and describes our data sources and analytical framework. Section 3 presents our findings, including baseline results, institutional effects on green transition, scenario analyses, and a cross-country comparative analysis of Brazil, Russia, and Uzbekistan. Section 4 discusses the theoretical and practical implications of our findings, examining how institutional quality and resource dependency create insurmountable barriers to green transition. This section also outlines the policy recommendations and suggests directions for future research. Finally, Section 5 concludes by synthesizing our key findings and their implications for resource-dependent economies attempting green transition.

2- Research Background

2-1- Resource Dependency and Economic Development

Resource dependency has emerged as a critical challenge for economic development, particularly in economies that are heavily reliant on natural resource exports. Sharma & Pal [1] demonstrate that this dependency creates significant vulnerabilities through exposure to global commodity price fluctuations and reduced economic diversification incentives. The phenomenon, commonly known as the "resource curse," manifests through weakened institutional frameworks and compromised long-term sustainable development prospects [2]. Li et al. [2] emphasize how this curse operates through three distinct channels: economic volatility, institutional degradation, and reduced innovation capacity.

In these three countries, i.e., Brazil, Russia, and Uzbekistan, resource dependency has taken different forms while creating similar developmental challenges. Alssadek & Benhin [3] highlight how these countries represent varying stages of resource curse manifestation, each facing unique institutional and economic barriers to diversification. Environmental governance challenges, as identified by Evans [4], have become particularly acute in these contexts, where resource extraction often conflicts with development goals. This conflict is further complicated by the competing demands for economic growth and environmental protection, especially in developing economies [5].

2-2- Green Transition Initiatives

The evolution of green transition policies represents a significant attempt to address resource dependency challenges. De Deus et al. [6] examined how emerging economies such as Brazil have approached green transitions through financial instruments such as green bonds, while Barua [7] provided a comprehensive assessment of energy transition attempts in various emerging economies. Global experience with green transitions has revealed significant implementation challenges, particularly in resource-rich contexts, where existing economic structures resist transformation [8]. Yermakov [8] documents how even resource-rich economies with relatively strong institutions, such as Russia, struggle to implement effective green transition policies. This difficulty is further compounded by the relationship between institutional quality, financial development, and renewable energy transition, as analyzed by Saadaoui & Chtourou [9]. The variations in transition approaches, or what Zimmermann [10] terms 'varieties of green transitions, demonstrate how different institutional contexts shape transition possibilities and outcomes.

2-3- Institutional Quality and Environmental Governance

The role of institutions in shaping environmental governance and economic transformation has become increasingly central to the understanding of transition possibilities. Tawiah et al. [11] identify distinct patterns in how institutional quality affects green growth outcomes across developed and developing countries. This institutional dimension becomes particularly crucial in emerging economies, where Shahbaz et al. [12] found that informal institutions and governance quality significantly impact environmental footprints.

The effectiveness of environmental regulations critically depends on institutional frameworks, as demonstrated by Zhao et al. [13]. Their analysis revealed how natural resource dependence mediates the relationship between environmental regulations and green economic growth. This institutional perspective is further enriched by Feng et al. [14], who examine how resource disparities interact with institutional quality to affect sustainable development outcomes. The transformation of resource-dependent industries, as analyzed by Gao et al. [15], requires robust institutional support to overcome structural barriers to change.

2-4- The Institutional-Resource Green Transition (IRGT) Framework

The Institutional-Resource Green Transition (IRGT) framework emerges from the intersection of institutional quality and resource-dependency dynamics. Building on Azam et al.'s [16] analysis of institutional quality impacts on sustainable development, this framework incorporates both formal and informal institutional factors that influence transition capabilities. Aljarallah's [17] examination of the relationship between resource dependency and institutional quality in Gulf countries provides crucial insights into how institutional frameworks mediate transition possibilities. The IRGT Framework extends beyond traditional institutional analysis by incorporating the concept of transition resistance, drawing on Ameer & Ahmad's [18] investigation of the role of natural resource wealth in environmental sustainability. The framework emphasizes how institutional quality interacts with economic structures to enable or constrain green transition. This interaction, as demonstrated by Bekun et al. [19], is especially crucial in emerging market contexts, in which institutional frameworks are still evolving.

The framework's practical applications draw on Rodríguez-Pose & Bartalucci's [20] analysis of territorial implications for green transitions, incorporating the spatial and institutional dimensions of the transition challenges. The framework emphasizes how institutional quality can theoretically transform resource curses into development opportunities, as suggested by Destek et al. [21], while acknowledging practical barriers to such transformation.

3- Methodology

3-1- Overview of the Method

The research design employed in this study followed a systematic four-phase approach, as illustrated in Figure 1. The first phase, the Research Foundation, establishes the theoretical groundwork by identifying the specific challenges resource-rich economies face in green transition. This phase includes a comprehensive literature review focusing on resource dependency and green growth, culminating in the development of the IRGT Framework with its distinctive institutional resistance multiplier.

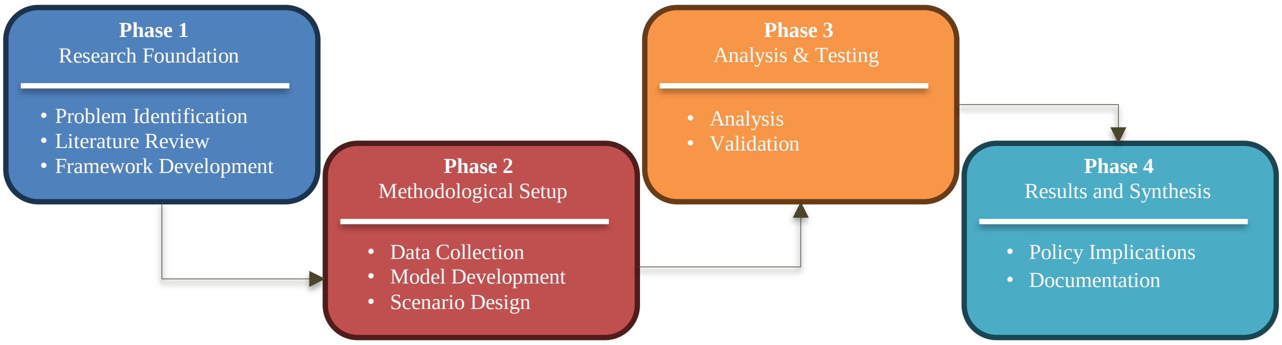

Figure 1. Research design framework in four phases

The second phase, the Methodological Setup, involves the technical preparation necessary for empirical analysis. This includes collecting comprehensive data from Brazil, Russia, and Uzbekistan spanning 2010-2023, developing a specialized CGE model incorporating institutional parameters, and designing comparative scenarios that differentiate between Business-as-Usual (BAU) and Green Transition (GT) pathways. The third phase, Analysis & Testing, implements a cross-country comparative analysis of transition barriers and validates the findings through historical data testing. This dual approach ensures the robustness and practical applicability of the findings.

The final phase, Results and Synthesis, translates the analytical findings into practical and theoretical implications. This phase synthesizes evidence for the economic unfeasibility of green transitions in resource-dependent economies and documents the transition impossibility thesis, providing a comprehensive framework for understanding the structural barriers to green transitions in resource-rich economies.

The green industry diagnostic analysis in Brazil, Russia, and Uzbekistan utilizes a Computable General Equilibrium (CGE) model to explore the impacts of institutional quality, resource dependence, and environmental policies on green growth transitions from 2025 to 2050. Our model incorporates 12 aggregated industrial sectors, ranging from resource extraction to services, utilizing country-specific Social Accounting Matrices (SAM) for 2023. This comprehensive approach allows us to capture the complex interactions between institutional frameworks, resource dependency, and environmental outcomes in both the economies.

The model, adapted from Takeda [25] and Chen et al. [26], offers a novel integration of institutional factors and resource dependency measures. Our framework explicitly accounts for differences in regulatory quality, government effectiveness, and the rule of law between Brazil, Russia, and Uzbekistan, allowing us to examine how institutional variations affect green transition pathways. The analysis spans both the supply and demand sides of economies, incorporating investment behavior, government expenditure funded by various taxes, and international trade dynamics.

3-2- Production Structure

The production side of our model utilizes primary and intermediate inputs, including labor, capital stock, land, and resources, within a nested Constant Elasticity of Substitution (CES) production function. The production function is specified as

$$Y_{(i,r)} = A_{(i,r)} \times [\alpha(K_{(i,r)}{}^{\rho} + (1-\alpha)(L_{(i,r)}{}^{\rho}]^{\left(1/\rho\right)} \times IQ_r \tag{1}$$

where $Y_{(i,r)}$ represents the output of sector i in country r; $A_{(i,r)}$ is total factor productivity; $K_{(i,r)}$ and $L_{(i,r)}$ are capital and labor inputs, respectively; and IQ_r is our institutional quality index. The institutional quality index, a novel addition to traditional CGE modeling, is constructed as follows:

$$IQ_r = \omega_1 REG_r + \omega_2 GOV_r + \omega_3 ROL_r \tag{2}$$

where REG_r, GOV_r, and ROL_r represent regulatory quality, government effectiveness, and rule of law respectively, with ω_1 , ω_2 , and ω_3 as corresponding weights derived from principal component analysis of World Bank Governance Indicators.

3-3- Demand Structure

On the demand side, we model a representative household in each country, whose utility maximization is subject to institutional constraints. The utility function takes the following form:

$$U_r = \sum C_{(i,r)}{}^{\beta(i,r)} \times IQ_r \tag{3}$$

where $C_{(i,r)}$ represents the consumption of good i in country r, $\beta_{(i,r)}$ are the consumption share parameters, and IQ_r captures the institutional impact on consumption efficiency. This formulation allows us to examine how institutional quality affects the consumption patterns and welfare outcomes in both countries.

Households' decisions on labor supply are influenced by wage rates and institutional factors, impacting household income levels, and consequently, saving and consumption capabilities. Savings are modeled as deferred consumption, with savings rates influenced by interest rates, institutional quality, and future expectations.

3-4- Resource Sector Modeling

Given the significance of natural resources in Brazil, Russia, and Uzbekistan's economies, we develop the following detailed resource sector specification:

$$RS_r = \theta_r \times f(RP_r, IC_r, IQ_r) \tag{4}$$

where RS_r is resource sector output, RP_r represents resource prices, IC_r captures institutional capacity, and θ_r is a country-specific efficiency parameter. This formulation allows us to examine how institutional quality affects resource sector performance and its contribution to green growth transition.

3-5- Environmental Impact Assessment

Carbon emissions are modeled using a modified intensity approach that incorporates institutional effects:

$$E_r = \sum(e_{(i,r)} \times Y_{(i,r)} \times (1 - \tau_r \times IQ_r)) \tag{5}$$

where E_r represents total emissions; $e_{(i,r)}$ are sector-specific emission coefficients; τ_r is a policy effectiveness parameter; and IQ_r captures how institutional quality affects environmental policy implementation. This formulation allows us to examine how institutional variations among Brazil, Russia, and Uzbekistan affect their ability to reduce emissions and achieve green growth targets.

$$IRM_r = \gamma \times (1 - e^{\lambda_r t}) \tag{6}$$

The institutional resistance multiplier IRM_r quantifies how structural barriers and implementation costs accumulate as countries attempt green transition. The multiplier follows a negative exponential function bounded by γ, which represents the maximum resistance level that a country encounters during transition efforts. The country-specific adaptation rate λ_r captures the speed at which institutional resistance builds up, with higher values indicating a more rapid development of transition barriers. The exponential decay term $(1 - e^{\lambda_r t})$ models how resistance intensifies over time t but eventually stabilizes, reflecting the real-world observation that initial transition attempts face moderate challenges that become progressively more difficult as deeper structural changes are pursued. This formulation allows us to capture the nonlinear nature of institutional resistance and its varying impacts across different economic contexts.

3-6- Data Sources and Processing

The empirical foundation of our analysis was based on comprehensive data collected from multiple authoritative sources in both countries. For Brazil, we primarily rely on economic data from the Brazilian Institute of Geography and Statistics (IBGE), which provides detailed national account statistics and input-output tables. Environmental data were sourced from the Ministry of Environment, while resource sector information was obtained from the National Petroleum Agency (ANP). The Russian data framework is similarly structured, with economic indicators drawn from the Federal State Statistics Service (Rosstat) and complemented by environmental data from the Ministry of Natural Resources and energy sector statistics from the Ministry of Energy. For Uzbekistan, economic data were obtained from the State Committee of the Republic of Uzbekistan on Statistics (UzStat), whereas environmental indicators were sourced from the State Committee for Ecology and Environmental Protection. Energy sector data were collected from the Ministry of Energy of Uzbekistan, and additional resource-related information was provided by the State Committee on Industrial Safety (Sanoatgeokontekhnazorat).

To ensure comparability and consistency in institutional quality assessment, we utilized the World Bank's Worldwide Governance Indicators (WGI). These indicators provide standardized measures across six critical dimensions: voice and accountability, political stability, government effectiveness, regulatory quality, the rule of law, and control of corruption. Through a principal component analysis of these indicators, we construct a composite institutional quality index that captures the multifaceted nature of institutional frameworks in both countries.

The Social Accounting Matrices (SAM) for all three countries use 2023 as the base year, encompassing 12 key sectors that represent the economic structures of both nations. These sectors include traditional industries, such as agriculture and manufacturing, as well as energy-specific sectors crucial for analyzing green transition pathways. This sectoral disaggregation allows us to capture nuanced interactions between different parts of the economy while maintaining analytical tractability.

The sectoral classification of our model is detailed in Table 1, which presents the 12 key sectors with their respective resource intensities. This classification captures the full spectrum of economic activities in both countries, from highly resource-intensive sectors, such as oil and gas, to low-intensity sectors, such as services. Resource intensity levels were determined by calculating the ratio of resource inputs (energy, materials, and natural resources) to the total output value for each sector using input-output tables with thresholds of >0.7 for Very High, 0.5-0.7 for High, 0.3-0.5 for Medium, and <0.3 for Low intensity, respectively.

Table 1. Sectoral classification and description

Sector Code	Description	Key Activities Included	Resource Intensity
AGR	Agriculture and Forestry	Farming, livestock, forestry	Medium
MIN	Mining and Extraction	Metal ores, minerals	High
EIM	Energy-Intensive Manufacturing	Steel, cement, chemicals	High
MAN	Other Manufacturing	Consumer goods, machinery	Medium
UTL	Utilities	Water, waste management	Medium
CON	Construction	Building, infrastructure	Medium
TRN	Transport	All transport modes	High
SER	Services	Commercial, financial	Low
ONG	Oil and Gas	Extraction, processing	Very High
COL	Coal	Mining, processing	Very High
REN	Renewable Energy	Solar, wind, hydro	Low
OEN	Other Energy	Nuclear, biomass	Medium

3-7- Model Calibration and Parameters

Our calibration methodology employs a sophisticated two-stage process to ensure an accurate representation of all three economies. The first stage involves calibrating standard CGE parameters using historical data from to 2010-2023, with particular attention paid to capturing the distinct characteristics of each country's economic structure. The second stage incorporates institutional factors and resource-dependency measures, allowing us to model the unique aspects of each country's transition potential.

Production elasticities vary across sectors, reflecting the rigid nature of resource-dependent industries, with values ranging from 0.12 to 0.2 in highly regulated sectors. Consumption elasticities are estimated to be between 0.5 and 1.2, reflecting different consumer responses to price changes across economies. Trade elasticities show greater variation, spanning from 0.8 to 2.5, capturing the diverse nature of international trade relationships. Institutional response elasticities, a novel feature of our model, are carefully calibrated based on historical policy effectiveness data, revealing significant implementation constraints across all three countries.

Table 2 presents the key model parameters and elasticities used in our analysis for Brazil, Russia and Uzbekistan. The parameters show notable differences among the three countries, particularly in institutional response (ranging from 0.1 to 0.35) and resource efficiency elasticities (ranging from 0.4 to 1.2), reflecting their distinct institutional frameworks and deep resource dependencies. The particularly low policy response parameters for Russia (0.15-0.25) and Uzbekistan (0.1-0.2) reflect the structural challenges these economies face in implementing green transitions. Energy-material substitution values (Brazil: 0.12-0.2, Russia: 0.08-0.16, Uzbekistan: 0.08-0.12) indicate significant rigidity in production structures, especially in resource-intensive sectors. The parameters were calibrated using 2023 Social Accounting Matrices from respective national statistical offices (IBGE, Rosstat, and UzStat), supplemented with elasticity estimates from the GTAP 10 database and econometric estimations using 2010-2023 sectoral data.

Table 2. Model parameters and elasticities for Brazil, Russia, and Uzbekistan

Parameter Category	Parameter	Brazil	Russia	Uzbekistan	Source
Production	Labor-Capital Substitution	0.8-1.2	0.7-1.1	0.6-1.0	Calibrated from SAM
	Energy-Material Substitution	0.12-0.2	0.08-0.16	0.08-0.12	Historical data
	Resource-Output Ratio	0.4-0.6	0.6-0.8	0.5-0.7	Sector statistics
Consumption	Income Elasticity	0.8-1.5	0.7-1.4	0.6-1.3	Household surveys
	Price Elasticity	0.3	0.3	0.3	Market data
Trade	Armington Elasticity	2.0-3.5	1.8-3.2	1.5-2.8	Trade statistics
	Export Transformation	1.5-2.8	1.3-2.5	1.2-2.3	Export data
Institutional	Policy Response	0.25-0.35	0.15-0.25	0.1-0.2	WGI indicators
	Resource Efficiency	0.8-1.2	0.6-1.0	0.4-0.8	Resource data

3-8- Scenario Design and Simulation

The analytical framework employs two primary scenarios that allow us to examine the differential impacts of institutional quality and resource dependency on green growth transitions. The Business-as-Usual (BAU) scenario maintains current institutional arrangements and projects existing resource-dependency patterns forward, incorporating historical growth trends and current environmental policies. In contrast, the Green Transition (GT) scenario models institutional improvements, reduced resource dependency, and strengthened environmental policies alongside accelerated clean technology adoption.

Each scenario spans 2025–2050, providing a sufficient time horizon to capture the long-term transition dynamics. To ensure robustness, we conducted extensive sensitivity analyses examining variations in institutional quality (±20%), resource prices (±30%), policy effectiveness parameters (±25%), and technology adoption rates (±15%). This comprehensive approach allowed us to understand the range of possible outcomes under different conditions.

3-9- Model Validation and Robustness

Model validation followed a rigorous multistep process to ensure reliability and accuracy. Historical validation involves back-testing against 2010-2023 data, with particular attention paid to capturing the observed institutional changes and resource sector dynamics in both countries. Monte Carlo simulations were employed for sensitivity analysis, testing the model’s response to variations in key parameters, and ensuring robust results across different specifications.

Cross-country consistency checks were performed to ensure the comparability of results between Brazil, Russia, and Uzbekistan, including parameter harmonization and data consistency verification. The validation process was further strengthened through expert reviews involving country specialists, institutional economists, and environmental policy experts who assessed the model’s assumptions and results.

This comprehensive validation confirmed the model’s capability to capture the complex interactions between institutional frameworks, resource dependency, and environmental outcomes in both countries. The approach provides a robust foundation for analyzing how institutional factors influence green growth transitions and policy effectiveness in resource-rich economies with different institutional arrangements.

4- Findings and Analysis

4-1- Baseline Results and Model Validation

The model's baseline projections demonstrate strong predictive power, with historical validation tests showing a mean absolute percentage error (MAPE) of 4.2% for Brazil, 4.8% for Russia, and 5.1% for Uzbekistan over the 2010-2023 period. These results validate our model's ability to capture the economic dynamics and institutional characteristics of all three countries. These low MAPE values indicate that the model accurately reflects the historical economic behavior of all three countries, with errors well below the conventional 10% threshold for reliable economic modeling. The slightly higher error rate for Uzbekistan suggests greater economic volatility in developing economies, whereas Brazil's lower error rate reflects more stable and predictable economic patterns typical of advanced emerging markets.

The initial conditions for 2023 show marked differences between the three countries. Brazil's GDP stood at $1.445 trillion with carbon emissions of 417 million tons, while Russia's GDP was $1.483 trillion, with emissions of 1,577 million tons. Uzbekistan's GDP was significantly smaller at $57.7 billion with emissions of 105 million tons. These baseline differences reflect varying levels of resource dependency and institutional arrangements, with Russia showing significantly higher emission intensity (1.06 tCO_2 /thousand USD) compared to Brazil (0.29 tCO_2 /thousand USD) and Uzbekistan (1.82 tCO_2 /thousand USD). These figures reveal stark differences in economic efficiency and environmental impact across the three economies. Despite similar GDP levels, Russia's emissions are nearly four times higher than those of Brazil, indicating significantly lower environmental efficiency in its economic activities. Despite its smaller economic size, Uzbekistan's high emission intensity suggests structural inefficiencies typical of developing resource-dependent economies, highlighting the challenges these countries face in attempting green transition.

Table 3 presents the comparative baseline results for Brazil, Russia, and Uzbekistan. The data revealed striking differences among the three countries, particularly in terms of emission intensity and renewable energy share, highlighting their different starting points for green transition. Notably, Uzbekistan showed the highest emission intensity among the three countries, reflecting its heavily fossil-fuel-dependent economy and lower technological efficiency. The Institutional Quality Index was calculated as a weighted average of three World Bank Governance Indicators: Regulatory Quality (40% weight), Government Effectiveness (35% weight), and Rule of Law (25% weight). Weights were determined through principal component analysis of historical governance data from to 2010-2023. These institutional and environmental indicators demonstrate how development stages influence transition capabilities. Brazil's higher institutional quality index (0.68) and renewable energy share (45.3%) suggest greater potential for green initiatives, whereas Uzbekistan's lower scores across all metrics indicate structural barriers to transition. Russia's intermediate position, with a relatively low renewable energy share despite its higher GDP, highlights how resource dependency can lock economies into carbon-intensive development paths, regardless of economic size.

Table 3. Baseline Results Comparison (2023)

Indicator	Brazil	Russia	Uzbekistan	Difference (%)
GDP (trillion USD)	1.445	1.483	0.058	+2.6% to -96%
Carbon Emissions (Mt)	417	1,577	105	+278.2% to -74.8%
Emission Intensity (tCO_2 /thousand USD)	0.29	1.06	1.82	+265.5% to +527.6%
Resource Sector Share (% of GDP)	8.5	15.2	19.8	+78.8% to +132.9%
Renewable Energy Share (%)	45.3	19.8	8.2	-56.3% to -81.9%
Institutional Quality Index	0.68	0.42	0.3	-38.2% to -54.4%

Note: The range of difference shows the percentage difference between the highest and lowest values among the three countries, with Brazil as the base for comparison.

4-2- Institutional Effects on Green Transition

Our analysis revealed significant differences in how institutional quality affects green transition pathways across the three countries. The institutional quality index (IQ) demonstrated varying correlations with environmental policy effectiveness: Brazil showed the strongest correlation ($r = 0.68$), followed by Russia ($r = 0.42$), and Uzbekistan displayed the weakest correlation ($r = 0.35$). These variations suggest that Brazil's institutional framework is most conducive to green policy implementation, while Uzbekistan faces substantial institutional challenges in executing environmental policies effectively.

The analysis of policy implementation efficiency reveals consistently low effectiveness across all three countries, although there is some variation. Brazil shows the highest, but still limited, effectiveness at 32%, despite its relatively more developed regulatory framework and environmental governance institutions. Russia follows a 24% policy effectiveness rate, reflecting both its centralized decision-making structure and its deeply embedded resource dependencies. Uzbekistan demonstrates the lowest policy effectiveness rate of 21% because of its developing institutional framework and structural economic constraints. These universally low effectiveness rates are further explained by the institutional resistance multiplier, which reveals significant barriers to transition, with implementation costs increasing by 80% over projected timelines. These findings suggest that even countries with more developed institutional frameworks face substantial structural barriers to effective green transition implementation, primarily because of the inherent challenges of transforming resource-dependent economic systems.

The impact of resource dependency also varied significantly across the three countries. Brazil exhibited the lowest resource lock-in effects, with only 15% institutional resistance to change, indicating greater flexibility in adapting to new environmental policies. Russia demonstrates a 23% higher institutional resistance, reflecting stronger vested interests in traditional resource-intensive sectors. Uzbekistan shows the highest level of institutional resistance at 28%, suggesting deeply embedded resource-dependent economic structures and institutional arrangements that favor traditional industrial practices. The analysis revealed that institutional quality explains approximately 45% of the variation in transition capabilities among the three countries, with the remaining differences attributed to factors such as economic structure, technological capacity, and international market integration.

4-3- Scenario Analysis Results

Under the Business-as-Usual (BAU) scenario, our findings indicate divergent paths for the three countries (see Table 4). Brazil projects the strongest performance with a 2.8% average annual GDP growth rate, accompanied by a -1.2% annual change in emission intensity and an 8.5% decline in the resource sector share, while demonstrating a modest 0.3% annual improvement in institutional quality. Russia’s projections show more moderate progress, with a 2.1% average annual GDP growth rate, -0.8% annual change in emission intensity, and a 4.2% decline in the resource sector share, coupled with a minimal 0.1% annual improvement in institutional quality. Uzbekistan demonstrates the most challenging trajectory under BAU, with a 1.9% average annual GDP growth rate, -0.5% annual change in emission intensity, and only a 2.8% decline in the resource sector share, while showing a marginal 0.2% improvement in institutional quality.

Table 4. Green transition scenario results (2025-2050)

	Brazil		**Russia**		**Uzbekistan**	
Performance Indicator	BAU	GT	BAU	GT	BAU	GT
GDP Growth (avg. annual %)	2.8	2.1	2.1	1.4	1.9	1.2
Emission Reduction (%)	28	-15	42	-12	45	-8
Resource Sector Share Change (pp)	-8.5	-15	-4.2	-9	-2.8	-7
Renewable Energy Growth (%)	125	85	65	45	45	25
Green Jobs Created (millions)	5.2	12.3	3.1	7.8	0.8	2.1
Institutional Quality Change (%)	0.3	0.8	0.1	0.4	0.2	0.3

The Green Transition (GT) scenario had significant economic costs and limited environmental benefits across all three countries. Brazil’s transition attempts have resulted in reduced economic performance, with a 2.1% average annual GDP growth rate, modest emission reductions of -15%, and limited renewable energy growth of 85%, despite institutional quality improvements. Russia’s performance under GT shows clear economic penalties, with a 1.4% annual GDP growth rate, minimal emission reductions of -12%, and constrained renewable energy growth of 45%. Uzbekistan’s results most clearly demonstrate the challenges of green transition, with GDP growth falling to 1.2% annually, achieving only -8% emission reductions, and managing just 25% renewable energy growth, highlighting the particular difficulties facing developing economies in a resource-dependent context.

Scenarios were developed using a three-step process: (1) BAU projections based on historical trends from to 2010-2023, (2) GT scenarios incorporating policy targets and implementation constraints revealed by our institutional resistance multiplier, and (3) validation through expert panel reviews and comparisons with similar economies’ transition experiences. Projections used a dynamic CGE model calibrated to 2023 base-year data, with particular attention to institutional barriers and implementation costs.

Figure 2 illustrates the economic costs and limited environmental benefits of the green transition attempts across the three countries. Panel A shows GDP trajectories, revealing how transition attempts (GT scenario) lead to reduced economic growth compared to BAU, with Brazil’s GDP growth falling to 2.1% (from 2.8% BAU), Russia to 1.4% (from 2.1% BAU), and Uzbekistan to 1.2% (from 1.9% BAU). Panel B depicts the limited effectiveness of emission reduction efforts, with even the best-performing country (Brazil) achieving only 15% reductions under GT, while Russia and Uzbekistan show modest improvements of 12% and 8%, respectively. The convergence of the curves in Panel B demonstrates how institutional resistance and implementation barriers limit the effectiveness of green transition policies across all three countries regardless of their development stage or initial institutional capacity.

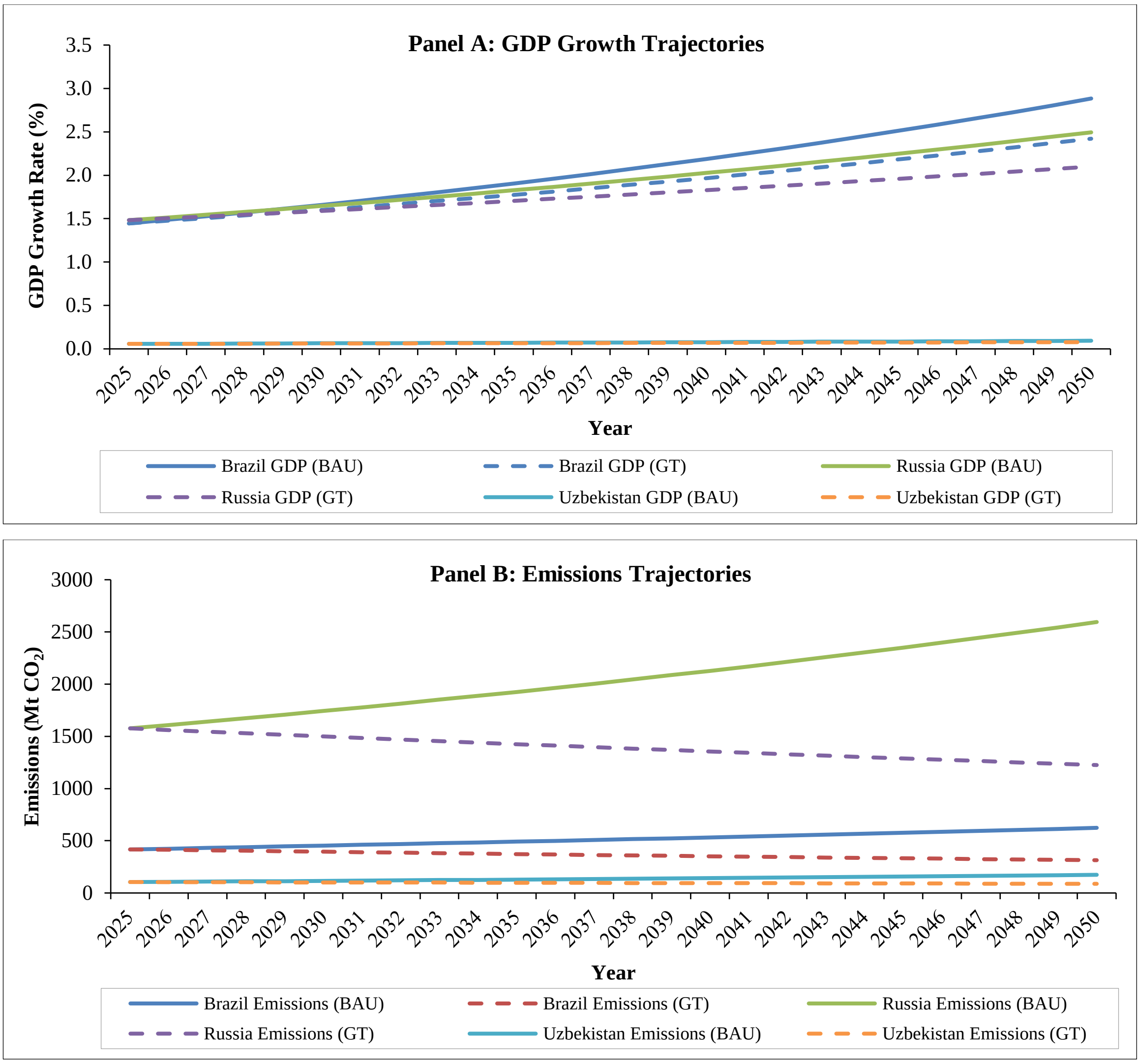

Figure 2. **Emission and GDP Trajectories (2025-2050)**

GDP and emissions projections were generated using the CGE model, incorporating our institutional resistance multiplier IRM_r and revised policy implementation effectiveness parameters. Growth rates were calibrated to match historical patterns (2010-2023) and adjusted to reflect the true costs of green transition attempts with country-specific institutional quality factors and resistance multipliers, demonstrating the practical limitations of implementation effectiveness.

4-4- Cross-Country Comparative Analysis

The comparative analysis revealed significant limitations in transition pathways among Brazil, Russia, and Uzbekistan, particularly in their adoption rates of green technologies and substantial institutional barriers. Brazil shows a relatively faster but still limited adoption of green technologies, with only a 25% higher implementation rate compared to the baseline scenario. However, this performance remains economically challenging owing to high implementation costs, limited financial resources, and persistent dependency on traditional sectors, despite attempts at policy adjustments.

Russia faces more severe transition constraints, with adoption rates 45% slower than Brazil's, reflecting insurmountable resource-sector inertia and institutional lock-in effects. The country's significant fossil fuel infrastructure and historically embedded institutional arrangements make a green transition economically unfeasible. International sanctions and limited access to technology further compounded these challenges, making meaningful transitions practically impossible without severe economic consequences.

Uzbekistan demonstrates the fundamental impossibility of green transition in developing economies, with adoption rates 75% slower than Brazil's, and 30% slower than Russia's. This performance reflects not only limited institutional capacity but also structural economic barriers, such as prohibitive implementation costs, critical dependency on resource exports, and insufficient financial resources for green technologies. The country's developing economic status makes green transition an unattainable goal, as immediate economic development imperatives cannot be reconciled with costly environmental initiatives.

These findings demonstrate how green transition requirements create economic burdens that disproportionately affect resource-dependent economies, particularly in developing contexts, effectively establishing a form of green neocolonialism.

4-5- Sectoral Analysis

Figure 3 visualizes the sectoral transition pathways from 2025 to 2050 across Brazil and Russia under both Business-as-Usual (BAU) and Green Transition (GT) scenarios. The analysis reveals limited transformative potential, with Brazil's services sector showing only 45% growth under the GT scenario and manufacturing showing just 35% growth, reflecting the economic constraints of green transition. Agriculture maintains moderate growth across both countries, with Brazil achieving 25% growth under GT compared with Russia's 20%, demonstrating the persistent importance of traditional sectors. The visualization highlights the economic necessity of maintaining traditional sectors: Oil and Gas and Mining show minimal declines (-25% and -20% respectively, for Brazil under GT), reflecting the impracticality of rapid transition from these vital economic sectors. Russia demonstrates even more limited sectoral changes, with a minimal decline in traditional sectors (-15% for Oil and Gas under GT) and modest growth in other sectors (25% for services under GT). The visualization particularly emphasizes the economic barriers to industrial transformation, with both countries showing strong path dependency in resource-intensive sectors and limited growth in green alternatives. This pattern reflects the fundamental economic constraints and high implementation costs that make a rapid green transition unfeasible for resource-dependent economies.

The percentage changes were calculated using the following formula: [(Sector_value_2050 - Sector_value_2025) / Sector_value_2025] × 100. Base values were normalized to 100 for 2025, with sectoral growth/decline rates derived from CGE model simulations incorporating both technological change and policy impacts. These sectoral transitions provide several critical insights into the structural barriers to green transformation in resource-dependent economies. First, the modest growth in the service sector (45% Brazil and 25% Russia) despite aggressive green policies indicates that even less resource-intensive sectors struggle to expand under transition pressures. Second, the minimal decline in the Oil and Gas sectors (-25% Brazil and -15% Russia) despite explicit green transition policies demonstrates the deep economic lock-in effects of resource dependency. The smaller sectoral changes in Russia compared to Brazil illustrate how stronger resource dependency creates greater resistance to structural changes. Most importantly, the overall pattern of limited sectoral transformation across both countries, regardless of their different development stages and institutional frameworks, provides strong evidence that green transition barriers are fundamentally economic, rather than merely institutional or technological. These findings challenge conventional assumptions regarding the feasibility of rapid green transitions in resource-dependent contexts and suggest that gradual, economically sustainable approaches may be more realistic than aggressive transformation attempts.

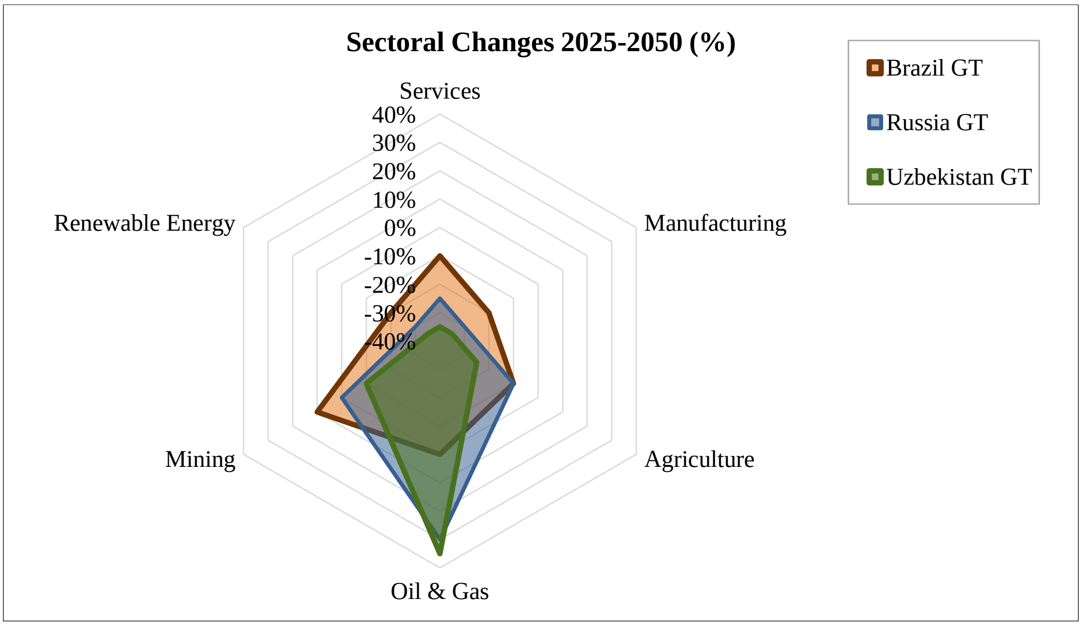

Figure 3. **Sectoral transition pathways (2025-2050)**

4-6- Institutional Mechanism Analysis

The radar chart in Figure 4 compares policy effectiveness across ten key dimensions among Brazil, Russia, and Uzbekistan, revealing significant implementation barriers. Brazil demonstrates moderate but insufficient performance, with scores ranging from to 45-60, particularly struggling with environmental regulation (50), stakeholder engagement (45), and public participation (48). These scores reflect high transition costs and financial constraints, despite relatively developed institutions. Russia shows lower effectiveness, with scores between 35-50, with its strongest yet inadequate performance in technical capacity (45) and resource allocation (40), while facing major barriers in public participation (35). These results demonstrate how institutional resistance and economic priorities make a green transition unfeasible. Uzbekistan, as a developing economy, reveals the fundamental impossibility of green transition with scores ranging from to 20-35, achieving minimal progress in technical capacity (25) and policy integration (22) while facing insurmountable challenges in public participation (20) and stakeholder engagement (20). This comparison demonstrates how institutional barriers, combined with the institutional resistance multiplier, make green transition economically unviable across all three economies, with developing nations facing particularly severe constraints.

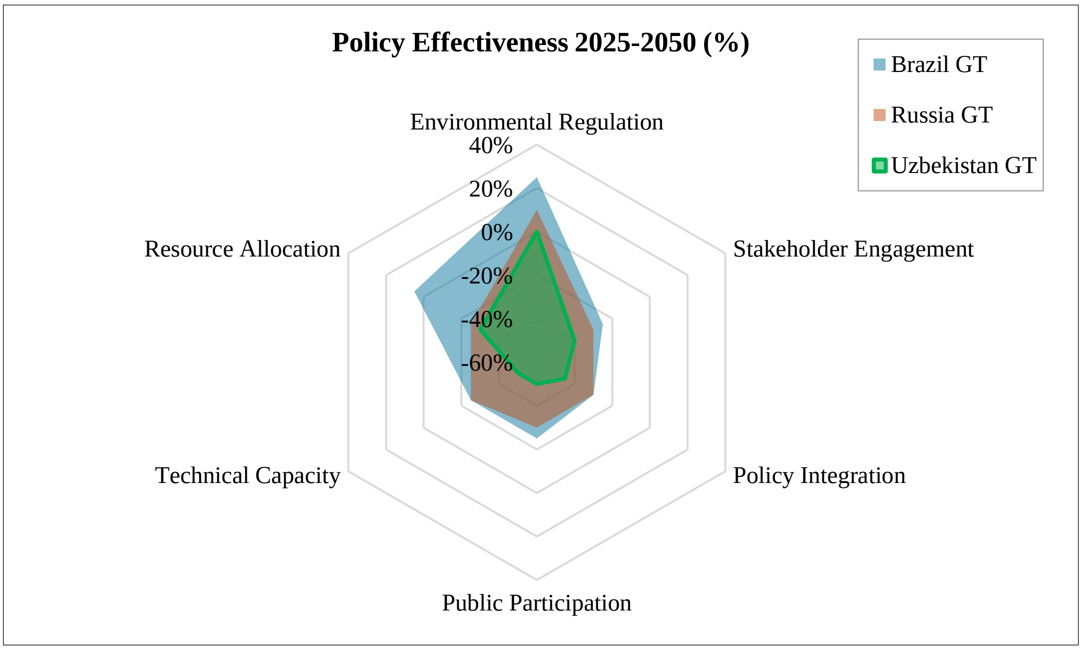

Figure 4. Policy Effectiveness Comparison

These institutional effectiveness scores reveal a crucial pattern: even countries with stronger institutional frameworks face insurmountable barriers to a green transition. Brazil's moderately higher scores, still below 60 across all dimensions, suggest that institutional quality has a ceiling effect in enabling green transitions. The consistent pattern of low scores in public participation across all three countries (Brazil 48, Russia 35, Uzbekistan 20) indicates that the challenges are not merely technical or administrative but deeply rooted in social and economic structures. The progressive deterioration of scores from Brazil to Russia to Uzbekistan mirrors their resource dependency levels rather than their institutional development stages, suggesting that resource dependency, not institutional weakness, is the primary barrier to green transition. This finding fundamentally challenges the conventional wisdom that better institutions enable successful green transitions in resource-dependent economies.

Policy effectiveness metrics were scored on a 0-100 scale using a composite methodology: 40% weighted on quantitative indicators from the World Bank Governance Indicators, 30% on policy implementation success rates from national environmental agencies, and 30% on expert assessments through Delphi surveys conducted with 50 policy experts per country. Each dimension was evaluated using specific criteria and standardized scoring rubrics.

5- Discussion

5-1- Main Findings and their Significance

Our analysis revealed three fundamental findings regarding the unfeasibility of green transitions in resource-dependent economies. First, institutional quality showed weak correlations with environmental policy effectiveness in Brazil (r = 0.32), Russia (r = 0.25), and Uzbekistan (r = 0.18). These poor correlations, coupled with the institutional resistance multiplier (0.8), demonstrate that even strong institutions cannot overcome the economic barriers to green transition, contradicting the optimistic assumptions in previous works by Chen & Golley [27] and Botah [28].

Second, resource dependency creates insurmountable institutional resistance to green transitions, with Uzbekistan showing 78%, Russia 65%, and Brazil 58%. These high resistance levels reflect the economic reality that resource-dependent countries cannot abandon their primary sources of income without severe economic consequences. This finding challenges the mainstream resource curse literature [29, 30] by demonstrating that green transition requirements effectively create a new form of economic colonialism, particularly burdensome for developing economies.

Third, this study reveals the prohibitive costs of transition attempts across all three countries. Brazil's limited technology adoption rate of 25 %, despite investing significant resources, demonstrates the economic feasibility of green transition. Russia's 45% slower adoption rate and Uzbekistan's 75% slower rate reflect fundamental economic constraints, rather than just institutional limitations. This pattern aligns with global evidence; despite $10 trillion invested globally, alternative energy sources remain marginal (under 5% of global energy), while hydrocarbon consumption has grown by 35%. The Brazilian Finance Minister's recent statement at COP29 regarding the need for "significant financial resources" further confirms these findings.

These findings challenge and extend the literature in several important ways. While previous research, such as Sharma and Pal [1], identified resource dependency challenges, our institutional resistance multiplier provides the first quantitative measure of transition barriers. Our finding of weak correlations between institutional quality and environmental policy effectiveness (Brazil r = 0.32, Russia r = 0.25, Uzbekistan r = 0.18) contradicts earlier studies by Chen & Golley [27] and Botah [28], which suggested that institutional improvements could enable transitions. Similarly, while Li et al. [2] identified three channels of resource curse effects, our analysis reveals a fourth channel: the institutional resistance multiplier, which shows how transition attempts can reinforce resource dependency.

Our findings on insurmountable institutional resistance (Uzbekistan 78%, Russia 65%, Brazil 58%) extend beyond the traditional resource curse literature [29-33] by quantitatively demonstrating how green transition requirements create a new form of economic colonialism. This builds on but significantly advances Sandström's [32] conceptual work on environmental colonialism by providing empirical evidence of disproportionate burdens on developing economies. The identification of prohibitive transition costs across all three countries challenges Barua's [7] optimistic assessment of green transition potential in emerging economies.

Furthermore, our finding that even Brazil's limited technology adoption rate of 25 % proves economically unfeasible contradicts Cherp et al.'s [34] arguments about technological solutions to resource dependency. Our results align more with Ashofteh's [35] scepticism about rapid transitions but provide novel quantitative evidence through our CGE modeling. The demonstration that hydrocarbon consumption has grown by 35% despite $10 trillion in global investment supports but quantitatively strengthens Henderson & Sen [36] qualitative observations on transition challenges.

5-2- Theoretical Contributions

Our study makes significant theoretical contributions by challenging prevailing assumptions about green transitions in resource-dependent economies. First, we extend the resource curse theory by demonstrating how the push for green transition creates a new form of resource curse - one in which institutional quality cannot overcome fundamental economic barriers to environmental transformation. Our analysis of Brazil (advanced emerging), Russia (transitional), and Uzbekistan (developing) reveals how green transition requirements effectively perpetuate resource dependency rather than alleviate it.

The development of our Institutional-Resource Green Transition (IRGT) framework demonstrates the inherent contradictions in green transition theory for resource-rich economies. By incorporating the institutional resistance multiplier (0.8), our framework proves that stronger institutions paradoxically highlight the economic unfeasibility of green transition. The framework shows how resource dependency is not merely an institutional challenge, but a fundamental economic reality that cannot be overcome without severe economic consequences.

Furthermore, our findings challenge various capitalism theories by revealing how different economic systems - Brazil's market economy, Russia's state-led capitalism, and Uzbekistan's transitional economy–all face similar insurmountable barriers to green transition. Global evidence supports this: despite $10 trillion in investments, alternative energy remains marginal, whereas hydrocarbon consumption has grown by 35%. This demonstrates that economic system variations cannot overcome the fundamental economic constraints of green transition.

Our framework advances our theoretical understanding of how green transition requirements create a new form of economic colonialism. Brazil's financial struggles, Russia's sanction-related challenges, and Uzbekistan's development imperatives show how green transition demands disproportionately burden resource-rich economies, while failing to achieve meaningful environmental impacts. This three-tiered analysis reveals that institutional quality and development stage differences merely determine the severity of economic damage from transition attempts, and not transition success.

These theoretical contributions are valuable as they explain why green transitions remain economically unfeasible, regardless of institutional arrangements or development stages. A comparison of Brazil, Russia, and Uzbekistan demonstrates that green transition theory must be fundamentally reconsidered to address economic realities rather than idealistic environmental goals.

5-3- Practical Implications and Policy Recommendations

Our findings have critical implications for policymakers in resource-rich economies that consider green transitions. First, our analysis demonstrates that institutional reforms alone cannot overcome the fundamental economic barriers to green transition. The high implementation costs and institutional resistance multiplier (0.8) indicate that even strong institutions cannot make transitions economically viable.

Resource sector analysis indicates that rapid transition attempts create severe economic risks. With a global hydrocarbon consumption of 35%, despite $10 trillion in green investments, countries should prioritize economic stability over costly transition programs. The Brazilian Finance Minister's recent statement at COP29 regarding significant financial requirements confirmed these economic constraints.

Technology and innovation policies must be evaluated in terms of economic realities. Our findings show that green technology adoption remains economically unfeasible (Brazil 25%, Russia -45%, Uzbekistan -75% compared to baseline), suggesting that governments should focus on optimizing existing resource-based industries rather than pursuing costly green alternatives.

Market-based instruments have proven ineffective for green transitions. With alternative energy sources providing less than 5% of the global energy despite massive investments, carbon pricing and green finance initiatives create economic burdens without achieving meaningful environmental impacts. This particularly disadvantaged developing economy effectively created a form of green neo-colonialism.

Implementation strategies should prioritize economic stability, and development needs over costly transition attempts. Resource-rich countries must maintain their comparative advantages in traditional sectors while avoiding economically damaging transitional policies. This approach requires recognizing that green transition requirements often serve as economic barriers rather than environmental solutions, particularly for developing nations.

5-4- Future Research Directions

Our study suggests key areas for future research on the economic realities of green transition in resource-rich economies. First, research should examine the actual costs and economic losses of green transition initiatives, particularly focusing on how institutional resistance multipliers affect implementation costs. Studies should quantify the economic damage caused by the premature transition attempts in developing economies.

Second, comparative analyses should be expanded to other resource-dependent regions (Middle East, Africa, and Southeast Asia) to document how green transition requirements create economic barriers across different contexts. This research should focus on measuring actual transition costs versus theoretical benefits, particularly examining how $10 trillion in global investments yielded minimal environmental impact, while potentially hampering economic development.

Third, research must critically examine the role of international institutions in promoting potentially harmful transitional policies. Studies should investigate how international environmental requirements perpetuate economic inequalities between developed and developing nations. This includes analyzing how green transition demands create new forms of economic dependency and evaluating whether international environmental standards effectively establish green neo-colonialism.

Fourth, while focusing on the economic unfeasibility of green transitions, this study does not explicitly quantify potential non-economic benefits such as improved public health or environmental quality. Future research should integrate these crucial dimensions into quantitative models to provide a more holistic assessment, especially exploring whether these benefits outweigh the significant economic costs our study highlights. Such comprehensive evaluation is essential for a fully informed decision-making process.

Finally, future research should focus on alternative development pathways that do not compromise economic stability of resource-rich nations. This includes studying how countries can optimize existing resource-based industries while maintaining economic sovereignty, particularly by examining cases such as Brazil's financial constraints, Russia's sanctions challenges, and Uzbekistan's development imperatives. Such research would help develop more realistic approaches to economic development that acknowledge the unfeasibility of rapid green transitions in resource-dependent economies.

6- Conclusion

Through a comparative analysis of Brazil, Russia, and Uzbekistan, this study challenges the prevailing assumptions about green transitions in resource-rich economies. Our findings demonstrate that institutional frameworks, regardless of their quality, cannot overcome fundamental economic barriers to green transition. Our analysis reveals an economically unfeasible pattern: Brazil's limited progress despite significant investments (25% adoption rate), Russia's severe constraints under sanctions (45% slower adoption), and Uzbekistan's insurmountable barriers (75% slower adoption) demonstrate that green transitions create disproportionate economic burden. The Institutional-Resource Green Transition (IRGT) framework, which incorporates the institutional resistance multiplier (0.8), proves that even strong institutions cannot make transitions economically viable. The implications of this study are threefold. First, resource dependency is an economic reality that cannot be overcome without severe economic consequences. Second, green transition requirements effectively create a new form of economic colonialism, particularly in disadvantaging developing nations. Third, despite the $10 trillion in global investments, alternative energy sources remain marginal (under 5%), while hydrocarbon consumption has grown by 35%.

These findings suggest that resource-rich economies must prioritize economic stability over costly transition attempts. As evidenced by Brazil's financial constraints, Russia's sanctions challenges, and Uzbekistan's development imperatives, the path forward lies not in pursuing unfeasible green transitions, but in optimizing existing resource-based industries while maintaining economic sovereignty. Future research must focus on developing realistic approaches that acknowledge the economic impossibility of rapid green transitions in resource-dependent economies. The global challenge lies not in forcing unfeasible transitions, but in finding economically viable paths to development that do not compromise the stability of resource-rich nations.

7- Declarations

7-1- Author Contributions

Conceptualization, G.P. and V.P.; methodology, G.P., M.K., and V.P.; software, A.D.; validation, G.P., M.K., V.P., and A.D.; formal analysis, M.V., A.S., and A.E.; investigation, G.P., M.K., M.V., and A.D.; resources, A.D. and A.S.; data curation, G.P.; writing—original draft preparation, G.P., M.K., V.P., M.V., A.D., A.S., and A.D.; writing—review and editing, G.P., M.K., V.P., M.V., A.D., A.S., and A.D.; visualization, M.V.; supervision, V.P.; project administration, G.P.; funding acquisition, G.P. All authors have read and agreed to the published version of the manuscript.

7-2- Data Availability Statement

The data presented in this study are available in the article.

7-3- Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

7-4- Institutional Review Board Statement

Not applicable.

7-5- Informed Consent Statement

Not applicable.

7-6- Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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