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The Effects of Trade-Induced Technological Progress and Resource-Endowment Patterns on Economic Growth: Evidence from the Central American and Caribbean (CAC) Region

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Abstract

This study reexamines the trade-growth nexus in Central America and the Caribbean (CAC) region by incorporating technical absorptive capacity (AC) and natural resource dependence (NR) based on a semi-endogenous growth framework. Utilizing panel data from 1996 to 2019 across 21 CAC economies and employing the fixed effects estimator, AC—measured by high-technology imports—enhances economic growth by amplifying trade's productivity spillovers through "learning-by-importing" mechanisms. In contrast, natural resource-intensive exports exhibit an inverted U-shaped relationship, where moderate dependence supports growth, but excessive reliance leads to economic stagnation. However, government effectiveness plays a critical role in mitigating this resource curse with stronger institutions moderating the adverse effects of high NR dependence. These findings refine the understanding of economic development in small, trade-exposed economies, emphasize the need for policies that foster technology adoption, promote economic diversification, and strengthen institutional frameworks for the sustainable long-term growth.

Keywords: Trade Openness, Economic Growth, Absorptive Capacity, Resource Curse,

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Ⅰ. Introduction

The Central America and Caribbean (CAC) region, comprising of small and trade-dependent economies, faces complex challenges in achieving sustained economic growth. Geographically positioned with easy access to major global markets, the region's economies are shaped by a mix of agriculture, natural resource extraction, manufacturing, and service-oriented industries. However, despite the importance of trade openness and export-driven growth, many CAC economies remain heavily reliant on primary commodity exports—such as minerals, agricultural products, and tourism—leaving them vulnerable to global price fluctuations and external economic shocks. Trade liberalization, particularly through agreements such as the Central America-Dominican Republic Free Trade Agreement (CAFTA-DR) (ECLAC, 2020), has provided these economies with access to global markets and technologies, yet the promised economic benefits have often been elusive. While trade openness theoretically fosters growth (Romer, 1990; Lucas 1988), in practice, many countries in the region struggle to capitalize on it. A potential source may be the inability to translate imported technology into productivity gains. This challenge is compounded by the region's heavy dependence on natural resource exports, which may cause a "resource curse" problem, where growth stagnates due to volatile commodity prices and limited value-added production.

The main problem addressed in this study is that trade openness alone does not guarantee sustainable growth in CAC countries, particularly those reliant on natural resources. While trade can provide access to foreign technologies and knowledge, the inability to internalize and apply these technologies limits their contribution to productivity and long-term economic growth. A crucial factor for overcoming this barrier is the introduction of technical absorptive capacity (AC)—the ability of economies to absorb and apply technology-intensive inputs, such as production machinery and advanced technologies. As Cohen & Levinthal (1990) and Keller W., (2004) have highlighted the role of absorptive capacity in fostering growth, but much of this literature has focused on general human capital and R&D investments, which may be insufficient to discuss the issue in small, resource-dependent economies. In this context, the technical skills required to utilize imported technologies and transform raw natural resources into higher-value products may be more important than broad measures of human capital or traditional innovation capacity.

The objectives of this study are threefold: (1) to examine how technical absorptive capacity, as measured by the imports of high technology-intensive intermediate goods, influences economic growth in the CAC region; (2) to assess whether the relationship between natural resource dependence and economic growth is non-linear, supporting the resource curse hypothesis; and (3) to explore how government effectiveness moderates the impact of natural resource dependence on economic growth. These questions are crucial for understanding the conditions under which trade can foster sustainable growth in the region, and how countries can better leverage their natural resource wealth through technological advancement and improved governance.

Using panel data from 1996 to 2019 across 21 CAC economies, this study employs fixed effects regression models to investigate these relationships. The results suggest that technical absorptive capacity plays a critical role in translating trade openness into growth, while the non-linear relationship between natural resource dependence and growth supports the resource curse hypothesis. Furthermore, the study finds that government effectiveness significantly moderates these dynamics, highlighting the importance of governance in overcoming the challenges posed by natural resource dependence.

The rest of the paper is structured as follows: Section 2 provides a review of the trade-growth literature. Section 3 constructs a semi-endogenous growth framework to anchor our hypotheses. Section 4 describes the empirical models, data sources, and estimation techniques. Section 5 reports the results and unpacks their economic significance, while Section 6 summarizes the findings and explores their implications for policy and future research.

Ⅱ. Background of CAC region's Economy and Literature Review

CAC region's Economy

The Central American and Caribbean (CAC) region, geographically positioned with access to major global markets, has pursued trade liberalization through agreements such as the Dominican Republic-Central America Free Trade Agreement (CAFTA-DR) and the Caribbean Community (CARICOM) (ECLAC, 2020), facilitating deeper integration into international trade networks. As a result, many CAC economies exhibit high export-to-GDP ratios, reflecting their dependence on external markets. However, this openness has not uniformly translated into sustained economic growth, as many economies remain reliant on primary commodity exports—such as agricultural goods, minerals, and fossil fuels—leaving them vulnerable to price volatility and external shocks.

While trade liberalization has enhanced market access and foreign direct investment (FDI) inflows, structural challenges persist. These CAC countries with concentrated export structures often experience cyclical economic fluctuations, particularly when global demand shifts or commodity prices decline. In contrast, economies that have successfully leveraged trade openness to diversify into higher-value industries—such as manufacturing and technology—demonstrate more stable growth patterns. This variation underscores the importance of absorptive capacity in translating trade integration into long-term economic gains. Trade openness alone may not be sufficient for long-term development without complementary factors like technological advancement, innovation, and the ability to absorb and adapt foreign knowledge.

Theoretical Contours of the Trade-Growth Nexus

Neoclassical models (Solow, 1956) cast trade as a static efficiency enhancer, driving growth through specialization—an elegant but rigid view that sidesteps technological dynamism. However, endogenous growth theory (Romer, 1990; Lucas, 1988) reframes trade as a catalyst for innovation and spillovers, embedding growth in human capital accumulation. Aghion and Howitt (1992) elaborate on the Schumpeterian disruption: trade accelerates technological leaps, but only for economies equipped to adapt—a condition which Rodriguez and Rodrik (2000) argue rarely holds in institutionally fragile contexts like Central America and the Caribbean (CAC) region. Feenstra (1996) shows trade's gains erode in small, open economies under terms-of-trade volatility—a structural reality for CAC's resource-dependent states.

Technology Diffusion and Absorptive Capacity

Trade's role as a technological conduit hinges on a pivotal question: can openness alone drive progress, or does absorptive capacity govern its impact? Keller (2002) asserts the former, demonstrating that imports of capital goods and FDI channel productivity gains—a mechanism Coe and Helpman (1995) anchor in R&D spillovers from advanced economies. Narula (2004) challenges this optimism: without human capital and infrastructure, diffusion stalls—a constraint Henry et al. (2009) quantify, finding capital goods imports boost efficiency only where capacity permits. In CAC, where innovation is stifled (Lall, 2000), technology-intensive imports emerge as a plausible proxy for absorptive capacity, a hypothesis Alcalá and Ciccone (2004) bolster: trade lifts Total Factor Productivity (TFP) via resource reallocation, yet falters in institutionally weak settings—a CAC hallmark. Haq et al. (2022) push this further, linking technology-intensive imports to robust TFP gains, but Rodrik et al. (2004) deliver a rebuttal, openness unmoored from structural resilience yields scant returns. Blyde and Fentanes (2020) show that technology-intensive imports boost Caribbean productivity, but gains depend on scarce skills and governance. Cirera and Winters (2015) extend this discussion across Latin America, and note imports rarely spur innovation without absorptive capacity. Zhang et al. (2021) highlight technology's role in converting raw resources into value-added exports, while Lederman and Maloney (2007) argue trade enhances resource wealth's potential when domestic capabilities align.

Resource Dependence: Curse or Catalyst ?

Resource wealth's growth legacy is still under controversy: does it doom economies to a curse, or can technology and trade forge a catalyst ? Sachs and Warner (2001) anchor the pessimistic camp, tracing slower growth in resource-rich states to volatility, rent-seeking, and human capital neglect—a structural lock-in Auty (1993) ties to inertia and Collier and Hoeffler (2005) to governance collapse. Arezki and van der Ploeg (2011) stress this statement: resource booms displace manufacturing, tethering CAC to global price swings. Yet Lederman and Maloney (2007) mount a counteroffensive: absorptive capacity, fueled by trade, redirects resource rents into technology and skills, yielding value-added exports—a transformation Zhang et al. (2021) evidence through green innovation's sustainable gains. Manzano and Rigobon (2001) furthers this by attributing stagnation to policy failures, not endowment itself.

The crux lies in execution. Brunnschweiler and Bulte (2008) upend the curse, arguing resource abundance spurs growth with robust institutions—a rarity in CAC (Helian et al., 2019). Carmignani and Chowdhury (2012) reveal a TFP penalty from resource reliance absent human capital, while Van der Ploeg and Poelhekke (2010) underscore volatility's trade-disrupting sting. Frynas et al. (2017) contextualize that in Latin America's post-1990s liberalization: resource dependence magnifies instability unless diversification—via technology—intervenes. Havranek et al. (2016) crystallize the stakes: trade-growth links weaken in resource-heavy economies, mirroring CAC's uneven trajectory.

Uncharted Terrain: Gaps and the CAC Lens

The trade-growth nexus in Central America and the Caribbean (CAC) region remains poorly understood due to persistent analytical blind spots. Canonical studies link trade to growth through absorptive capacity (Keller, 2004; Henry et al., 2009), but their reliance on proxies like human capital and R&D (Lall, 2000) misaligns with CAC's resource-constrained, import-dependent profile, where technology-intensive imports offer a more fitting measure (Blyde & Fentanes, 2020). Their studies oversight masks a vital mechanism this research leverages: a regionally tailored gauge of capacity attuned to CAC's realities. Similarly, resource curse literature (Sachs & Warner, 2001; Arezki & van der Ploeg, 2011) unpacks volatility and governance risks, yet its broad strokes neglect CAC's small, open economies, where trade and resource exports intertwine in distinctive, underexplored patterns (De Ferranti et al., 2002). Existing literature overlooks the non-linear dynamics of resource dependence—shifting from catalyst to curse as reliance intensifies—and by failing to examine how trade-driven technology could reverse this arc.

Governance deepens these lacunae. Identified as a pivotal growth mediator (Rodrik et al., 2004; Carmignani & Chowdhury, 2012), its influence in CAC remains uncalibrated to the region's institutional fragility (Sawyer, W. 2011) or its idiosyncratic trade features (Thacker et al., 2012). The interplay between technology and resource dependence—value-added opportunities versus entrenched traps—remains a theoretical sidelight rather than an empirical focal point. These omissions leave CAC as a critical blind spot, a region sidelined by generic frameworks and poised for a nuanced synthesis of capacity, resources, and governance to redefine trade-growth dynamics.

Ⅲ. Theoretical Framework

The theoretical discourse on economic growth has evolved to address the complexities of long-term output dynamics. Solow's (1956) neoclassical model provides a foundational lens to economic growth. This framework posits capital accumulation as the primary driver of growth, subject to diminishing returns, where steady-state per capita income hinges on exogenous technological progress. The model predicts conditional convergence—economies with lower initial capital stocks grow faster, converging to a common income level. Yet, this prediction falters in developing regions like Central America and the Caribbean (CAC), where structural constraints and limited technological progress hinder catch-up effects.

Endogenous growth theories, notably Romer (1990), counter this limitation by internalizing technological progress through knowledge accumulation and innovation, assuming constant or increasing returns to capital. These models suggest that sustained growth is possible via dynamic externalities from human capital and technology spillovers. However, for CAC economies, such optimism is tempered by weak institutions, low innovation capacity, and trade dependence, which stifle endogenous growth mechanisms. Semi-endogenous growth models (Jones, 1995) offer a synthesis, positing that technological progress depends on research effort and exogenous factors like population growth, providing a more realistic lens for regions with limited homegrown innovation.

In the CAC context, international trade emerges as a critical conduit for technology transfer, a theme underscored by regional studies. Bulmer-Thomas (2001) highlights how CAC economies, reliant on primary commodity exports (e.g., bananas, coffee) and tourism, face structural barriers to productivity gains, echoing the "resource curse" hypothesis (Sachs & Warner, 1997). This dependence, coupled with volatile commodity prices, limits diversification and technological deepening (Prebisch 1950; Singer, 1950). Conversely, trade in technology-intensive intermediate goods offers a pathway to access the global technology frontier, as evidenced by Grossman and Helpman (1991) and Coe and Helpman (1995). For CAC countries, where R&D investment is minimal—averaging below 0.5% of GDP (ECLAC, 2020)—importing such high-tech goods becomes pivotal for productivity spill-overs.

While importing advanced technologies is essential, the capacity to learn from and integrate them into domestic production processes is paramount, a process termed "learning-by-importing" (Barro & Sala-i-Martin, 1997). Paus (2004) finds that Costa Rica's growth in the 1990s stemmed from leveraging imported technologies in export-processing zones, unlike Honduras, where weak absorptive capacity constrained similar gains (Ocampo & Vos, 2008). Education, while complementary, often skews toward social sciences in CAC countries (UNESCO, 2022), misaligned with the technical skills needed for technology adoption. This study also integrates Heckscher-Ohlin (H-O) theory (Heckscher & Ohlin, 1933), which asserts that trade patterns mirror factor endowments. Natural resource exports align with this—complementing the semi-endogenous emphasis on technology diffusion—a risk that can lead to "resource curse", locking economies into low-productivity sectors (Auty, 2001). This interplay shapes growth trajectories, which distinguishes our approach from classical trade theories (e.g., Ricardo's comparative advantage).

This study extends the semi-endogenous growth framework of Lucas (1988) by integrating trade-related technology diffusion, emphasizing technical absorptive capacity (AC)—proxied by the share of technology-intensive imports—over traditional human capital measures and natural resource dependence (NR) proxied by share of natural resource-intensive exports. Aggregate output follows a Cobb-Douglas production function form:

$$Y_t = A_t K_t^{\alpha} H_t^{1-\alpha}, \quad 0 < \alpha < 1 \tag{1}$$

where Y_t is output, K_t is physical capital, $H_t = h_t L_t$ (with h_t as per-worker human capital and L_t as population), and A_t represents TFP.

Human capital per worker accumulates through education and learning-by doing:

$$\frac{\partial h_t}{\partial t} = \gamma u h_t \tag{2}$$

where u represents the fraction of time allocated to human capital accumulation (e.g., education, training), and $\gamma > 0$ is the efficiency of learning. Solving this differential equation yields an exponential path:

$$h_t = h(0) e^{\gamma u t} \tag{3}$$

This implies that human capital grows at the constant rate γu, contributing to long-term output growth.

Physical capital follows the standard accumulation equation:

$$\frac{\partial K_t}{\partial t} = sY_t - \delta K_t \tag{4}$$

Where s is the savings rate and δ is the depreciation rate. Over time, the capital-output ratio stabilizes, implying that the long-run growth rate of output is largely determined by human capital and TFP growth.

Unlike standard Lucas-type models where TFP is assumed exogenous, we modify TFP to be influenced by trade-related variables. This means that the growth of the CAC economies depends heavily on adopting and adapting technologies developed elsewhere. Therefore, their TFP growth isn't just some random, external force; it's something that's influenced by their own actions and choices, particularly those related to international trade. Therefore, this model aims to explain why TFP grows, not just assume it does. By making it endogenous, we can explore the factors that drive it.

Specifically, we model the growth of domestic TFP as:

$$\frac{\dot{A}_t}{A_t} = \lambda g^* + \O\Omega(AC_t,\ NR_t) \tag{5}$$

where $\dot{A}_t = \frac{\partial A_t}{\partial t}$, g^* is the exogenous global technology frontier growth rate, $\lambda \in (0,\ 1)$ measures frontier linkage. Eq. (5) captures AC_t as the positive dimension of technology adoption, NR_t as dependence that can generate negative externalities. This distinction is crucial because the "resource curse" manifests through channels that are not fully encompassed by measures of AC_t (which captures the country's ability to internalize foreign knowledge and technical progress through import of high-tech goods). Specifically, a heavy reliance on NR exports can induce distortions that hinder knowledge diffusion, diversification, and overall economic dynamism, ultimately impacting economic growth. These distortions, include the "Dutch Disease" and its associated deindustrialization, increased commodity price volatility and its dampening effect on investment, the potential for rent-seeking behavior and diminished incentives for innovation in other sectors.

NR_t represents natural resource-intensive exports, which may reduce incentives for industrial diversification and slow learning processes. Moreover, $\Omega(AC,\ NR)$ is a function capturing trade-related knowledge spillovers, where $\frac{\partial \Omega}{\partial AC} > 0$ (positive learning effects from higher technical absorptive capacity) and $\frac{\partial \Omega}{\partial NR} < 0$ (negative growth effects due to resource dependence).

With the dynamics of capital accumulation established, the focus now shifts to understanding how physical capital, human capital, and TFP evolve together to determine the long-run growth trajectory of the economy. The interplay between capital deepening, human capital formation through learning and education, and TFP growth influenced by technical absorptive capacity (AC) and natural resources dependence (NR) dictates the steady-state characteristics of the model. The balanced growth path provides a framework to evaluate how these factors coalesce over time, particularly how exogenous technological advancements (g^*), trade-related knowledge spillovers, and human capital investments jointly shape the long-term output growth rate.

On the balanced growth path, all key variables grow at constant rates. Given that human capital grows at γu and population expands at n, the long-run TFP growth rate stabilizes at:

$$g^*_A = \lambda g^* + \O\Omega^* \tag{6}$$

where Ω^* represents the steady-state effect of trade. The long-run per capita output growth rate is then:

$$g^*_{Y/L} = g^*_A + (1-\alpha)\gamma u \tag{7}$$

Since g^*_A remains dependent on the exogenous g^* (the growth rate of the global technology frontier) the model is inherently semi-endogenous, meaning that domestic policy can only alter the speed of convergence, not the steady-state growth rate in the long-run. Unlike a fully endogenous model, in which human capital or innovation investments could generate self-sustained, permanent growth independent of external forces, our extended framework maintains an external anchor in the form of g^*, ensuring that productivity gains remain constrained by global technological progress.

Ⅳ. Methods, Data, and Empirical Strategy

(1) Model Specification

Based on the discussion of the previous section. This section starts with the Lucas (1988) semi-endogenous model's production function:

$$Y_t = A_t K_t^{\alpha} H_t^{1-\alpha}, \quad 0<\alpha<1 \tag{8}$$

where $H_t = h_t L_t$ is per-worker human capital h_t and population L_t. The term A_t represents TFP, which evolves endogenously through technical absorptive capacity (AC) and natural resource exports (NR), through its long-run trend remains anchored to the exogenous global technology frontier. The parameter α indicate the elasticity of output with respect to physical capital, constrained between $0<\alpha<1$.

$$A_t = f(AC_t,\ NR_t), \quad \text{where } A_t = A_0 e^{\lambda_1 AC_t + \lambda_2 NR_t} \tag{9}$$

From equation (9), the initial technology is a function of the existing stock of technology, where A_0 is baseline TFP, where $\lambda_1>0$.

Amending the original Lucas (1988) production function includes this relationship as follows:

$$Y_t=(A_0(e^{\lambda_1 AC_t+\lambda_2 NR_t}))K_t^{\alpha}H_t^{1-\alpha} \quad (10)$$

To express the function in per capita terms, dividing both sides of (10) by labor force L_t, yields:

$$y_t=(A_0(e^{\lambda_1 AC_t+\lambda_2 NR_t}))k_t^{\alpha}h_t^{1-\alpha}, \text{ where } y_t=Y_t/L_t, \; k_t=K_t^{\alpha}/L_t^{\alpha}, \text{ and } h_t=H_t^{1-\alpha}/L_t^{1-\alpha} \quad (11)$$

Applying the natural logarithm to both sides of (11) makes linearize as (12):

$$ln(y_t)=ln(A_0)+\lambda_1 AC_t+\lambda_2 NR_t+\alpha ln(k_t)+(1-\alpha)ln(h_t) \quad (12)$$

In the equation above, $ln(A_0)$ is constant β_0 because A_0 is initial stock of the technology, which does not change over time.

For empirical analysis with panel data, where observations vary across countries and time, we introduce subscript i (country) and t for (time), yielding to a final empirical model:

$$ln(y_{it})=\beta_0+\beta_1 ln(k_{it})+\beta_2 ln(h_{it})+\beta_3 AC_{it}+\beta_4 NR_{it}+\beta_5 X_{it}+\eta_i+\pi_t+\in_{it} \quad (13)$$

where $\beta_1=\alpha$, $\beta_2=1-\alpha$, $\beta_3=\lambda_2$, X_{it} includes other control variables such as governance quality, and financial development, η_i captures unobserved country-specific effects, π_t controls for common time shocks across countries, and $\in_{it}$ is the idiosyncratic error term.

(2) Data Description

This study employs an unbalanced panel dataset covering the period from 1996 to 2019 across 21 Central American and Caribbean (CAC) economies.[1)] Output (y) is measured as logged GDP per capita in constant 2015 US dollars, sourced from the World Bank's World Development Indicators (WDI). Capital stock per capita (k) is represented by the logged capital stock per capita, obtained from the Penn World Table, and is expected to positively influence growth (i.e., $\beta_1>0$). Human capital (h) is captured as the logged secondary enrollment rate, also sourced from WDI, reflecting general educational attainment with an anticipated positive effect (i.e., $\beta_2>0$). Control variables (X) include inflation rate (CPI) in percent from WDI and government effectiveness (GE), an unscaled score ranging from -2.5 to 2.5 from the Worldwide Governance Indicators (WGI), indicating institutional quality (Kaufmann et al., 2010).

Given the absence of a direct measure for technical absorptive capacity (AC), we construct a proxy tailored to the Central American and Caribbean (CAC) context. AC, a central explanatory variable, is defined as the percentage share of technology-intensive intermediate imports—classified under Broad Economic Categories (BEC) codes 22 (industrial supplies), 42 (capital goods parts), and 53 (transport equipment parts)—in total imports, sourced from UN COMTRADE (Todo & Inoue, 2021). This trade-based metric departs from traditional proxies such as education or research and development (R&D) expenditure, offering a lens better suited to CAC's economic structure. Secondary enrollment rates, while indicative of general adaptability, fail to capture the specialized technical skills (e.g., engineering or machinery operation) required to exploit imported technologies (Cohen & Levinthal, 1990; Narula, 2004). This limitation is pronounced in CAC, where educational systems often emphasize social sciences over technical disciplines (UNESCO, 2022; Lall, 2000). Similarly, R&D spending, a robust indicator in innovation-driven economies (Coe & Helpman, 1995), holds limited relevance in CAC due to limited domestic research activity (De Ferranti et al., 2002). By contrast, our AC proxy directly measures engagement with global knowledge flows through technology-intensive imports (Keller, 2002), reflecting CAC's dependence on external technological inputs rather than internal innovation (Blyde & Fentanes, 2020). Rooted in the "learning-by-importing" framework (Grossman & Helpman, 1991), this measure captures firms' ability to transform imported inputs—such as machinery components—into productivity gains, with an expected positive effect on economic growth (Griffith et al., 2004).

Complementing AC, natural resource dependence (NR) is another key explanatory variable, constructed as the percentage share of resource-intensive exports in total exports, derived from UNCTAD data following Sachs and Warner (2001). This variable enables an investigation of the "resource curse" hypothesis, whereby resource reliance may influence growth dynamics, potentially exhibiting non-linear effects. Together, these proxies provide a robust foundation for analyzing the interplay of trade-driven technology adoption and resource dependence in shaping CAC's economic performance.

Table 1: Variable and Sources

Variable	Description	Construction of Variable	Sources
y	GDP per capita	GDP per capita constant 2015 US$	World Bank: WDI
k	Capital per capita	Capital Stock	Penn World Table (PWT)
h	Human Capital	School Enrollment, secondary (% gross)	World Bank: WDI
AC	Technical Absorptive Capacity	Share of Technology-Intensive Intermediate Imports: BEC classification code B4 for cmd codes: 22 (Industrial supplies nes, processed), 42 (Parts and Accessories of capital goods; Except transport equipment), 53 (Parts and Accessories of transport equipment) Aggregate of Low, Medium and High skill technology intensive manufactured intermediate goods imports.	UNCOMTRADE
NR	Natural Resources	Natural Resource-share of natural resource Intensive goods exports as share of Total Export	UNCTAD
X	Control Variables	1. Government Effectiveness: estimate 2. Inflation, consumer prices (annual %),	Worldwide Government Indicator: WGI, World Bank: WDI

(3) **Estimation Process**

Fixed effects regression is applied for equations (14) through (17), to control for time-invariant, country-specific heterogeneities (e.g., geography, culture) in CAC economies (Wooldridge, 2010). This estimation isolates within-country variation over time, mitigating endogeneity from omitted variables. Year fixed effects account for common time trends (e.g., global shocks), with standard errors clustered at country level to address heteroskedasticity and serial correlation. The hypotheses of this empirical model are as follows:

H1: Technical absorptive capacity (AC) positively drives growth in CAC economies.

Technical absorptive capacity (AC), reflecting "learning-by-importing" (Keller, 1998), is posited to translate technology-intensive imports into productivity gains. The baseline model tests this direct effect:

$$ln(y_{it}) = \beta_0 + \beta_1 AC_{it} + \beta_2 \ln(k_{it}) + \beta_3 \ln(h_{it}) + \beta_4 X_{it} + \mu_i + \pi_t + \in_{it} \quad (14)$$

H2: Natural resource dependence (NR) exhibits an Inverted U-Shape.

Following Sachs and Warner's (2001), natural resource curse dependence may boost growth up to a certain level, beyond which the presence of stagnation exists (Gylfason, 2001). To test the non-linear effect, we estimate:

$$ln(y_{it}) = \beta_0 + \beta_1 NR_{it} + \beta_1' NR^2_{it} + \beta_2 ln(k_{it}) + \beta_3 ln(h_{it}) + \beta_4 X_{it} + \mu_i + \pi_t + \in_{it} \quad (15)$$

A positive $\beta_1 > 0$ and negative $\beta_1' < 0$ would confirm an inverted U-shaped, supporting H2.

H3: Government effectiveness (GE) moderates AC and NR.

Drawing on North (1990) and Rodrik et al. (2004), institutional quality (GE) is expected to enhance technology adoption and resource allocation (Acemoglu et al., 2005). We test this moderation with two interaction models:

For AC:

$$ln(y_{it}) = \beta_0 + \beta_1 AC_{it} + \beta_2 ln(k_{it}) + \beta_3 ln(h_{it}) + \beta_4 (AC_{it} * GE_{it}) + \beta_5 X_{it} + \mu_i + \pi_t + \in_{it} \quad (16)$$

For NR:

$$ln(y_{it}) = \beta_0 + \beta_1 NR_{it} + \beta_2 ln(k_{it}) + \beta_3 ln(h_{it}) + \beta_4 (NR_{it} * GE_{it}) + \beta_5 X_{it} + \mu_i + \pi_t + \in_{it} \quad (17)$$

Positive $\beta_4 > 0$ in either model would indicate that GE amplifies the growth effect of AC or mitigates NR's adverse impacts, supporting H3.

V. Empirical Results and Discussions

(1) Descriptive Analysis

Table 2 presents summary statistics and pairwise correlation matrix for all the variables. The descriptive statistics provide an initial insight into the variables central to our study's hypotheses regarding economic growth in Central America and the Caribbean (CAC) economies.

Table 2: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Gross Domestic Product (GDP) per capita	320	9.046	.743	7.285	11.283
Technical Absorptive Capacity	320	35.567	15.832	7.691	84.65
Natural Resource-intensive export	320	10.23	14.267	.054	57.468
Capital	320	10.787	1.975	6.81	16.153
Human Capital	320	88.763	17.593	47.049	137.016
Government Effectiveness	320	.206	.563	−.962	1.497
Inflation	320	4.43	6.075	−7.114	55.412

Source: Author's computation.

Notably, GDP per capita averages 9.05, and human capital proxied by logged secondary enrollment rates, averages 88.76. Technical absorptive capacity (AC) averages 35.57%, and natural resource dependence (NR) averages 10.23%. Government effectiveness (GE) averages 0.21, and inflation averages 4.43%.

The Pairwise correlations presented in Table 3 shows GDP per capita positively correlated with technical absorptive capacity, human capital, but government effectiveness, negatively correlated with natural resource dependence and capital stock. However, natural resource dependence shows a strong negative association with government effectiveness and human capital. Additionally, natural resource dependence shows a strong negative association with government effectiveness and human capital, possibly because resource wealth reduces incentives for institutional development and education investment, as rents from resources substitute for broad-based growth strategies.

Table 3: Pairwise Correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDP per capita	1.000						
Technical Absorptive Capacity	0.284*	1.000					
Natural Resource-intensive export	−0.571*	−0.046	1.000				
Capital	−0.217*	−0.069	−0.186*	1.000			
Human Capital	0.412*	−0.068	−0.502*	0.117*	1.000		
Government Effectiveness	0.756*	0.101	−0.508*	−0.098	0.468*	1.000	
Inflation	−0.236*	0.029	0.097	0.221*	−0.322*	−0.231*	1.000
Stars Indicate Significance at 5%							

Source: Author's computation.

(2) Empirical Results

Our baseline estimated results of Equations (14) is presented in Table 4. Technical absorptive capacity (AC) increases GDP per capita by 0.23-0.29% per 1% rise increase across specifications (e.g., columns 1-5) and, significant at the 1% level. The results support hypothesis 1. Column 3, AC and human capital together increases GDP per capita by 0.26% and 0.27% per 1% change in school enrollment, respectively, both are significant at the 1 % level. The coefficient of capital stock is 0.47(%) and significant at 5% level, higher than that of human capital.

Table 5 reports the results estimate of equation (15) for natural resource dependence (NR). The coefficient of NR (1st row) is insignificant. The coefficient of the squared term of NR is negative and significant at 1% level. Based on the results of column (5), threshold level is 13.81%.[2)] While human capital remains positive and significant, physical capital stock losses its significance once natural resources are included. Moreover, in both Table 4 and 5, government effectives exact a positive effect on economic growth while higher inflation rates hinder growth expansion.

Table 4: Fixed Effects Regression-Baseline (Technical Absorptive Capacity)

	(1)	(2)	(3)	(4)	(5)
VARIABLES	**Dependent Variable: Log of GDP per capita (constant 2015 US$)**				
Technical Absorptive Capacity	0.00287*** (0.0009)	0.00289*** (0.0009)	0.00259*** (0.0009)	0.00238*** (0.0008)	0.00228*** (0.0008)
Capital		0.0407 (0.0248)	0.0473** (0.0240)	0.0494** (0.0234)	0.0490** (0.0231)
Human Capital			0.00271*** (0.0006)	0.00210*** (0.0006)	0.00195*** (0.0006)
Government Effectiveness				0.0891*** (0.0228)	0.0807*** (0.0226)
Inflation					−0.00300*** (0.00098)
Constant	8.679*** (0.051)	8.284*** (0.246)	8.051*** (0.243)	8.033*** (0.237)	8.093*** (0.234)
Observations	320	320	320	320	320
R-Squared	0.523	0.527	0.561	0.584	0.598
Number of ID	21	21	21	21	21
YEAR FE	YES	YES	YES	YES	YES

Standard errors in parentheses ***$p<0.01$, **$p<0.05$, *$p<0.1$

Table 5: Fixed Effects Regression-The Role of Natural Resource Intensity

	(1)	(2)	(3)	(4)
VARIABLES	**Dependent Variable: Log of GDP per capita (constant 2015 US$)**			
Natural Resource-intensive Export	−0.000298 (0.0024)	0.00284 (0.0025)	0.00259 (0.0025)	0.00301 (0.0025)
Natural Resource-intensive Export squared	−7.88e-05** (3.97e-05)	−0.000116*** (4.20e-05)	−0.000110*** (4.09e-05)	−0.000109*** (4.05e-05)
Capital		0.0124 (0.0252)	0.0159 (0.0246)	0.0172 (0.0243)
Human Capital		0.00275*** (0.0006)	0.00210*** (0.0006)	0.00204*** (0.0006)
Government Effectiveness			0.0903*** (0.0223)	0.0832*** (0.0223)
Inflation				−0.00251** (0.00098)
Constant	8.814*** (0.0434)	8.480*** (0.249)	8.445*** (0.242)	8.466*** (0.240)
Observations	320	320	320	320
R-squared	0.546	0.577	0.601	0.610
Number of ID	21	21	21	21
Year FE	YES	YES	YES	YES

Standard errors in parentheses ***$p<0.01$, **$p<0.05$, *$p<0.1$

Table 6 shows the estimated results of equation (16). To assess the moderating role of government effectiveness (GE) on NR. Notably, the partial effect of AC remains positive and significant at 10%. However, the interaction between AC and government effectiveness is insignificant, on the other hand, the estimated results of equation (16) in column (4). Table

7 indicate that GE plays a crucial role in alleviating natural resource curse in the CAC region. Specifically, the NR-GE interaction is positive and significant at the 1% level. This finding suggests that in CAC countries with effective governance, natural resource endowment can be leveraged to foster economic growth.

Table 6: Fixed Effects Regression-The Role of Government Effectiveness and AC

	(1)	(2)	(3)	(4)
VARIABLES	**Dependent Variable: Log of GDP per capita (constant 2015 US$)**			
Capital	0.0395 (0.0252)	0.0466* (0.0243)	0.0463* (0.0239)	0.0491** (0.0231)
Human Capital		0.00285*** (0.0006)	0.00260*** (0.0006)	0.00188*** (0.0006)
Inflation			−0.00355*** (0.0010)	−0.00296*** (0.00098)
Government Effectiveness				0.0476 (0.0398)
Technical Absorptive Capacity				0.00175* (0.00099)
Government Effectiveness X Technical Absorptive Capacity				0.00106 (0.00105)
Constant	8.403*** (0.247)	8.145*** (0.244)	8.209*** (0.240)	8.105*** (0.234)
Observations	320	320	320	320
R-squared	0.510	0.547	0.566	0.599
Number of ID	21	21	21	21
Year FE	YES	YES	YES	YES

*Standard errors in parentheses ***p<0.01, **p<0.05, *p<0.1*

TABLE 7: Fixed Effects Regression-The Role of Government Effectiveness and NR

	(1)	(2)	(3)	(4)
VARIABLES	**Dependent Variable: Log of GDP per capita (constant 2015 US$)**			
Capital	0.0395 (0.0252)	0.0466* (0.0243)	0.0463* (0.0239)	0.0163 (0.0239)
Human Capital		0.00285*** (0.0006)	0.00260*** (0.0006)	0.00193*** (0.0006)
Inflation			−0.00355*** (0.0010)	−0.00222** (0.00098)
Government Effectiveness				0.0460* (0.0253)
Natural Resource-intensive Export				−0.00315*** (0.00099)
Government Effectiveness X Natural Resource-intensive Export				0.00443*** (0.0014)
Constant	8.403*** (0.247)	8.145*** (0.244)	8.209*** (0.240)	8.538*** (0.242)
Observations	320	320	320	320
R-Squared	0.510	0.547	0.566	0.615
Number of Id	21	21	21	21
Year FE	YES	YES	YES	YES

*Standard errors in parentheses ***p<0.01, **p<0.05, *p<0.1*

(3) Discussion

AC as a Gateway to Global Technology Spillovers

Our empirical results underscore the decisive role of technical absorptive capacity (AC) in facilitating trade-induced technological diffusion and driving long-term economic growth in CAC economies. Unlike traditional measures of human capital that often capture broad educational attainment, AC reflects a nation's ability to assimilate, deploy, and optimize foreign technologies within domestic production systems. This distinction is critical, as technological adoption does not occur automatically; rather, it depends on the technical proficiency required to extract value from imported knowledge and innovations. The strong and statistically significant effect of AC supports the argument that economies actively engaged in importing advanced intermediate goods are better positioned to internalize external knowledge flows, a process widely characterized as "learning by importing" (Cohen & Levinthal, 1990). Our findings align with theoretical predictions (Lucas, 1988) and other empirical studies (Henry et al., 2009; Haq et al., 2022), reinforcing the idea that trade is an effective vehicle for knowledge transfer when recipient economies possess the necessary technical capabilities.

Additionally, our results suggest that human capital serves as a key enabler in this process. A sufficiently skilled labor force enhances the efficiency of technology absorption, ensuring that imported innovations are effectively integrated into productive activities. The study suggests that further analysis between interaction AC and human capital would have a complementary relationship, where investments in workforce training and technical expertise strengthen the broader spillover effects of trade-induced technological diffusion. This dynamic impact is particularly evident in the trade sector, where human capital facilitates the transformation of imported knowledge into productivity gains and competitive advantages. Furthermore, these benefits extend beyond trade to accelerating the diffusion of technological improvements into other sectors such as manufacturing, agriculture, and tourism. As a result, human capital not only enhances the absorptive process but also catalyzes structural transformation, reinforcing the broader economic development trajectory. A deviation from conventional wisdom emerges in our findings—the apparent independence of technical absorptive capacity (AC) from institutional quality.

This finding introduces an important reconsideration of the institutional constraints often emphasized in development economics. While effective governance is broadly associated with improved policy implementation, reduced inefficiencies, and greater economic stability, its role in facilitating technological absorption appears to be less deterministic than commonly assumed. In other words, economies with a technically skilled workforce may still harness the benefits of imported knowledge, even in the absence of strong institutional frameworks. This nuance suggests that policies aimed at fostering long-run growth through trade-driven technology diffusion should adopt a dual approach—one that does not rely solely on institutional reform but also prioritizes direct investments in technical skill development, particularly in fields such as engineering, applied sciences, and advanced manufacturing. Strengthening these competencies enhances a nation's capacity to internalize and operationalize foreign technologies, making absorptive capacity a more immediate and actionable driver of growth. However, governance is not irrelevant. Rather, its influence on trade-induced technological progress and economic growth nexus may be more complex. For instance, institutional quality may shape the long-term sustainability of technology adoption by influencing research infrastructure, intellectual property protections, or the efficiency of public-private collaborations.

NR Transformation and the Global Commodity Trap

Natural resource dependence poses persistent structural challenges to long-run growth in trade-exposed Central America and Caribbean (CAC) economies. This analysis reveals an inverted U-shaped relationship between natural resource-intensive export share (NR) and GDP per capita, with a critical threshold at 13.81%. This finding refines the resource curse paradigm (e.g., Sachs & Warner, 1995), offering a precise benchmark for small, open economies where trade dependence amplifies resource effects.

Empirical patterns across CAC illustrate this dynamic. Belize, with sugar, bananas, and citrus comprising 20-25% of exports (Statistical Institute of Belize, 2021), exceeds the 13.81% threshold, correlating with GDP per capita stagnation at $4,800 (2010-2015) and a 14.1% drop in 2020 (World Bank, 2021). Jamaica's bauxite exports (50%, World Bank, 2021) and Trinidad and Tobago's oil and gas dominance (70%, Central Bank, 2020) similarly surpass this level, e.g., Trinidad's GDP per capita falling from $19,000 (2008) to $15,000 (2019). Conversely, Costa Rica's moderate NR share (10-12%, Central Bank, 2022) underpins sustained growth. The Dominican Republic (15-20%, Central Bank, 2021) and Guyana (>60%, IMF, 2023) straddle or exceed the threshold, balancing short-term gains with emerging risks. These contrasts highlight that while modest NR reliance fuels initial growth, excessive dependence exposes economies to commodity price shocks and structural rigidities.

Technical absorptive capacity (AC) emerges as a pivotal mediator, enabling CAC economies to transform resource revenues into productivity-enhancing diversification. In Belize, bolstering AC—e.g., through agricultural mechanization or value-added processing—could reduce reliance on volatile raw exports. Costa Rica's shift from coffee and bananas to high-tech sectors like medical devices exemplifies this, leveraging AC to internalize foreign knowledge and mitigate NR risks. This aligns with learning-by-doing frameworks (e.g., Arrow, 1962), suggesting that resource wealth, when paired with technical capabilities, can catalyze structural transformation beyond primary sectors.

Institutional quality further shapes this nexus, though its role diverges from conventional expectations. While correlation evidence links high NR to weaker human capital and governance, regression results indicate government effectiveness significantly moderates NR's adverse effects. Stronger institutions—evident in Costa Rica's stability versus Belize's governance gaps—offset roughly 4.6% of the resource curse's drag, channeling revenues into productive investments. Yet, the absence of a significant NR-institution interaction challenges assumptions (e.g., Mehlum et al., 2006) that governance is a prerequisite for resource benefits, underscoring economic structure's primacy in CAC contexts. These insights advocate a dual policy framework: enhancing AC to drive diversification and strengthening governance to sustain resource-led growth. For CAC economies, navigating the 13.81% threshold demands not just institutional reform but proactive investments in technical capacity, offering a robust pathway to reconcile resource wealth with long-term stability.

Ⅵ. Conclusion

This study advances our understanding of the trade-growth nexus in the Central America and Caribbean (CAC) region by integrating technical absorptive capacity (AC) and natural resource dependence (NR) based on a semi-endogenous growth framework. The result contributes to two distinct insights to the economic literature. First, while previous research on CAC has focused primarily on the causal relationships between trade openness, resource exports, and economic growth (e.g., Bulmer-Thomas, 2001), this study shifts the focus to technical absorptive capacity, proxied by technology-intensive imports, as a key driver of productivity growth. Through the mechanism of "learning-by-importing" (Cohen & Levinthal, 1990), the study finds that AC enhances GDP per capita with increases in technology-intensive imports, offering a nuanced understanding of how trade-induced technology assimilation drives growth in resource-constrained economies.

Second, the study refines the resource curse hypothesis (Sachs & Warner, 1995) by demonstrating a non-linear, inverted U-shaped relationship between NR dependence and GDP per capita, with a tipping point where moderate dependence on NR contributes to growth. However, exceeding this critical threshold leads to stagnation, a dynamic that has been underexplored in small, trade-dependent economies. Moreover, the research shows that government effectiveness (GE) mitigates the negative impact of high NR dependence, but it does not significantly enhance the impact of technical absorptive capacity. This finding challenges governance-centric assumptions in the literature (Mehlum et al., 2006) and underscores the independent role of AC in fostering growth.

These findings reframe the development narrative for CAC countries. Technical AC enables these economies to harness imported technologies, independent of institutional quality, challenging the framework set by Lucas (1988), where human capital is assumed to be the primary growth driver. The non-linear effect of NR dependence, illustrated by Costa Rica's success below the tipping point compared to Belize's stagnation above it, highlights the dual potential of trade: growth-promoting at low levels of resource dependence and growth-constraining at higher levels (Lederman & Maloney, 2007). The selective role of GE in moderating NR's negative effects suggests that governance influences resource outcomes more than technology absorption, adding depth to the structural challenges faced by CAC economies.

Policy implications are twofold: first, enhancing technical AC through targeted investments in skills (e.g., engineering, machinery operation) can amplify the growth benefits of trade; second, strengthening GE can help countries manage NR revenues more effectively, particularly by preventing them from surpassing the critical threshold. However, limitations of the study include the use of an import-based AC proxy, which may not capture informal learning channels, and the 1996–2019 dataset. Future research could refine the AC measure using firm-level data or explore the sector-specific effects of NR dependence, which would provide further insights into the dynamics outlined in this study. Ultimately, sustainable growth for CAC economies hinges on balancing technical capacity with effective governance to fully leverage the potential of trade and natural resource wealth.

Notes

1) See Table A1 in the appendix for the list of countries used in the study.

2) The turning point (level of natural resource dependence at which the effect on growth switches from positive to negative) can be calculated as: $-\frac{\beta_1}{\beta_2 \times 2}$
where β_1 is the coefficient of NR and β_2 is the coefficient of NR^2.

References

Acemoglu, D., Johnson, S., & Robinson, J. A. (2005). Institutions as a fundamental cause of long-run growth. In P. Aghion & S. N. Durlauf (Eds.), *Handbook of economic growth* (Vol. 1A, pp. 385–472). Elsevier. https://doi.org/10.1016/S1574-0684(05)01006-3

Aghion, P., & Howitt, P. (1992). A model of growth through creative destruction. *Econometrica, 60*(2), 323–351. https://doi.org/10.3386/w3223

Ahmed, G., Khan, M. A., Mahmood, T., & Afzal, M. (2017). Trade Liberalisation and Industrial Productivity: Evidence from Manufacturing Industries in Pakistan. *The Pakistan Development Review, 56*(4), 319–348. http://www.jstor.org/stable/44986424

Alcalá, F., & Ciccone, A. (2004). Trade and productivity. *The Quarterly Journal of Economics, 119*(2), 613–646. https://doi.org/10.1162/0033553041382139

Arezki, R., & van der Ploeg, F. (2011). Trade policies, institutions and the natural resource curse. *Applied Economics Letters, 17*(15), 1443–1451. https://doi.org/10.1080/13504850903035881

America, O. L. (1950). *The economic development of Latin America and its principal problems*. United Nations.

Auty, R. M. (2001). The political economy of resource-driven growth. *European Economic Review, 45*(4-6), 839-846. https://doi.org/10.1016/S0014-2921(01)00126-X

Auty, R. M. (2002). *Sustaining development in mineral economies: The resource curse thesis*. Routledge. https://doi.org/10.4324/9780203422595

Barro, R. J., & Sala-i-Martin, X. (1997). Technological diffusion, convergence, and growth. *Journal of Economic Growth, 2*(1), 1-27. https://doi.org/10.1023/A:1009746629269

Blyde, J. S., & Fentanes, O. (2019). The Heterogeneous Impacts of Import Competition on Mexican Manufacturing Plants. https://doi.org/10.18235/0002048

Brunnschweiler, C. N., & Bulte, E. H. (2008). The resource curse revisited and revised: A tale of paradoxes and red herrings. *Journal of Environmental Economics and Management, 55*(3), 248-264. https://doi.org/10.1016/j.jeem.2007.08.004

Bruno, M., & Easterly, W. (1998). Inflation crises and long-run growth. *Journal of Monetary Economics, 41*(1), 3-26. https://doi.org/10.1016/S0304-3932(97)00063-9

Bulmer-Thomas, V. (1983). *Economic Development over the Long Run. Central America since 1920. Journal of Latin American Studies,* 15(2), 269-294. http://www.jstor.org/stable/155881

Bustos, P. (2011). Trade liberalization, exports, and technology upgrading: Evidence on the impact of MERCOSUR on Argentinian firms. *American Economic Review, 101*(1), 304-340. https://doi.org/10.1257/aer.101.1.304

Carmignani, F., Chowdhury, A. The Geographical dimension of the development effects of natural resources. *Environ Resource Economics* 52, 479-498 (2012). https://doi.org/10.1007/s10640-011-9539-x

Cirera, X. et al., 2015. Aid for Trade and Structural Transformation in Sub-Saharan Africa, Commonwealth. *Commonwealth trade policy discussion papers. United Kingdom*. Retrieved from https://coilink.org/20.500.12592/bgmr3q COI: 20.500.12592/bgmr3q

Coe, D. T., & Helpman, E. (1995). International R&D spillovers. *European Economic Review, 39*(5), 859-887. https://doi.org/10.1016/0014-2921(94)00100-E

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*(1), 128-152. https://doi.org/10.2307/2393553

Collier, P., & Hoeffler, A. (2005). Resource rents, governance, and conflict. *Journal of Conflict Resolution, 49*(4), 625-633. https://doi.org/10.1177/0022002705277551

De Ferranti, D., Perry, G. E., Lederman, D., & Maloney, W. F. (2002). *From natural resources to the knowledge economy: Trade and job quality*. World Bank. https://doi.org/10.1596/0-8213-5009-9

ECLAC (Economic Commission for Latin America and the Caribbean). (2020). *Science and technology for sustainable development in Latin America and the Caribbean*. United Nations.

Feenstra, R. C. (1996). Trade and uneven growth. *Journal of Development Economics, 49*(1), 229-256. https://doi.org/10.1016/0304-3878(95)00059-3

Frankel, J. A., & Romer, D. (1999). Does trade cause growth? *American Economic Review, 89*(3), 379-399. https://doi.org/10.1257/aer.89.3.379

Frynas, J. G., Wood, G., & Hinks, T. (2017). The resource curse without natural resources: Expectations of resource booms and their impact. *African Affairs, 116*(463), 233-260. https://doi.org/10.1093/afraf/adx001

Grossman, G. M., & Helpman, E. (1991). *Innovation and growth in the global economy*. MIT Press.

Gylfason, T. (2001). Natural resources, education, and economic development. *European Economic*

Review, 45(4-6), 847-859. https://doi.org/10.1016/S0014-2921(01)00127-1

Gyimah-Boadi, E., & Prempeh, H. K. (2012). Oil, politics, and Ghana's democracy. *Journal of Democracy, 23*(3), 94-108. https://doi.org/10.1353/jod.2012.0042

Haq Iu, Mehmed B, Naradda Gamage SK, Allayarov P, Khan D, Khattak ZZ (2022) Nexus between export variety and carbon emissions in Pakistan: The role of FDI and technological development. *PLoS ONE* 17(1): e0263066. https://doi.org/10.1371/journal.pone.0263066

Hausmann, R., Hwang, J., & Rodrik, D. (2007). What you export matters. *Journal of Economic Growth, 12*(1), 1-25. https://doi.org/10.1007/s10887-006-9009-4

Havranek, T., Horvath, R., & Zeynalov, A. (2016). Natural resources and economic growth: A meta-analysis. *World Development, 88,* 134-151. https://doi.org/10.1016/j.worlddev.2016.07.016

Heckscher, E. F., & Ohlin, B. (1933). *Heckscher-Ohlin trade theory* (H. Flam & M. J. Flanders, Trans.). MIT Press (1991 reprint).

Henry, P. & Miller, C. (2008). Institutions vs. Policies: A Tale of Two Islands. *NBER Working Paper* 14604. National Bureau of Economic Research: Cambridge MA. https://doi.org/10.1257/aer.99.2.261

Henry, M., Kneller, R., & Milner, C. (2009). Trade, technology transfer and national efficiency in developing countries. *European Economic Review, 53*(2), 237-254. https://doi.org/10.1016/j.euroecorev.2008.05.001

Jones, C. I. (1995). R&D-based models of economic growth. *Journal of Political Economy, 103*(4), 759-784. https://doi.org/10.1086/262002

Karl, T. L. (1997). The paradox of plenty: Oil booms and petro-states. Berkeley: *University of California Press.* https://doi.org/10.1525/9780520918696

Kaufmann, D., Kraay, A., & Mastruzzi, M. (2011). The Worldwide Governance Indicators: methodology and analytical issues. *Hague J Rule Law, 3,* 220-246. https://doi.org/10.1017/S1876404511200046

Keller, W. (1998). Are international R&D spillovers trade-related? Analyzing spillovers among randomly matched trade partners. *European Economic Review, 42*(8), 1469-1481. https://doi.org/10.1016/S0014-2921(97)00092-5

Keller, W. (2002). Geographic localization of international technology diffusion. *American Economic Review, 92*(1), 120-142. https://doi.org/10.1257/000282802760015630

Keller, W. (2004). International technology diffusion. *Journal of Economic Literature, 42*(3), 752-782. https://doi.org/10.1257/0022051042177685

Lall, S. (2000). The technological structure and performance of developing country manufactured exports, 1985-98. *Oxford Development Studies, 28*(3), 337-369. https://doi.org/10.1080/713688318

Lederman, D., & Maloney, W. F. (2007). *Neither curse nor destiny. Latin American development forum Washington, DC: World Bank.* http://documents.worldbank.org/curated/en/521331468045070417

Lucas, R. E., Jr. (1988). On the mechanics of economic development. *Journal of Monetary Economics, 22*(1), 3-42. https://doi.org/10.1016/0304-3932(88)90168-7

Manzano, O., & Rigobon, R. (2001). Resource curse or debt overhang? *National Bureau of Economic Research, 2*(1), 47-83. https://doi.org/10.3386/w8390

Mehlum, H., Moene, K., & Torvik, R. (2006). Institutions and the resource curse. *The Economic Journal, 116*(508), 1-20. https://doi.org/10.1111/j.1468-0297.2006.01045.x

Monge-González, R., & Hewitt, J. (2010). Innovation, R&D and productivity in the Costa Rican ICT sector: A case study. *IDB Working Paper No. 63, 77*(5), 735-747. https://dx.doi.org/10.2139/ssrn.1818740

Narula, R. (2004). R&D collaboration by SMEs: New opportunities and limitations in the face of globalisation. *Technovation, 24*(2), 153–161. https://doi.org/10.1016/S0166-4972(02)00045-7

North, D. C. (1990). *Institutions, institutional change and economic performance.* Cambridge University Press. https://doi.org/10.1017/CBO9780511808678

Ocampo, J. A., & Vos, R. (2008). *Uneven economic development.* Zed Books.

Paus, E. (2004). Productivity growth in Latin America: The limits of neoliberal reforms. *World Development, 32*(3), 427–445.

Pietrobelli, C., & Rabellotti, R. (2011). Global value chains meet innovation systems: Are there learning opportunities for developing countries? *World Development, 39*(7), 1261–1269. https://doi.org/10.1016/j.worlddev.2010.05.013

Rasiah, R. (2006). Explaining Malaysia's export expansion in palm oil and related products. *Technology, adaptation, and exports: How some developing countries got it right* (pp. 163–192). World Bank. https://doi.org/10.1596/978-0-8213-6507-6

Prebisch, R. (1950). *The economic development of Latin America and its principal problems* (Report No. E/CN.12/89/Rev.1). United Nations Economic Commission for Latin America.

Rodriguez, F., & Rodrik, D. (2001). Trade policy and economic growth: A skeptic's guide to the cross-national evidence. *NBER Macroeconomics Annual, 15,* 261–325. http://www.nber.org/chapters/c11058

Rodrik, D., Subramanian, A., & Trebbi, F. (2004). Institutions rule: The primacy of institutions over geography and integration in economic development. *Journal of Economic Growth, 9*(2), 131–165. https://doi.org/10.1023/B:JOEG.0000031425.72248.85

Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy, 98*(5, Part 2), S71–S102. https://doi.org/10.1086/261725

Sachs, J. D., & Warner, A. M. (1995). Natural resource abundance and economic growth. *NBER Working Paper Series, No. 5398.* https://doi.org/10.3386/w5398

Sachs, J. D., & Warner, A. M. (1997). Sources of slow growth in African economies. *Journal of African Economies, 6*(3), 335–376. https://doi.org/10.1093/oxfordjournals.jae.a020932

Sachs, J. D., & Warner, A. M. (2001). The curse of natural resources. *European Economic Review, 45*(4–6), 827–838. https://doi.org/10.1016/S0014-2921(01)00125-8

Sawyer, W. (2011). Institutional quality and economic growth in Latin America. *Global Economy Journal, 10*(4). https://doi.org/10.2202/1524-5861.1710

Singer, H. W. (1950). The distribution of gains between investing and borrowing countries. *American Economic Review, 40*(2), 473–485. https://www.jstor.org/stable/1818065)

Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics, 70*(1), 65–94. https://doi.org/10.2307/1884513

Thacker, N., & Acevedo, M. (2010). Caribbean growth in an international perspective: The role of tourism and size. *IMF Working Paper, WP/10/235.*

Todo, Y., & Inoue, H. (2021). Geographic diversification of the supply chains of Japanese firms. *Asian Economic Policy Review, 16(2)*, 304–322. https://doi.org/10.1111/aepr.12337

UNESCO. (2019). Education in Latin America and the Caribbean at a crossroads: regional monitoring report SDG4-Education 2030; summary *UNESCO Digital Library.*

Van der Ploeg, F., & Poelhekke, S. (2010). The pungent smell of "red herrings": Subsoil assets, rents, volatility and the resource curse. *Journal of Environmental Economics and Management, 60*(1), 44–55. https://doi.org/10.1016/j.jeem.2010.03.003

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data* (2nd ed.). MIT Press.

World Bank. (2012). *Botswana development policy review: An agenda for competitiveness and diversification.* World Bank.

World Bank. (2015). *Latin America and the Caribbean: Economic recovery and growth prospects.* World Bank.

Zhang, Y., Zhang, J., & Cheng, Z. (2021). Stock market liberalization and corporate green innovation: evidence from China. *International Journal of Environmental Research and Public Health, 18*(7), 3412. https://doi.org/10.3390/ijerph18073412

Appendix

Table A1: List of Countries

Central America Region		Caribbean Region	
Costa Rica	Antigua and Barbuda	Dominican Republic	Saint Vincent and the Grenadines
El Salvador	Aruba	Grenada	Suriname
Honduras	Bahamas	Jamaica	Trinidad and Tobago
Mexico	Belize	Guyana	
Nicaragua	Cayman Islands	Saint Kitts and Nevis	
Panama	Dominica	Saint Lucia	