



The Effect of Corruption on Export Diversification in Selected Developing Countries: An Application of the Panel Smooth Transition Regression Model

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Highlights

- Corruption has a nonlinear effect on export diversification.
- A PSTR model identifies a corruption-control threshold of 0.3913.
- Corruption promotes diversification below the institutional threshold.
- Corruption reduces diversification after the threshold is exceeded.
- Institutional quality conditions the effects of finance, trade, income and ICT.

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Abstract

Achieving stable economic growth is a fundamental objective for many countries. However, developing economies face considerable challenges because of their dependence on exports of a single product. Export diversification is widely regarded as an effective policy for reducing economic vulnerability and a key component of development during the structural transformation from primary commodity production to industrial goods. Given the importance of export diversification and the prevalence of corruption, examining their relationship has become increasingly important. This study investigates the nonlinear effect of corruption on export diversification in a sample of developing countries from 2005 to 2023 using a Panel Smooth Transition Regression (PSTR) model, with the Control of Corruption (COC) index as the transition variable. The estimation results reveal a strong nonlinear relationship and support a two-regime specification with a threshold value of 0.3913 and a slope parameter of 1.93. Corruption has a positive and statistically significant association with export diversification in the first regime, but the relationship becomes negative and remains significant in the second regime, confirming an inverted U-shaped pattern. Natural resource abundance, financial development, and trade openness positively and significantly affect export diversification in both regimes. Moreover, real per capita income and information and communication technology have positive and significant effects after the threshold is exceeded. These findings offer important policy implications for promoting sustainable export diversification in developing economies.

1. Introduction

The concept of export diversification first emerged in Latin American economies during the crisis of the interwar period, following the sharp decline in

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commodity prices (Berthélemy, 2005). The theories of classical economists such as Smith (1776) and Ricardo (1817), as well as neoclassical economists such as Heckscher and Ohlin (1991), all emphasized the principle of countries specialization in production and exports based on comparative advantage. However, later economists such as Prebisch (1950) proposed strategies aimed at reducing economies dependence on commodities, and this perspective gained considerable attention. According to Prebisch, specialization is not an appropriate approach for developing countries endowed with abundant natural resources. He argued that adherence to earlier theories centered on specialization would deepen these countries' reliance on exports of raw materials and agricultural commodities, while also increasing their dependence on imports of consumer and industrial goods. In addition, because demand for primary commodities is characterized by low income elasticity, developing economies need to broaden the composition of their exports in order to reduce their exposure to commodity-price shocks and fluctuations in the terms of trade.

Export diversification can be pursued as a development objective in low- and middle-income countries for several reasons. One is its potential to lessen the economic risks associated with external trade shocks. A wider export basket may also generate dynamic spillovers that raise productivity and support economic growth. In economies where exports are heavily concentrated in natural resources, diversification can further contribute to job creation and, in turn, poverty reduction. Broadening the export base has also been viewed as one possible way of mitigating the effects commonly associated with the natural resource curse. Despite these potential gains, the determinants of export diversification remain insufficiently understood, particularly with respect to institutional factors.

At the same time, growing concern has been directed toward the adverse consequences of corruption for economic development by international organizations, governments, and foreign aid agencies. Although a large and expanding literature links corruption to weaker economic growth, far less attention has been given to whether corruption also limits the diversification of exports.

Empirical research examining the effect of corruption on export diversification is still relatively scarce, and the available evidence is not conclusive. Waldemar (2010) and Cabral and Veiga (2010) identified corruption as a constraint on export diversification, whereas Parteka and Tamberi (2013) found no clear evidence of such an effect.

Against this background of conflicting empirical findings, the present study focuses on how corruption affects export diversification. More specifically, it examines whether greater corruption alters the degree of export diversification. Because the influence of corruption may vary with the level of corruption prevailing in a country, the relationship between the two variables may be nonlinear. The empirical analysis therefore uses data for a selected sample of developing countries over the period 2005–2023 and applies the Panel Smooth Transition Regression (PSTR) approach.

The remainder of the paper is structured into six sections. Following the introduction, Section 2 reviews the relevant literature. Section 3 discusses the research background, and Section 4 presents the model and econometric methodology. Section 5 reports the estimation results and provides their analysis. The final section concludes the paper and sets out the policy recommendations.

2. Literature Review

2.1. Theoretical Literature

Traditional trade theory attributes the welfare gains from international trade to specialization according to comparative advantage (Smith, 1776; Ricardo, 1817; Krugman and Obstfeld, 2007). For developing economies, however, excessive specialization in a limited number of primary commodities may increase exposure to commodity price volatility, deteriorating terms of trade, and external demand shocks. The Prebisch–Singer hypothesis and the portfolio approach therefore regard export diversification as a mechanism for stabilizing export revenues, reducing external vulnerability, and promoting structural transformation toward higher-productivity and higher-value-added activities (Prebisch, 1950; Cadot et al., 2011). Diversification can take several forms, including the introduction of new products, expansion into new destination markets, a more even distribution of export revenues, or a transition toward exports with greater technological sophistication.

Corruption can constrain export diversification through four interrelated channels. First, bribery and discretionary regulation operate as uncertain and non-transparent taxes on firms, increase transaction costs, weaken contract enforcement, and discourage domestic and foreign investment (Pellegrini and Gerlagh, 2004; Mauro, 1995; Shleifer and Vishny, 1993). These effects are particularly important for new export activities, which generally require substantial fixed costs, long-term investment, and access to foreign technologies and markets. Second, corruption weakens innovation, entrepreneurship, and human-capital formation. New and innovative firms depend heavily on licences, permits, customs procedures, and other administrative approvals and may therefore be more exposed to bribery and regulatory discrimination than established and politically connected firms. By reducing the expected return to productive entrepreneurship and redirecting talent toward rent-seeking activities, corruption restricts technological upgrading and the development of new export products (Murphy et al., 1999; Mo, 2001). Third, corruption can distort both the allocation and the productivity of public spending. Corrupt officials may prioritize large-scale projects that offer greater scope for private appropriation instead of directing resources toward education, trade facilitation, logistics, and productive infrastructure. Consequently, corruption may increase the volume of public investment while simultaneously reducing its effectiveness in supporting productive capacity and export development (Tanzi and Davoodi, 1997; Mauro, 1998). Fourth, corruption undermines institutional legitimacy and policy

credibility, increases political and economic uncertainty, and discourages firms from entering risky and unfamiliar export activities.

The theoretical relationship between corruption and export diversification may, however, be nonlinear. According to the “grease-the-wheels” hypothesis, in economies marked by highly inefficient institutions and burdensome administrative restrictions, informal payments may temporarily enable firms to circumvent bureaucratic delays and gain access to licences, customs clearance, scarce inputs, or export markets (Huntington, 1968; Leff, 1964; Méon and Sekkat, 2005). Under such conditions, the marginal effect of corruption may be less harmful or, in some cases, temporarily facilitating. As institutional quality improves and formal administrative procedures become more effective, however, the potential facilitating role of corruption diminishes. Its conventional costs, including uncertainty, resource misallocation, rent seeking, reduced investment, and weakened competitiveness then become dominant. The effect of corruption on export diversification may therefore vary across institutional regimes rather than remain uniform across different levels of corruption control. This reasoning provides the theoretical foundation for examining a nonlinear, regime-dependent relationship between corruption and export diversification.

The effects of the other determinants of export diversification may also depend on institutional conditions. Natural resource revenues can finance infrastructure and productive capabilities, but they may generate Dutch disease pressures, rent seeking, and persistent dependence on primary commodities when institutions are weak (Zarach and Parteka, 2023; Bahar and Santos, 2018). Higher real per capita income generally expands productive capacity, human capital, infrastructure, and technological capabilities, although diversification may eventually slow as advanced economies specialize in technologically sophisticated activities (Cadot et al., 2011; Imbs and Wacziarg, 2003). Financial development may foster diversification by easing liquidity constraints and providing financing for risky export projects that involve substantial fixed costs and extended payback periods (Hausmann and Rodrik, 2003; Chaney, 2016). Trade openness may expand access to imported inputs, technology, and foreign markets, but it may also reinforce specialization in products consistent with existing comparative advantage. Similarly, information and communication technology reduces search, information, logistics, and transaction costs and facilitates participation in international markets. Nevertheless, corruption can reduce the effectiveness of these factors by distorting credit allocation, public investment, trade administration, and access to digital infrastructure. Institutional conditions may therefore shape both the direct impact of corruption and the effects of the main macroeconomic drivers of export diversification.

2.2. Empirical Literature

Empirical research has identified a wide range of structural, macroeconomic, and institutional determinants of export diversification, but the estimated effects vary substantially across countries, development levels, and model specifications. Cadot et al. (2011) reported a hump-shaped pattern in the association between income and export concentration, whereby countries become more diversified as income grows but may move back toward specialization at more advanced levels of development. Agosin et al. (2012) linked diversification to human capital, trade openness, exchange-rate conditions, and proximity to major markets, whereas Parteka and Tamberi (2013) obtained comparatively robust results for country size and development level, with institutional factors showing less consistent effects. Evidence from individual countries and regions points to similar variation. For Pakistan, Mubeen and Ahmad (2016) found that foreign direct investment, global income, and the real effective exchange rate favored greater export diversification, while trade openness was associated with increased export concentration. In Sub-Saharan Africa, however, Fonchamnyo and Akame (2017) documented diversification-enhancing effects of trade openness, foreign direct investment, and sectoral value added, but found per capita income to have a restrictive effect. Handoyo and Ibrahim (2021) further reported that the contributions of income, human capital, and innovation were not uniform across different income groups. Overall, the evidence suggests that the factors shaping export diversification vary with countries' structural features and stages of development.

Evidence from Iran and other developing economies also points to the importance of investment, financial conditions, institutional quality, and macroeconomic stability. Hafezieh et al. (2017) found that foreign direct investment and output growth supported diversification, whereas exchange-rate instability and international sanctions restricted it. Amiri and Amini Daran (2018) identified positive effects of investment, competitiveness, financial development, institutional quality, and exchange-rate conditions. Using multicountry panel data, Harighi et al. (2021, 2022) concluded that institutional reforms and financial development contributed to greater diversification. Fosu and Abass (2020) also showed that domestic credit can support diversification by alleviating firms' financing constraints. Collectively, these results suggest that finance and investment are more likely to support diversification when they are allocated to new and productive tradable activities.

Empirical research specifically addressing how corruption affects export diversification remains sparse relative to the wider literature on export structure, and the existing evidence does not point to a consistent conclusion. Starosta de Waldemar (2010) and Cabral and Veiga (2010) identified corruption as a factor that limits diversification, while Parteka and Tamberi (2013) found no statistically robust indication of a direct impact. Åberg (2014) provided evidence of nonlinearity using a quadratic corruption specification and showed that the effect varied with exporters' income levels. These conflicting results may reflect

differences in country samples, corruption indicators, diversification measures, and econometric specifications. More recent research has shifted attention from the isolated effect of corruption toward the institutional conditions under which diversification occurs. [Lei and Luo \(2022\)](#) found that stronger institutional quality was associated with greater export diversity. [Ngameni et al. \(2023\)](#) showed that, in Cameroon, the role of natural resources in shaping export diversification depends on the extent of corruption, with this moderating influence varying over short- and long-term horizons. Their results therefore imply that corruption can shape export patterns through two channels: directly, and indirectly by altering the contribution of other factors associated with diversification.

Studies of natural resource dependence reach a similar conclusion. [Kilolo \(2018\)](#) found that resource abundance generally increased export concentration, whereas [Ngameni et al. \(2023\)](#) showed that different categories of natural resources produced heterogeneous effects. Using product level data for 160 countries, [Zarach and Parteka \(2023\)](#) demonstrated that resource dependence, particularly dependence on fossil fuels, was negatively associated with the variety of non-resource and technologically advanced exports. They further showed that institutional quality influenced whether resource exporting countries could overcome this pattern. Recent evidence has reinforced the importance of the institutional and macroeconomic management of natural resources. [Olvera and Spinola \(2025\)](#) found that both product relatedness and macroeconomic conditions shaped diversification in resource-dependent economies, with macroeconomic conditions frequently playing a more decisive role than productive capabilities alone. Thus, the effect of natural resource abundance cannot be evaluated independently of the institutions and policies governing the allocation of resource revenues. Trade openness and digitalization also appear to have institution-dependent effects. [MILLOGO et al. \(2024\)](#) found that weak institutions intensified the adverse effect of trade openness in low-income Sub-Saharan African countries, whereas stronger institutions enabled countries to benefit more effectively from international integration. [Sultanova and Usmanova \(2024\)](#) reported that information and communication technology reduced export concentration in Central Asian economies. [Nham and Bao \(2023\)](#), however, reported a nonlinear relationship between digitalization and export activity, suggesting that the gains from digital transformation may materialize only when countries attain adequate levels of infrastructure, skills, and institutional capacity.

A growing strand of the literature has focused on innovation and technological capability as factors shaping export structure. [Saleem et al. \(2025\)](#) found that, in middle-income countries, stronger patenting activity and the use of technologies suited to domestic conditions were associated with a broader export base. [Parteka et al. \(2025\)](#) further showed that the technological content of diversification follows a systematic pattern as economies progress through different stages of development. Taken together, these studies suggest that the contribution of digital and technological capacity to export structure has become

increasingly important, although its influence varies with the level of economic development and the quality of institutions.

Recent empirical work has also devoted greater attention to differences across countries and to uncertainty over model specification. For Iraq, [Ismael \(2025\)](#) found trade openness and political stability to be among the main factors associated with a more diversified export structure. [Ul-Haq et al. \(2025\)](#), examining Chinese provinces, reported diversification-enhancing effects from natural resources, foreign direct investment, human capital, innovation, and openness. [Vogel \(2025\)](#), using Bayesian model averaging for a sample of African countries, found that export diversification reflects the combined influence of numerous trade-related and domestic factors, while the apparent contribution of any single determinant depends partly on the specification considered. This body of evidence suggests that the determinants of diversification are better assessed jointly rather than separately and provides support for an empirical framework that allows institutional conditions to modify both the size and the direction of their effects.

2.3. Summary of previous studies and contribution of the present study

The review of previous studies points to several unresolved issues in the corruption–export diversification nexus. First, while the adverse consequences of corruption for economic growth, investment, and international trade have been extensively investigated, its possible nonlinear influence on export diversification has received comparatively little empirical attention. Most existing studies either treat this relationship as invariant or rely on quadratic formulations that restrict it to a prespecified functional form. As a result, relatively little is known about whether the influence of corruption varies under different institutional settings. Against this background, the present study makes three contributions to the literature.

First, it offers a theoretical contribution by empirically assessing the “grease-the-wheels versus sand-the-wheels” hypothesis in relation to export diversification. The central argument is that the impact of corruption depends on the quality of the surrounding institutional environment. Where control of corruption is weak and bureaucratic frictions are substantial, corruption may, at least temporarily, function as an informal channel through which firms circumvent administrative obstacles and gain easier access to export markets. However, once corruption control exceeds a critical threshold and formal institutions become more effective, corruption loses this facilitating role and instead increases transaction costs, weakens competitiveness, and discourages productive and entrepreneurial activities. The analysis therefore extends the grease-the-wheels argument and the broader debate surrounding the “Asian paradox” to the export diversification literature within an institutional threshold framework.

Second, the study makes a methodological contribution by applying PSTR model and using the control of corruption index as the transition variable. Unlike

linear regressions, quadratic specifications, conventional interaction models, or separate subsample estimations, the PSTR approach allows regime changes to occur gradually and endogenously. It also permits all estimated coefficients, rather than only the coefficient of corruption, to vary with changes in the institutional environment. Accordingly, the model is used to assess whether the influence of natural resource abundance, trade openness, financial development, real per capita income, and information and communication technology on export diversification changes after countries move beyond the identified threshold of corruption control. By allowing these effects to vary across institutional settings, the framework offers a broader view of how governance conditions shape the contribution of major macroeconomic factors to export structure.

Third, the study offers a policy contribution by demonstrating that export diversification policies should be tailored to countries' institutional regimes. The results indicate that policies that are effective under strong corruption control may produce limited outcomes under conditions of systemic corruption. For instance, ICT development does not significantly improve export diversification in the high-corruption regime, whereas its effect becomes positive and significant after corruption control exceeds the estimated threshold. Similarly, the smaller effect of natural resource abundance in the second regime suggests that improvements in institutional quality can reduce resource dependence and support more genuine diversification. These findings provide a basis for regime-specific policy priorities, including gradual administrative and regulatory reforms in the high corruption regime and coordinated investment in productive, financial, trade, and digital infrastructure in the low-corruption regime. Taken together, the analysis helps fill an important gap by jointly assessing the nonlinear influence of corruption and allowing the main drivers of export diversification to vary across regimes within a single empirical setting. We are not aware of earlier work that has used the Control of Corruption index to govern regime transitions in a PSTR specification while examining these relationships jointly for a broad sample of developing economies.

3. Research Methodology

3.1. Model and variables

Following [Ul-Haq et al. \(2025\)](#), [Ngameni et al. \(2023\)](#), [Åberg \(2014\)](#), and the theoretical foundations of the study, the general research model is specified as follows:

$$EXPDiv_{it} = \alpha_0 + \alpha_1 COC + \sum_{k=3} \alpha_k Controls_{it} + \varepsilon_{it} \quad (1)$$

Where $EXPDiv_{it}$ represents the model's dependent variable, export diversification. Empirical studies generally describe export diversification as a broadening of the range of products sold abroad or an expansion in the number of foreign markets served by a country ([Dennis and Shepherd, 2011](#); [Bacchetta et al., 2009](#)). The concept may also refer to a more balanced allocation of export

earnings across different product categories (Starosta and Waldemar, 2010). Several measures can be used to quantify diversification, including the number of distinct products a country exports during a particular year and concentration measures such as the Herfindahl–Hirschman index.

The present study employs the diversification index developed by Finger and Kreinin (1979), for which UNCTAD provides country-level time-series data. The index measures the extent to which the composition of a country's trade differs from the structure of world trade. Larger deviations indicate a more concentrated trade structure and thus a lower degree of diversification, whereas smaller deviations correspond to a more diversified export structure. The index is expressed as follows:

$$S_j = \frac{\sum_i |h_{ij} - h_i|}{2} \quad (2)$$

where:

h_{ij} : the share of product i in the total exports of country j

h_i : the share of product i in total world exports

The index is normalized on a scale from zero to one. Values approaching one indicate a larger deviation from the global export structure and therefore correspond to a lower degree of export diversification. Thus, higher values of the index reflect less diversified exports.

COC refers to the Control of Corruption index and serves as the measure of corruption in the model. The index takes values from -2.5 to 2.5 . Values closer to 2.5 are associated with lower levels of corruption, whereas values approaching -2.5 indicate higher levels of corruption. Hence, the COC index moves inversely with corruption: higher scores imply less corruption, while lower scores indicate more corruption. Data on COC are taken from the Worldwide Governance Indicators (WGI) database.

The term *Controls* refers to the set of control variables included in the model, defined as follows:

Natural resource abundance (NR) is measured by the share of fuel exports, including oil and gas, in total exports of goods and services; $LGDP$ is the logarithm of real per capita income; financial development (FD) is proxied by domestic credit extended by the banking system to the private sector as a share of GDP; trade openness ($Openness$) is measured by total exports and imports relative to GDP; and infrastructure quality is represented by information and communication technology (ICT), measured by the share of the population using the Internet. Data for these variables are obtained from the World Bank database. The empirical analysis covers a selected sample of developing countries over the period 2005–2023.

3.2. Research Method

The empirical framework employs a panel smooth transition regression (PSTR) specification characterized by two limiting regimes connected through a

single transition function. The model can be expressed as:

$$y_{it} = \alpha_i + \beta_1'x_{it} + \beta_2'x_{it}F(T_{it}, \gamma, c) + u_{it}, i = 1, \dots, N, t = 1, \dots, T$$

In this specification, y_{it} denotes the dependent variable, while x_{it} contains the exogenous explanatory variables. The term α_i captures unit-specific fixed effects, and u_{it} denotes the disturbance component, which is assumed to satisfy $u_{it} \sim i.i.d.N(0, \sigma^2_\varepsilon)$. The function $F(T_{it}, \gamma, c)$ governs the movement between regimes and takes values within the interval $[0, 1]$, with its magnitude depending on the transition variable. Following González et al. (2005), the logistic transition function is written as:

$$F(T_{it}, \gamma, c) = \left[1 + \exp \left(-\gamma \prod_{j=1}^m (T_{it} - c_j) \right) \right]^{-1}, \gamma > 0, c_1 \leq c_2 \leq \dots \leq c_m$$

Here, γ controls the smoothness of the transition and, consequently, how rapidly observations move between the two regimes. The variable T_{it} serves as the transition variable and can be drawn from the explanatory variables, a lagged value of the dependent variable, or another theoretically relevant variable not explicitly included in the baseline specification that may induce nonlinear behavior. In addition, $c = (c_1, \dots, c_m)'$ denotes an m -element vector containing the threshold values that determine the points around which transitions between regimes take place (Khodavisi et al., 2017).

3.3. Descriptive Statistics and the Status of the Countries under Study in the Main Research Variables

Table 1 reports the descriptive statistics for the variables considered in the analysis, providing an overall summary of their empirical distributions.

Table 1. Descriptive statistics of the research variables

Variable	Mean	Maximum	Minimum	Standard deviation
ED	0.6915	0.9380	0.3670	0.1327
COC	-0.4662	1.5435	-1.5996	0.6173
NR	20.3369	98.3701	0.0000	28.2363
LGDP	8.1667	9.7345	5.5351	0.8956
FD	40.1032	189.6067	4.2035	28.2197
Openness	76.0239	183.8080	22.2402	33.1879
ICT	39.2167	94.4574	0.5421	27.5178

Source: Research finding

The cross-country pattern of export diversification and corruption is examined next. As illustrated in Figure 1, Botswana records the highest mean export diversification index, at 0.9043, implying the least diversified export structure within the sample. Gabon follows with an average index value of 0.8476,

making it the country with the second-lowest degree of export diversification. By comparison, Hungary exhibits the smallest average index value, at 0.4093, and therefore shows the greatest degree of export diversification among the countries included in the analysis.

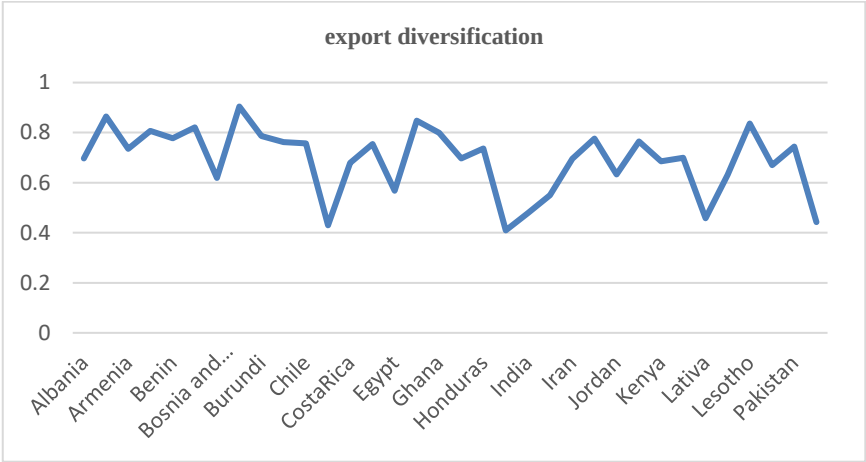


Figure 1. Average of the export diversification variable for the countries under study
Source: Research finding

According to Figure 2, Chile records the highest average value of the Control of Corruption index, at 1.22, indicating the lowest degree of corruption among the countries included in the sample. Botswana follows with a mean value of 0.8427 and therefore ranks second in terms of having the lowest level of corruption. By contrast, Burundi has the smallest average value of the Control of Corruption index, at -1.32, reflecting the highest level of corruption among the countries examined.

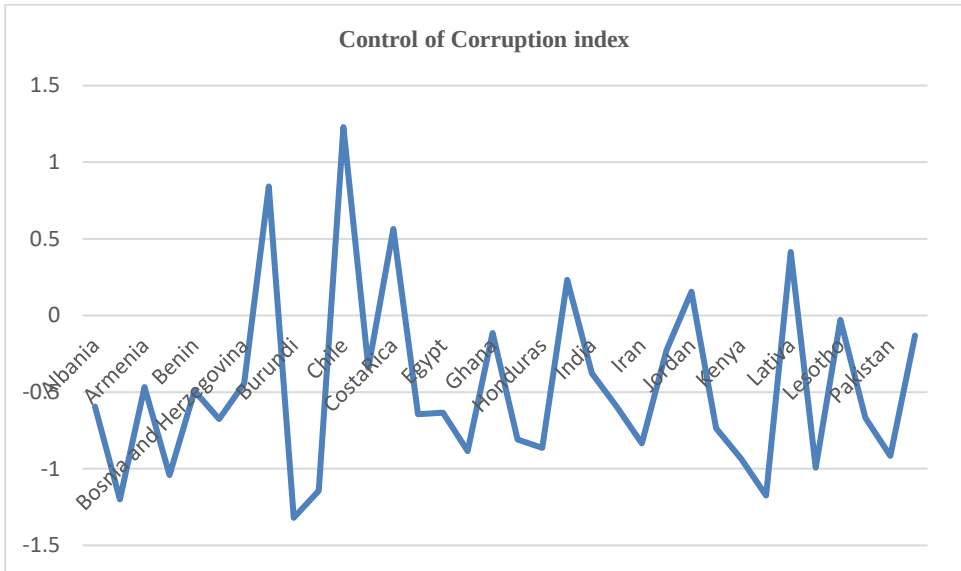


Figure 2. Average of the control of corruption index for the countries under study

Source: Research finding

4. Research Findings

4.1. Data properties: stationarity

Prior to estimating the PSTR model, the time-series properties of the variables were assessed using the unit root test (Breitung, 2002). As reported in Table 2, the results indicate that all variables are non-stationary in levels at the 95% confidence level but become stationary after taking their first differences. Accordingly, the variables are integrated of order one, $I(1)$.

Table 2. Results of the unit root test for the variables

Variables	Level Statistic	Level Probability	First Difference Statistic	First Difference Probability
ED	-1.04	0.8820	-2.12	0.0012
COC	-1.61	0.0534	-5.24	0.0000
NR	-1.11	0.1329	-4.69	0.0000
LGDP	-1.51	0.0650	-5.40	0.0000
FD	1.97	0.9758	-5.44	0.0000
Openness	-1.23	0.1123	-5.77	0.0000
ICT	3.76	0.9999	-5.49	0.0000

Source: Research finding

The presence of unit roots in the model variables can result in spurious regression and may consequently lead to unreliable or misleading inferences. A conventional approach to addressing this problem is to transform the variables by first differencing and estimate the model using the resulting differenced series (Tashkini, 2005). However, this transformation may eliminate information

concerning long-run relationships among the variables. Cointegration analysis provides an alternative framework that preserves such long-term information. Accordingly, this study applies the Kao cointegration test to investigate whether a stable long-run relationship exists among the variables included in the model. Under this test, the null hypothesis specifies the absence of cointegration, whereas the alternative hypothesis implies that the variables are cointegrated. Thus, rejection of the null hypothesis provides evidence of a long-run cointegrating relationship among the variables. The results presented in the following table reject the null hypothesis of no cointegration and support the alternative hypothesis, confirming the existence of cointegration among the model variables.

Table 3. Results of the kao cointegration test

Test type	t-statistic	Probability	Result
Kao cointegration Test	-5.0754	0.0000	Rejection of H ₀ and existence of cointegration among the model variables

Source: Research finding

Before applying the nonlinear panel estimation procedure, the cross-sectional units must first be assessed for homogeneity or heterogeneity, since the suitability of a panel framework depends on the presence of heterogeneity across units. The F-Limer test was therefore applied to determine whether a pooled specification or a panel-data model is more appropriate. Subsequently, the Hausman test was conducted to identify whether the fixed-effects or random-effects estimator should be preferred. The findings presented in Table 4 support the use of the panel-data approach.

Table 4. Test results for determining the model estimation method

Test type	t-Statistic	Probability	Result
F-Limer Test	249.37	0.0000	Rejection of H ₀ and confirmation of the panel data method
Hausman Test	13.75	0.0325	Rejection of H ₀ and confirmation of the fixed effects method

Source: Research finding

4.2. Results of the panel smooth transition regression estimation

As an initial step, the linear specification was tested against the alternative of a PSTR structure, with the Control of Corruption index (COC) serving as the transition variable. As shown by the MATLAB results reported in Table 5, the relevant test statistics for both $m = 1$ and $m = 2$ provide evidence in favor of the nonlinear PSTR specification at the 10% significance level.

Table 5. Test for the presence of a nonlinear relationship

Test Statistic	M=1			M=2		
	LM_W	LM_F	LR	LM_W	LM_F	LR
$H_0 : r = 0$						
$H_1 : r = 1$	11.523 (0.074)	1.834 (0.090)	11.627 (0.000)	23.901 (0.021)	1.921 (0.029)	24.355 (0.000)

Source: Research finding

Once nonlinearity among the variables was established, the next step was to determine whether an additional transition function was required. For this purpose, a PSTR specification containing one transition function was taken as the null hypothesis and compared with an alternative specification involving at least two transition functions. According to the results presented in Table 6, the null hypothesis cannot be rejected for either the one-threshold or the two-threshold specification. This finding indicates that a single transition function adequately captures the nonlinear relationship between the Control of Corruption index and export diversification.

Table 6. Test for nonlinear relationship in the residuals

Test statistic	M=1			M=2		
	LM_W	LM_F	LR	LM_W	LM_F	LR
$H_0 : r = 1$						
$H_1 : r = 2$	6.379 (0.382)	0.987 (0.433)	6.411 (0.379)	24.178 (0.019)	1.905 (0.031)	24.642 (0.017)

Source: Research finding

The next specification was then chosen by comparing models with one and two threshold parameters. Each alternative PSTR specification was estimated separately, and model selection was carried out using the residual sum of squares together with the Schwarz and Akaike information criteria. The results reported in Table 7 indicate that the one-threshold specification performs better according to both information criteria. Consequently, the empirical analysis adopts a PSTR model containing one transition function and a single threshold to capture the nonlinear relationship among the variables considered in the study.

Table 7: Determination of the number of thresholds in the transition function

M=1			M=2		
Bayesian Information Criterion (BIC)	Akaike Information Criterion (AIC)	Sum of Squared Residuals	Bayesian Information Criterion (BIC)	Akaike Information Criterion (AIC)	Sum of Squared Residuals
-7.1374	-7.1342	0.452	-7.0516	-7.0554	0.469

Source: Research finding

After identifying the appropriate number of transition functions and selecting the optimal threshold value, the model is estimated under a two-regime

specification. The corresponding estimation results are reported in Table 8. Because the coefficients are not constant across countries or over time and change with the transition variable, namely the Control of Corruption index, as well as with the slope parameter, their numerical magnitudes cannot be interpreted in a straightforward manner. Accordingly, the analysis focuses primarily on the direction of the estimated coefficients rather than their absolute values. For a more transparent interpretation of the findings, the two limiting regimes are considered separately. The model specifications associated with the first and second limiting regimes are provided at the end of Table 8.

Table 8. Estimation results of the PSTR model

Linear part of the model			Nonlinear part of the model		
COC ₀	0.0003	t-statistic	COC ₁	-0.0009	t-statistic
		3.40			-2.69
NR ₀	-0.0546	-5.29	NR ₁	0.0256	2.30
LGDP ₀	-0.0002	-0.84	LGDP ₁	-0.0014	-2.50
FD ₀	-0.0004	-3.01	FD ₁	-0.0002	-4.48
Openness ₀	-0.0003	-2.85	Openness ₁	-0.0001	-2.42
ICT ₀	-0.0063	-0.37	ICT ₁	-0.11	-4.44
Threshold Point (C=0.3913)					
Slope Parameter (γ=1.93)					
First Regime:					
ED= C + 0.0003 COC – 0.0546 NR – 0.0002 LGDP - 0.0004 FD – 0.0003 OPennes – 0.0063 ICT					
Second Regime:					
ED= C - 0.0006 COC – 0.0290 NR – 0.0016 LGDP - 0.0006 FD – 0.0004 OPennes – 0.1163 ICT					

Source: Research finding

Based on the estimation results, the slope parameter is estimated at 1.93, indicating a relatively gradual transition between the two regimes. The estimated location parameter is 0.3913, which represents the threshold value at which the behavior of the model begins to shift. As the transition variable approaches this threshold, the relationship between the explanatory variables and export diversification progressively departs from the characteristics of the first regime and moves toward those of the second. Accordingly, the value of 0.3913 can be interpreted as an approximate boundary at which both the magnitude and the pattern of the explanatory effects begin to change.

The results reported in Table 8 provide evidence in support of an inverted U-shaped relationship between corruption and export diversification. In the first regime, where the Control of Corruption index remains below the estimated threshold, the index exerts a positive and statistically significant effect on the export diversification index. By contrast, in the second regime, where the Control of Corruption index exceeds the threshold, its effect becomes negative and statistically significant. Since both the Control of Corruption index and the export diversification index are inverse measures of corruption and export diversification, respectively, these findings imply that corruption is positively and

significantly associated with export diversification in the first regime but negatively and significantly associated with it in the second regime. The estimated results therefore support the hypothesis of an inverted U-shaped relationship between corruption and export diversification in the sample countries. More specifically, when corruption control is weak and corruption is relatively high, further increases in corruption are associated with greater export diversification. Once the corruption-control threshold is exceeded and the economy enters the second regime, however, additional corruption becomes detrimental to export diversification.

This regime-dependent pattern can be interpreted through differences in institutional quality. In the first regime, characterized by relatively high corruption, institutions tend to be weaker and regulatory procedures more burdensome. Under such circumstances, corruption may operate as “grease for the wheels” by accelerating administrative processes, shortening the time required to obtain permits, and facilitating access to foreign-exchange resources, thereby easing the entry of new firms into non-oil export markets. In the second regime, where corruption is comparatively low, institutions are more effective and transparent and legal rules are more consistently enforced. In such an environment, corruption no longer provides a facilitating function and instead acts as an additional cost imposed on productive activity. This raises transaction costs, undermines export competitiveness, and weakens entrepreneurial incentives. Consequently, the effect of corruption changes from positive to negative as its role shifts from a potential lubricant in weak institutional environments to a constraint in stronger institutional settings. This result is in line with Åberg (2014), who also identifies an inverted U-shaped association between corruption and export diversification and interprets it within an institutional threshold framework.

Natural resource abundance has a negative and statistically significant coefficient on the export diversification index in both regimes, implying a positive and significant effect on the actual degree of export diversification. Nevertheless, the size of this effect is substantially smaller in the second regime, where the Control of Corruption index lies above the threshold, than in the first regime, where it remains below the threshold. The decline in coefficient magnitude arises as the transition variable crosses the estimated threshold. In the first regime, natural resource abundance has a stronger influence on diversification because weak institutional transparency allows oil revenues to be allocated through rent-seeking mechanisms; at the same time, the large volume of resource-generated income may support the creation of additional export capacity, resulting in a dominant income effect.

In the second regime, stronger control of corruption alters the way resources are allocated by channeling them toward more productive uses. Consequently, the economy becomes less dependent on revenues derived from natural resources, and the influence of resource abundance on export diversification weakens. Hence, the smaller coefficient observed in the second regime may reflect a gradual

reduction in resource dependence and a shift toward more genuine forms of diversification, which can itself be viewed as an outcome of improved institutional quality.

The findings reported in Table 8 indicate that real per capita income has a negative and statistically significant effect on the export diversification index in the second regime, implying a positive and significant influence on the actual degree of export diversification. This effect becomes stronger once the Control of Corruption index exceeds the estimated threshold, whereas real per capita income is statistically insignificant in the first regime. The change in both the size and statistical significance of the coefficient therefore appears to be associated with the transition variable crossing its threshold.

An economic explanation for this result can be derived from differences in institutional conditions across regimes. Under the first regime, characterized by relatively high corruption, increases in per capita income are largely absorbed by consumption and imports because investment security is weak and part of the available resources is diverted through corrupt networks. As a result, higher income does not translate effectively into expanded productive capacity or a more diversified export structure. In the second regime, by contrast, stronger corruption control and greater institutional integrity allow additional income to be directed toward productive investment, human capital formation, and the development of export-related infrastructure rather than primarily toward consumption. More transparent institutions also improve the ability of an economy to transform rising income into the production of more complex and diverse export goods. Accordingly, the responsiveness of export diversification to changes in per capita income becomes considerably stronger. The beneficial role of higher income in promoting diversification therefore appears to depend on whether the corruption-control threshold has been exceeded. This result highlights the importance of institutional quality in transforming income gains into broader export capacity and is consistent with [Espoir \(2020\)](#) and [Handoyo and Ibrahim \(2021\)](#), who stress the complementary role of institutions in shaping the relationship between income and diversification.

Financial development also exhibits a negative and statistically significant coefficient on the export diversification index in both regimes, which corresponds to a positive and significant effect on export diversification itself. However, this effect is substantially stronger in the second regime, where corruption control exceeds the threshold, than in the first regime. The increase in the magnitude of the effect can therefore be associated with the movement of the Control of Corruption index across the estimated threshold.

This pattern may be explained by differences in the efficiency with which financial resources are allocated. In the first regime, although financial development can expand access to credit, widespread corruption may prevent available financing from supporting export diversification. Credit may instead be directed toward rent-seeking activities, speculative investments, or import-dependent sectors rather than toward the development of new export industries.

In the second regime, stronger corruption control and greater institutional transparency improve the allocation of financial resources. Under these conditions, credit is more likely to finance long-term, risk-bearing, and diversified investment in non-oil sectors. Financial development can therefore become an important source of funding for firms seeking to enter new export markets, causing the responsiveness of export diversification to financial development to increase substantially. The results thus suggest that the contribution of financial development to diversification becomes stronger when corruption is more effectively controlled. This interpretation is consistent with [Harighi et al. \(2023\)](#) and [Amiri and Amini Daran \(2018\)](#), who emphasize the moderating role of institutions in determining the efficiency of the financial system.

Trade openness has a negative and statistically significant effect on the export diversification index in both regimes and therefore corresponds to a positive and significant influence on export diversification. The magnitude of this effect is considerably greater in the second regime, where the Control of Corruption index is above the threshold, than in the first regime. This difference suggests that the effectiveness of trade openness changes as the economy moves across the corruption-control threshold.

In the first regime, characterized by relatively high corruption, reductions in formal tariff barriers may not be sufficient to stimulate substantial export diversification because corruption-related non-tariff obstacles remain in place. Practices such as bribery at customs, non-transparent administrative procedures, and import monopolies controlled by influential groups may prevent firms from fully benefiting from trade liberalization. Consequently, part of the potential gains from openness may be captured by rent-seeking networks, limiting the entry of new firms into export markets. In the second regime, stronger corruption control and institutional transparency enable trade openness and sound institutions to operate jointly. This combination can reduce transaction costs while simultaneously improving the competitiveness of domestic producers in international markets. As both tariff and non-tariff barriers decline, firms are better positioned to expand into the production and export of new and more complex goods. The effect of trade openness on export diversification therefore becomes stronger. These findings suggest that the diversification benefits of trade openness depend substantially on effective corruption control and that trade liberalization alone may be insufficient in a weak institutional environment. This interpretation is consistent with [Fonchamnyo and Akame \(2017\)](#), [Espoir \(2020\)](#), and [Ismael \(2025\)](#), who emphasize the complementary contribution of institutions to the effectiveness of trade policies.

The results for information and communication technology (ICT) also vary across regimes. The ICT coefficient is positive and statistically significant in the second regime, where the Control of Corruption index exceeds the threshold, while it remains statistically insignificant in the first regime. This change suggests that the effect of ICT becomes more pronounced after the transition variable crosses its estimated threshold. In a highly corrupt environment, the availability

of ICT infrastructure alone may be insufficient to reduce transaction costs or lower export barriers because information can be concentrated within corrupt networks, market signals may be distorted, and technological systems may be employed through non-transparent mechanisms. As a result, the potential economy-wide benefits of digitalization may not be translated into stronger export performance. Under the second regime, however, stronger corruption control and transparent institutions enable ICT to function more effectively as a complement to institutional quality. Digital technologies can facilitate firms' entry into new markets and support the production of more diversified export goods by lowering search and transaction costs, improving access to international markets, strengthening logistics services, and increasing the transparency of customs procedures. The contribution of ICT to export diversification therefore appears to depend on the quality of corruption control. This finding is consistent with [Sultanova and Usmanova \(2024\)](#) and [Nham and Bao \(2023\)](#), who emphasize the role of institutions in enabling economies to capture the benefits of digitalization.

5. Conclusion and discussion

This study investigates the threshold effect of corruption on export diversification across 34 developing countries during the 2005–2023 period using the PSTR framework. The empirical findings provide strong evidence of a nonlinear association between the Control of Corruption index and the export diversification index. The results further indicate that a specification with a single transition function and one threshold adequately captures this nonlinear pattern. The estimated regime change occurs when the Control of Corruption index, which serves as the transition variable, crosses the threshold value of 0.3913. In addition, the estimated slope parameter of 1.93 suggests that the movement from the first regime to the second takes place gradually rather than abruptly. The findings reveal that corruption exerts a positive and statistically significant effect on export diversification in the first regime, whereas its effect becomes negative and statistically significant in the second regime. Accordingly, the results support the existence of an inverted U-shaped relationship between corruption and export diversification in the countries examined. Natural resource abundance, financial development, and trade openness are also found to promote export diversification significantly in both regimes. By contrast, real per capita income and information and communication technology become positive and statistically significant determinants of export diversification only after the estimated threshold is exceeded.

A narrow export structure exposes many economies to considerable instability because their export revenues depend on only a few products. Such vulnerability is particularly pronounced when global demand for these products is volatile or relatively inelastic. Export diversification is therefore an important policy objective, especially for developing economies. This importance partly reflects the instability of world prices for primary commodities and substantial changes in the terms of trade between primary and manufactured products. A

more diversified export portfolio can reduce these vulnerabilities by allowing unfavorable price movements in one group of export products to be compensated for by stronger performance in others. Such diversification can consequently improve the predictability of foreign-exchange earnings and strengthen a country's capacity to finance imports and meet its external debt obligations. Given these benefits, particularly for developing countries, the findings of this study highlight the need for policy measures aimed at promoting a broader and more resilient export structure.

1. **Corruption:** Considering that the PSTR model confirmed the existence of two different regimes and that the change in the function of corruption from a “lubricant” in the first regime to a “deterrent” in the second regime was established, policy recommendations in this area should be differentiated based on the current status of each group of countries: For countries located in the first regime (high corruption): Given the positive effect of corruption on export diversification in this regime, any anti-corruption policy should not be implemented in a sudden and shock-like manner, because the existing bureaucratic system, which has unintentionally become dependent on corruption, may be disrupted if corruption is eliminated all at once, thereby disrupting the processes for issuing export licenses. Therefore, the first priority of these countries should be the gradual reform of administrative procedures, the reduction of redundant and cumbersome regulations, and the step-by-step enhancement of transparency in customs and banking processes, so that the need for corruption as an informal mechanism gradually decreases and the economy can move toward the second regime without experiencing a shock. For countries located in the second regime (low corruption): Given the negative and significant effect of corruption in this regime, any increase in corruption (a reduction in the control of corruption) severely harms export diversification. Therefore, in these countries, the full transparency of customs processes, continuous supervision of the banking system, strengthening the independence of the judiciary, and supporting public oversight institutions should be placed at the highest priority of policymaking in order to prevent a return to the high-corruption regime and preserve the achievements of export diversification.
2. **Natural resource abundance:** Given that the coefficient of natural resource abundance was estimated to be larger in the first regime (high corruption) and smaller in the second regime (low corruption), two distinct approaches can be recommended:

For countries in the first regime (high corruption): Despite the positive effect of natural resources in this regime, this effect is mainly generated through rent-seeking and unproductive channels. Therefore, it is recommended that a portion of oil revenues be deposited into national development funds and be allocated in a targeted and transparent manner to non-oil sectors such as industry, agriculture, and services. Moreover, establishing binding regulations for the public reporting of resource revenues can gradually transform the positive rent-based effect into a productive and sustainable effect. For countries in the second regime (low

corruption): Given the smaller coefficient of resource abundance in this regime, the economy has moved away from heavy dependence on resources, and the conditions for genuine diversification have been established. This provides a suitable opportunity to gradually reduce the share of oil revenues in the annual budget and, instead, introduce tax exemptions for non-oil exporting companies in order to increase incentives to enter new markets and produce more complex goods.

3. Real per capita income: Given the insignificance of the per capita income coefficient in the first regime and its significance and larger magnitude in the second regime, the policy recommendations are as follows: For countries in the first regime (high corruption): An increase in per capita income alone cannot enhance export diversification, because the new resources are mainly absorbed through consumption and imports. Therefore, it is recommended that income-enhancing policies be accompanied by reforms in the income distribution system, measures to combat tax evasion, and the direction of capital toward productive sectors. In other words, institutional infrastructures should be reformed before implementing any income-related policy.

For countries in the second regime (low corruption): Given the high elasticity of diversification with respect to income in this regime, an increase in per capita income substantially enhances diversification. Therefore, extensive investment in production infrastructure, the development of technical and vocational education, support for applied research in export-oriented industries, and the establishment of specialized industrial parks are recommended as key strategies for converting higher income into greater diversification.

4. Financial Development: Given that the coefficient of financial development is smaller in the first regime and becomes larger in the second regime, the following policy approaches can be proposed:

For countries in the first regime (high corruption): Expanding the banking network and increasing credit facilities alone do not have the required effectiveness, because credit is diverted toward rent-seeking and speculative sectors. Therefore, it is recommended that strict control over the allocation of credit to productive and export-oriented sectors, greater transparency in banks' financial statements, and the establishment of a monitoring system for large loans be prioritized, so that banking facilities lead to the creation of export diversification rather than the creation of rents.

For countries in the second regime (low corruption): Given the high efficiency of the financial system in this regime, it is recommended that low-interest credit facilities for knowledge-based and export-oriented companies, the development of export credit insurance, and the establishment of venture capital funds for new export projects be placed on the policy agenda, so that the risks associated with entering new markets are reduced for firms and incentives for diversification are increased.

5. Trade Openness: Given that the coefficient of trade openness is smaller in the first regime and becomes larger in the second regime, the policy recommendations can be differentiated as follows:

For countries in the first regime (high corruption): Tariff reductions alone cannot increase export diversification, because corruption-related non-tariff barriers—such as bribery in customs, excessive administrative procedures, and import monopolies—continue to persist. Therefore, it is recommended that, before any trade liberalization measure is implemented, customs procedures be made transparent, a single-window trade system be established, and administrative formalities be reduced to the minimum possible level.

For countries in the second regime (low corruption): Given the strong effect of trade openness on diversification in this regime, it is recommended that signing preferential trade agreements with major target markets, reducing import tariffs on the raw materials and intermediate goods required by export-oriented industries, and supporting the establishment of export associations be placed at the highest priority of policymaking, so that domestic firms can enter global markets at lower cost and with broader access and diversify their export baskets.

6. Information and communication technology: Given the insignificance of the ICT coefficient in the first regime and its becoming significant and positive in the second regime, the policy recommendations are as follows:

For countries in the first regime (high corruption): Investment solely in digital infrastructure will not, by itself, have an effect on export diversification, because corruption networks distort market information and turn technology into an instrument of control. Therefore, it is recommended that, before any large-scale investment in ICT, information transparency systems—such as a single-window trade system, customs transparency systems, and open access to economic data—be established in order to create the conditions necessary for technology to become effective. For countries in the second regime (low corruption): Given the positive effect of ICT in this regime, information technology can serve as a major engine of diversification. Therefore, it is recommended that the development of broadband infrastructure in industrial areas, support for e-commerce platforms, digital training for exporters, and the establishment of comprehensive databases on global markets be placed on the policy agenda, so that search and transaction costs in international markets are reduced to the lowest possible level and small and medium-sized enterprises can also easily enter the export sector.

Author Contributions

R.A. was responsible for the conceptualization and methodology of the study. Validation and formal analysis were carried out by all authors. R.A. also contributed to resources and preparation of the original manuscript draft. S.D.K. and A.Kh. supervised the study, while all authors participated in reviewing and editing the manuscript. All authors reviewed and approved the final version of the manuscript for publication.

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Conflicts of Interest

The authors report no conflicts of interest.

Data Availability Statement

The data supporting the findings of this study can be obtained from the authors upon reasonable request.

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