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Determinants of Nepal's Bilateral Trade in the SAARC Region: A Gravity Model Approach using PPML Estimator

Sujan Bhattarai[1*] *& Sandu Subedi*[1]

[1]Central Department of Economics, Tribhuvan University, Kirtipur, Kathmandu
[*]Corresponding Email: sujanbhattarai.nepal@gmail.com

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Abstract

Background: International trade is crucial for economic growth, particularly for landlocked developing countries like Nepal. Despite regional trade agreements like SAFTA, Nepal faces a persistent trade deficit within the SAARC region, obstructed by structural constraints and political tensions.

Purpose: Using a gravity model, this study will analyse the determinants of Nepal's bilateral trade and exports with SAARC countries. It sought to assess the effectiveness of regional integration efforts for Nepal and identify key economic and policy factors shaping its trade performance.

Methods: A panel dataset for seven SAARC countries (2009-2022) was analysed using the Poisson Pseudo-Maximum Likelihood (PPML) estimator. Models for total trade and exports incorporated traditional gravity variables (GDP, distance), socio-economic factors (exchange rates, tariffs, economic freedom), policy-related dummies (common border, BIMSTEC, India blockade, COVID-19), and an interaction term between tariffs and economic freedom.

Findings: This research reveals that economic size and geographic distance significantly affect trade flows. Similarly, Partner country GDP and common borders positively influenced trade. Further, Nepal's exchange rate depreciation has negatively affected trade. The effect of several dummy variables on total trade flow and exports is diverse, such as the economic blockade by India, which has shown significant negative effects on exports. While COVID-19 negatively impacted total trade, it positively influenced exports. Higher economic freedom was found to reduce the adverse impact of tariffs on both total trade and exports.

Conclusion: While Nepal's landlocked geography poses trade barriers, strong institutions help mitigate these constraints. Shifts in GDP-trade patterns reflect evolving export potential, though currency depreciation remains challenging. Strengthening governance, trade infrastructure, and export diversification is essential for deeper regional integration.

Keywords: *International Trade, Export Performance, Gravity Model, PPML estimators, SAARC*

JEL Codes: *F14, F15, F18*

1. Introduction

International trade drives economic growth, enhances competitiveness, and fosters regional cooperation (Gyawali, 2024; Moore, 2018; Paudel & Cooray, 2018). As countries increasingly integrate into the global economy, trade has become a powerful tool for accessing larger markets, diversifying production, and achieving economies of scale. Classical and modern international trade theories emphasise mutual benefits from exchanging goods and services across borders. In recent decades, regional trade agreements (RTAs) have emerged as key instruments to promote trade by reducing barriers and improving connectivity among member countries (Jaloliddin, 2024; Mamasoliev, 2024). While these dynamics have transformed global trade patterns, their outcomes vary significantly based on country-specific characteristics. For landlocked and developing nations like Nepal, international trade is crucial for overcoming geographic disadvantages and stimulating economic development (Mao et al., 2024). Despite being a member of various trade agreements, including the South Asian Free Trade Area (SAFTA), Nepal continues to experience a persistent trade deficit, particularly within the South Asian region (Kumar, 2022). This study aims to analyse the determinants of Nepal's bilateral trade and exports with SAARC countries using a gravity model approach, thereby assessing the effectiveness of regional integration efforts and identifying the economic and policy factors shaping Nepal's trade performance.

Despite sharing cultural, historical, and geographical ties with its SAARC neighbours, Nepal's trade balance remains persistently negative, raising concerns about the efficacy of regional integration mechanisms. Although the South Asian Free Trade Area (SAFTA) was envisioned to boost intra-regional trade and economic synergy, actual trade performance, especially for smaller economies like Nepal, has remained modest. In this regard, Previous studies have identified structural constraints such as limited industrial capacity (Nepal, 2024), high trade costs (Dahal et al., 2024; Sharma, 2025), and insufficient trade diversification (Adhikari & Ghimire, 2025; Dahal et al., 2024) as key impediments to Nepal's trade growth.

Most of the literature on intra-regional trade after the 1990s (Freund & Ornelas, 2010; Kumar, 2020; Rahman, 2008; Whalley, 1998) has consistently demonstrated that Regional Trade Agreements (RTAs) generally lead to an increase in trade among member countries. This positive impact on trade is attributed to reducing or eliminating tariffs and other trade barriers, which lowers the cost of trading and encourages greater volumes of trade (Freund & Ornelas, 2010). The magnitude of the trade effect, however, can vary significantly depending on the specific characteristics of the RTA, such as its depth, scope, and the level of commitment among member countries. Some RTAs may have a more pronounced impact on trade due to their comprehensive nature and strong enforcement mechanisms, while others may have a more limited effect due to their narrower scope or weaker implementation.

Nepal's gradual adoption of liberal trade policies since the 1980s and its membership in regional and multilateral trade organisations, including the WTO and SAFTA, underscore its commitment to global economic integration (Sobhan, 2006; Van Hoa, 2010). Yet, the country grapples with a structural trade deficit, especially with its closest neighbours. Furthermore, SAARC has encountered difficulties stemming from political tensions and regional disputes (Alam et al., 2011; Bishwakarma and Hu, 2022a). The complex political landscape of South Asia, characterised by historical rivalries, territorial disputes, and cross-border conflicts, has posed significant challenges to regional cooperation (Bishwakarma & Hu, 2022b; Majid, 2020). Given these dynamics, an empirical reassessment using the gravity model provides an opportunity to test the relevance of traditional trade determinants in the South Asian context and to offer policy insights tailored to Nepal's trade realities. Therefore, Nepal's trade engagement within the South Asian Association for Regional Cooperation (SAARC) presents an interesting case for gravity model analysis.

While numerous studies (Masood et al., 2023; Kumar, 2020; Maroof et al., 2019; Tahir et al., 2016 & Rahman, 2008) have explored the impact of Regional Trade Agreements (RTAs) on trade flows globally, there remains a limited body of empirical research focusing specifically on Nepal's intra-regional trade

performance within the SAARC framework. Existing literature tends to analyse trade at a broader regional or global level or emphasise structural and policy constraints without systematically quantifying their effects through rigorous empirical models. Moreover, many studies rely on traditional estimation techniques such as pooled OLS or fixed effects, which may not adequately address the presence of zero trade flows or unobserved heterogeneity, which is common in South Asian trade data. Despite SAFTA's potential to deepen trade integration, there is insufficient empirical evidence assessing its effectiveness for smaller, landlocked economies like Nepal. Additionally, the role of non-traditional factors, such as regional political disruptions (e.g., the India blockade in Nepal), pandemic shocks (COVID-19), and overlapping regional agreements (e.g., BIMSTEC), remains underexplored. This study fills these gaps by employing a gravity model framework with a PPML estimator, incorporating classical trade variables, other socio-economic variables, and policy-related dummies, to provide a more comprehensive and context-specific understanding of Nepal's trade dynamics within SAARC.

This research aims to empirically investigate the determinants of Nepal's trade, specifically total trade and exports, with its SAARC partners using the gravity model framework. By focusing on intra-regional trade, the study assesses whether proximity and shared regional agreements have transformed into meaningful trade integration. Unlike broader global studies, this research narrows its scope to the SAARC region, allowing a more focused exploration of regional economic linkages, trade barriers, and potential policy gaps. In doing so, it also reflects on whether regional trade agreements like SAFTA effectively serve their intended purpose for smaller economies within the bloc.

This article makes three significant contributions to the literature. First, it utilises a recent and comprehensive dataset to examine Nepal's bilateral trade and export patterns specifically within the SAARC region, offering updated insights into regional trade dynamics. Second, unlike previous studies that rely on pooled OLS, fixed effects, or random effects models, this study employs the Poisson Pseudo-Maximum Likelihood (PPML) estimator. This approach is better suited for trade data as it effectively handles heteroscedasticity, accommodates zero or small trade values, and addresses unobserved heterogeneity. Third, the model incorporates core gravity variables alongside relevant socio-economic and policy-related dummy variables such as common borders, SAARC and BIMSTEC membership, the India blockade, and the COVID-19 pandemic. This comprehensive specification enhances the robustness and policy relevance of the results.

This research is organised into four different sections. Along with the background, the research objective is introduced in the first section. The second section reviews the relevant literature; the third section constructs methodology; the fourth section presents the findings and discusses the results. Finally, the fifth section concludes the study and offers key policy recommendations.

2. Literature Review

South Asia's trade dynamics present a complex landscape with opportunities and challenges. Studies highlight that varying trade openness trends and improvements in education and investment drive trade growth within SAARC nations (Kumar, 2020; Maroof et al., 2019; Tahir et al., 2016). Employing a linear forecast model, the estimate shows rising exports to Nepal, Bhutan, Maldives, and Sri Lanka, while exports to Afghanistan, Bangladesh, and Pakistan are expected to decline in quantity. Conversely, Pakistan's trade potential could be significantly boosted through tariff reduction and enhanced economic integration, particularly with India, Nepal, and Bangladesh. Similarly, (Rahman, 2008) finds strong positive effects of regional trade on regional GNP and consumption. It indicates inter-country differences in economic structures but reveals significant mutual trade benefits, especially for smaller economies like Nepal and Bangladesh, supporting the case for deeper regional integration.

Furthermore, India's economic growth exhibits positive spillover on its neighbours, especially Bangladesh, Sri Lanka, Nepal, and Bhutan, emphasizing India's role as a re-gional growth engine (R. Kumar, 2020). Sub-regional initiatives like the BBIN (Bangladesh, Bhutan, India, and Nepal) and SAGQ (South Asia

Growth Quadrangle) face hurdles such as infrastructural gaps and policy coordination issues, hindering deeper integration (Palit & Islam, 2010). Impediments in service trade also persist, with South Asian economies showing more openness to countries outside the region (Banik & Bhaumik, 2014). Governance, FDI, and equity openness are significant determinants of industrial development in South Asia (Maroof et al., 2019). These factors collectively influence the region's trade dynamics, highlighting the need for comprehensive strategies to unlock its full potential.

The determinants of trade in the SAARC region have been explored through diverse lenses, ranging from macroeconomic policies and infrastructure development to sector-specific analyses and institutional frameworks. A recurring theme across studies is the role of macroeconomic stability and structural reforms in fostering trade. Goswami (2013) identified per capita income growth, trade liberalisation, and infrastructure development as critical drivers of long-term trade growth, emphasising the importance of economic reforms. Similarly, Tahir et al. (2018) linked trade openness to investments in physical and human capital and per capita GDP growth, noting that exchange rate volatility and labour force size hinder openness. These findings align with Khan et al. (2021), who underscored infrastructure (transport, energy, telecom) as pivotal for reducing trade deficits by enhancing export competitiveness. However, disparities emerge regarding the role of FDI. While Ejaz et al. (2017) found FDI and trade openness to positively influence industrial growth, Nepal and Thapa (2021) reported no significant long-term impact of FDI on trade balance, suggesting sectoral or temporal variations in FDI efficacy.

Sectoral analyses reveal distinct determinants. Dembatapitiya (2013) applied gravity models to agricultural trade, identifying GDP, population, and colonial ties as key factors, with bilateral agreements (e.g., Pakistan-Afghanistan) proving more impactful than multilateral frameworks like the WTO. On the other hand, Valbuena et al. (2015), who focused on crop residue use in smallholder farms, indirectly highlighted agricultural intensification's role in shaping trade-related resource management. For industrial growth, Ejaz et al. (2017) emphasised governance quality and government expenditure as complementary to trade openness, suggesting that political stability enhances industrial capacity and by extension, trade..

Studies on trade balance and openness reveal nuanced relationships. Nepal and Thapa (2021) identified inflation, exchange rates, and GDP as positively correlated with trade balance in the long run, but government consumption expenditure (GCE) had adverse effects. Their use of panel regression underscored the importance of distinguishing short vs. long-term impacts, as short-term results were insignificant overall. In contrast, Khan et al. (2021) highlighted domestic consumption as a positive determinant of trade deficits, complicating the narrative on consumption's role.

Institutional quality and regional integration policies emerge as contested determinants. Kumari and Bharti (2020) identified trade facilitation and financial development as critical for reducing intra-regional trade costs, while political corruption exacerbated them. Conversely, Dembatapitiya (2013) found that regional trade agreements (e.g., SAARC) had limited influence on agricultural trade, advocating targeted bilateral partnerships instead. This dichotomy suggests that institutional effectiveness—rather than the mere presence of agreements—drives integration.

A growing body of literature investigates the determinants and dynamics of trade within South Asia, focusing on macroeconomic, institutional, and policy variables. Studies show that GDP, financial development, and FDI significantly influence bilateral trade flows, as seen in Nepal–India trade, where economic expansion in both countries smooths exports, while domestic growth in Nepal reduces reliance on Indian imports (P. K. Adhikari, 2024). Similarly, gravity model analyses of India’s rice and spice exports underscore the importance of partner GDP, population, proximity, and trade agreements such as SAFTA in enhancing trade flows (Kalpana et al., 2025; Ravi Kumar et al., 2024). Nepal’s export performance is also shaped by similar variables, including distance and economic size of partners, reinforcing the relevance of gravity-based approaches in South Asian trade analysis (Kadel & Bhusal, 2024).

On the other side, trade openness and FDI are consistently linked with economic growth across SAARC countries, highlighting their importance in human development and regional integration (Azhar Iqbal &

Dr. Sadia Safdar, 2024). Conversely, non-tariff measures (NTMs) significantly dampen trade, as seen in Afghanistan's constrained exports due to trade distortions (Wani, 2024). Structural gravity models further emphasize the role of free trade agreements and institutional capacity in shaping export patterns and facilitating high-value trade (A. Masood et al., 2025). While most studies affirm the benefits of regional trade integration, only a few explore bilateral trade potential including trade potential of Nepal within the SAARC countries, pointing to a valid research gap in the context of Nepal.

Existing studies on SAARC trade determinants predominantly analyze the region as a bloc, overlooking country-specific structural and other economic challenges. For Nepal—a landlocked economy with asymmetric dependencies (For example; 60% trade reliance on India) the role of SAARC integration versus bilateral/global partnerships remains underexplored. This study addresses these gaps by quantifying Nepal's unique trade determinants, evaluating SAARC's effectiveness in mitigating its constraints.

3. Research Methodology

3.1 The Gravity Model

This study uses the gravity model to examine Nepal's trade position within the SAARC region. Originally introduced by Tinbergen (1962) and later improved by economists Pöyhönen (1963), the gravity model is based on the idea from Newton's law of gravity. It suggests that trade between two countries increases with their economic size and decreases with the distance between them. Mathematically, the model is expressed as:

$$Tij = A * (Yi * Yj) / Dij \quad \text{.....(1)}$$

In Model 1, Tij represents the trade flow between countries *i* and *j*. The term *A* is a constant that captures other factors affecting trade, such as transportation costs or cultural connections. Yi and Yj indicate the two countries' economic sizes (usually measured by GDP), while Dij is the geographical distance between them.

The model is inspired by Newtonian physics, where the force of attraction between two objects is proportional to the product of their masses and inversely related to the square of the distance between them. This "law" was transferred to the social sciences by an astronomer, Stewart, and a sociologist, Zipf, who attempted to apply this model to spatial interactions by employing the following specification:

$$I_{ij} = G(POP_i\ POP_j)/D^{\alpha}_{ij} \quad \text{.....(2)}$$

Where,

Iij is the number of trips between city i and city j, POPI is the population in city k, Dij is the distance between city i and city j, and G is a coefficient.

The formulation is generalised as:

$$Iij = G\ (w_{ij}POP_i^{\alpha 1}w_jPOP_j^{\alpha 2})/D_{ij}^{\alpha 3} \quad \text{..... (3)}$$

Where w_i and w_j are unspecified weights suited to specific applications of the Gravity model, such as international trade, in which case, however, the population is Replaced by GNP as the counterpart of physical "masses".

3.2 Data Description

The dataset for this study is compiled from various government and non-government sources, resulting in a panel dataset of seven SAARC trade partner countries, excluding Afghanistan due to the unavailability of bilateral trade data.

Table 1: Description of Variables

Variable Name	Unit of Measurement	Type	Expected Sign	Data Source
Dependent Variables				
Trade(ij)	United States Dollars (USD)	Time-variant	-	International Trade Centre (ITC) Trade Map
Export(ij)				
Traditional Factors				
GDP_i (Nepal)				
GDP_j (Partner)	Constant USD	Time-variant	Positive	World Bank (WDI)
Distance_ij	Kilometers	Time-invariant	Negative	www.timeanddate.com (distance between capital cities)
Other Economic Factors				
Weighted_Tariff_j	Percentage (%)	Time-variant	Negative	World Bank (WDI)
ExchangeRate_i	LCU per USD	Time-variant	Ambiguous	World Bank (WDI)
ExchangeRate_j				
EconFreedom_j	Index Score	Time-variant	Positive	Heritage Foundation
Dummy Variables				
COVID 19	1 = Yes, 0 = No	Time-invariant	Negative	Author's compilation
India blockade				
Common border	1 = Yes, 0 = No	Time-invariant	Positive	Author's compilation
BIMSTEC				

The panel spans 14 years, from 2009 to 2022, with no missing values, making it a balanced panel consisting of 83 observations. The dependent variables are total trade and exports, measured in USD. Key explanatory variables include the GDP of Nepal and partner countries (in constant USD), which is expected to positively influence trade, and the distance between capital cities, which is expected to have an adverse effect. Economic factors include partner country tariffs, exchange rates, and the Economic Freedom Index. Dummy variables capture specific conditions such as a common border, BIMSTEC membership, the India economic blockade in Nepal, and COVID-19. These variables help identify how economic, geographic, policy-related, and other external factors influence Nepal's international trade performance.

3.3 Data Analysis Procedure and Instrument

We estimated trade and export volume using the Poisson Pseudo-Maximum Likelihood (PPML) estimator. PPML estimator is well-suited for estimating gravity models such as equations 4 and 5, especially when trade data include many zero values and exhibit heteroskedasticity. Unlike traditional pooled Ordinary Least Squares (OLS), PPML does not require log-transforming the dependent variable, allowing zero trade flows to be included in the estimation. This is crucial in Nepal's trade, where small or zero trade values are common.

The Poisson Pseudo-Maximum Likelihood (PPML) estimator is widely employed in trade analysis, typically within the gravity model framework. Its robustness in handling zero trade flows and heteroskedasticity makes it a preferred method. Current literatures showcase PPML's use in quantifying the impact of digital trade, Global Value Chain participation (Ravi Kumar et al., 2024), and regional agreements like RCEP (Faizi et al., 2025) on export performance and trade patterns. It also helps analyse determinants of bilateral trade and explore trade's influence on related outcomes such as carbon emissions (Song et al., 2024),

providing crucial insights for policy.

Moreover, PPML addresses unobserved heterogeneity by providing consistent estimates even when the variance of trade flows changes with country characteristics. It allows for including fixed effects to control for country-pair or time-specific unobserved factors, capturing structural differences across trading partners. Thus, PPML produces unbiased and efficient results, making it the most appropriate estimator for this study's gravity model specification.

3.4 Econometric Model Specification

In this study, we have employed the econometric model with the total trade of Nepal as the major dependent variable, following the gravity model of international trade. The model can be specified as:

$$T_{ijt} = \beta_0 + \beta_1 lnY_{jt} + \beta_2 lnY_{it} + \beta_3 lnD_{ij} + \beta_4 Exchange\_rate_{it} + \beta_5 Exchange\_rate_{jt} + \beta_6 Weighted\_tariff_{jt} + \beta_7 Econ\ Freedom + \beta_8\ Tariff * Econ\_freedom + \beta_9 Common\_border + \beta_{10} BIMSTEC + \beta_{11} India\ blockade + \beta_{12} COVID + e_{ijt} \ldots\ldots (4)$$

Similarly, we have further employed a model with total export of Nepal as the dependent variable that is specified as:

$$X_{ijt} = \beta_0 + \beta_1 lnY_{jt} + \beta_2 lnY_{it} + \beta_3 lnD_{ij} + \beta_4 Exchange\_rate_{it} + \beta_5 Exchange\_rate_{jt} + \beta_6 Weighted\_tariff_{jt} + \beta_7 Econ\ Freedom + \beta_8\ Tariff * Econ\_freedom + \beta_9 Common\_border + \beta_{10} BIMSTEC + \beta_{11} India\ blockade + \beta_{12} COVID + e_{ijt} \ldots\ldots (5)$$

The specified panel regression model in equations 4 and 5 analyses the determinants of bilateral trade flows between Nepal and its SAARC member nations from 2009 to 2022, employing a gravity model framework to explain the trade volume (T*ijt*) and export trade volume (Between Nepal (country *i*) and partner *j* in year *t* as a function of economic, geographic, institutional, and other external factors. In both models, the independent variables include the log of GDP (lnY*it*, lnY*jt*) for Nepal and partner *j* to capture economic and market size effects, the log of geographic distance (lnD*ij*) as a proxy for trade costs. Nominal exchange rates (Exchange_rate*it*, Exchange_rate*jt*) to account for currency valuation impacts. Partner-specific weighted tariffs (Weighted_tariff*jt*) and economic freedom indices (Econ_free_index*jt*) to reflect trade policy and institutional quality. An interaction term (Tariff × Econ_Freedom) is included to assess how institutional quality may moderate the effects of tariff barriers.

The models incorporate several dummy variables for external shocks and regional dynamics. The COVID-19 dummy (1 for 2020–2022, 0 otherwise) captures the pandemic's impact on trade disruptions, while the India blockade dummy (1 during the 2015–16 blockade, 0 otherwise) reflects politically motivated trade constraints. A common border dummy (1 if Nepal shares a border with the partner country, 0 otherwise) is included to represent the trade-enhancing effect of geographic proximity. Additionally, the BIMSTEC dummy captures the influence of overlapping regional trade agreements on bilateral trade flows.

4. Results

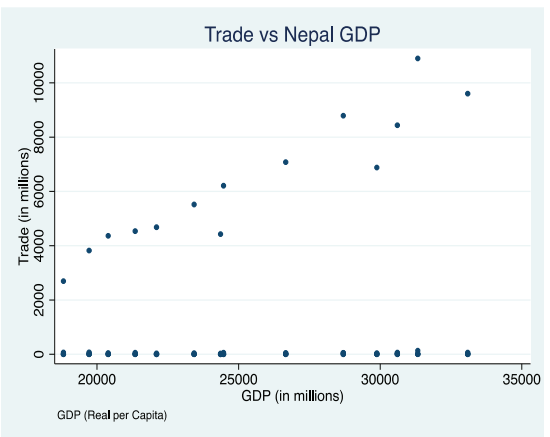
Table 2 provides an overview of the variables used to examine Nepal's trade performance across 84 country-year observations. On average, Nepal's trade with its partners amounts to NPR 1.06 billion, while average exports stand at NPR 108.5 million. Both variables display significant variation, indicating unequal trade flows across partners.

Table 2: Summary Statistics of variables used in the study

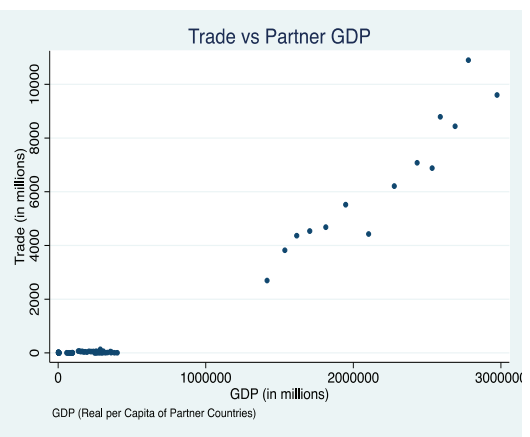
Variable	Obs	Mean	Std. Dev.	Min	Max
Total trade	84	1.061e+09	2.538e+09	0	1.090e+10
Exports	84	1.085e+08	2.521e+08	0	1.334e+09
Distance (in km)	84	1422.833	919.773	426	2898
GDP of the partner country	84	4.642e+11	8.027e+11	1.491e+09	2.974e+12
GDP of Nepal	84	2.535e+10	4.560e+09	1.881e+10	3.309e+10
Exchange rate of the partner country	84	100.048	46.514	45.726	322.633
Exchange rate of Nepal	84	99.874	16.54	73.262	125.199
Tariff weighted mean	84	8.279	3.991	.855	20.75
Economic freedom	84	55.021	3.193	47.3	62.9
Common border	84	.167	.375	0	1
BIMSTEC	84	.667	.474	0	1
India blockade	84	.143	.352	0	1
COVID 19	84	.214	.413	0	1

The average distance between Nepal and its trading partners is approximately 1,423 kilometres, with a minimum of 426 km and a maximum of nearly 2,900 km, highlighting Nepal's landlocked position and logistical challenges. The GDP of partner countries ranges widely, from USD 1.49 billion to USD 2.97 trillion, reflecting a diverse set of economies. In contrast, Nepal's GDP remains relatively stable, averaging USD 25.35 billion. Exchange rates also show variability for both Nepal and its partners, which can influence trade competitiveness. The average tariff rate is 8.28%, with some partners imposing tariffs up to 20.75%, while the mean economic freedom score is 55.02, indicating moderate institutional quality. Dummy variables indicate that only 17% of trade occurs with neighbouring countries, while 67% involves BIMSTEC members. The India blockade and the COVID-19 pandemic are reflected as specific shocks, with 14% and 21% of observations, respectively. These statistics underscore the diverse economic and geographic landscape of Nepal's trade and environmental distribution.

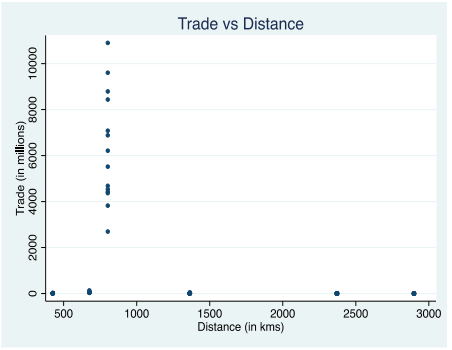
Figure 1: Scatter Plot for the relationship between Trade (in million) and other factors



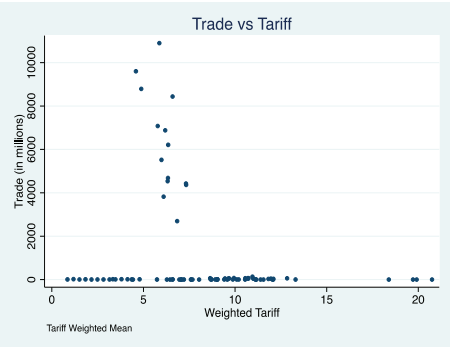
(A)



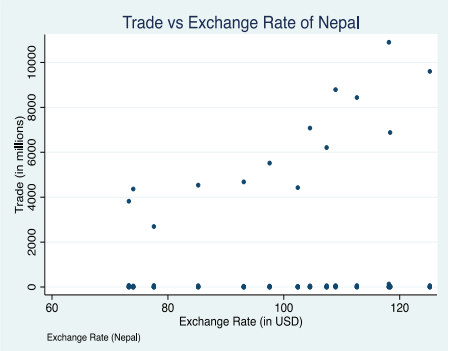
(B)



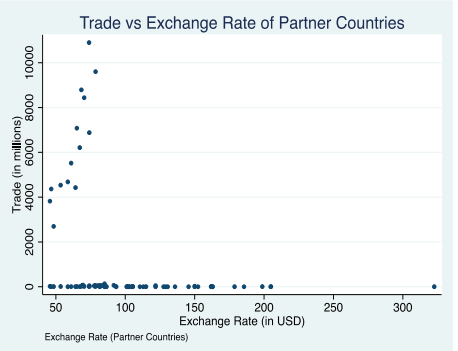
(C)



(D)



(E)

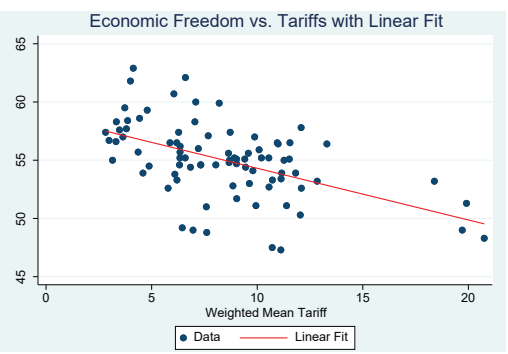


(F)

Source: Author's visualisation using STATA 17

Figure 1 presents scatter plots illustrating the relationship between Nepal's trade volume and key explanatory variables. Panels (A) and (B) show a positive association between trade and Nepal's GDP per capita and partner countries' GDP, respectively, suggesting that domestic and partner nations' economic growth is linked to increased trade. Panel (C) reveals a negative relationship between trade and distance, consistent with the gravity model, indicating that trade tends to decline as geographical distance increases. Similarly, panel (D) demonstrates that higher weighted tariffs are associated with lower trade volumes, highlighting the trade-restricting effect of tariff barriers. Panels (E) and (F) examine exchange rate dynamics, where Nepal's exchange rate shows a weak positive relationship with trade, while the exchange rate of partner countries exhibits a negative association, implying that depreciation of partner currencies may dampen trade flows. These visualisations collectively support the theoretical expectations of the gravity trade model.

Figure 2: Scatter Plot for the relationship between Economic Freedom and Tariffs with Linear Fit



Source: Author's visualisation using STATA 17

Figure 2 visualises the relationship between "Economic Freedom" and "Weighted Mean Tariff." Each blue dot represents a country's data, with its economic freedom score on the vertical axis and its average tariff rate on the horizontal axis. The red line is a linear fit, showing a clear downward trend. This downward slope indicates a negative correlation: as weighted mean tariffs increase, economic freedom tends to decrease. Essentially, countries with higher tariffs generally experience lower levels of economic freedom, suggesting that protectionist trade policies may be associated with reduced economic liberties.

Empirical Analysis of Nepal's Trade with SAARC Countries

This section presents the empirical results of the gravity model estimation using the Poisson Pseudo Maximum Likelihood (PPML) approach. Three different model specifications are employed to investigate the key determinants of Nepal's bilateral trade with SAARC countries. Model 1 includes the core gravity variables—economic size and geographic distance—representing the traditional or "pure" gravity model. Model 2 expands the specification by incorporating additional explanatory variables such as exchange rates, tariffs, economic freedom, common borders, and relevant dummies for regional factors and global shocks. Model 3 further introduces an interaction term between tariffs and economic freedom to capture how institutional quality influences the effectiveness of trade policies. The use of PPML is particularly suitable given the presence of heteroskedasticity and zero trade flows in the dataset, which are common in trade data. The regression results are reported in Table 4, and robust standard errors are used to ensure reliable inference.

Table 4: Regression Results for Nepal's Trade Determinants Using Gravity Model Specifications

VARIABLES	Model (1)	Model (2)	Model (3)
	Trade (pure gravity)	Trade (without interaction term)	Trade (with interaction term)
lndis	-3.822***	-2.835***	-2.420***
	(1.073)	(0.612)	(0.421)
lnGDP of the partner country	2.080***	0.902***	0.914***
	(0.181)	(0.122)	(0.112)
lnGDP of Nepal	-0.610**	2.364***	2.376***
	(0.237)	(0.104)	(0.0793)
Exchange_partner		0.00393	-0.000148
		(0.00509)	(0.00339)
Exchange_Nepal		-0.0234***	-0.0208***
		(0.00338)	(0.00221)
Weighted Tariff		-0.111***	1.407***
		(0.0159)	(0.404)
Econ_freedom		0.0625***	0.228***
		(0.0133)	(0.0474)
Tariff*freedom			-0.0278***
			(0.00749)
Common border		2.544***	2.451***
		(0.359)	(0.313)
BIMSTEC		0.408**	0.467**

		(0.192)	(0.187)
India blockade		0.0666***	0.0733***
		(0.0121)	(0.00985)
COVID 19		-0.0270**	-0.0253***
		(0.0126)	(0.00809)
Constant	3.617	-44.34***	-56.78***
	(6.930)	(5.097)	(4.016)
Observations	84	84	84
Wald test for interaction term (Tariff*Econ_freedom)			
chi2(1)			99.28
Prob > chi2			0.000

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

Source: Author's calculation using STATA17

Table 4 summarises three gravity model specifications explaining the determinants of Nepal's trade flows with 84 observations. This study estimates three gravity trade models between Nepal and its trading partners to deepen understanding of the relationship between trade policy and institutional quality. Model (1) adopts a basic gravity framework, incorporating fundamental variables such as geographic distance and economic size (GDP). Model (2) extends this by integrating macroeconomic indicators and geopolitical controls, including exchange rates, tariff levels, economic freedom, and regional affiliations. The Model (3) introduces an interaction term between tariffs and economic freedom (*tariff* × *econ_freedom*) to examine whether institutional quality moderates the effect of trade barriers on trade flows.

In Model (1)**,** the log of distance (lndis) has a strong and negative effect on trade (**–**3.822), confirming that greater geographic separation deters trade. The GDP of the partner country is highly positive (2.080) and significant, indicating that larger economies attract more trade. Interestingly, Nepal's GDP has a negative coefficient (-0.610), suggesting that as Nepal's production increases, it may substitute imports.

With the addition of macroeconomic and geopolitical controls in Model (2), the effect of distance decreases to –2.825 but remains highly significant. The partner GDP coefficient drops to 0.935, and Nepal's GDP reverses to a strong positive (1.916)**,** indicating that a growing Nepalese economy fosters trade once broader factors are controlled. Tariffs appear to have a negative effect (–0.108), while economic freedom is positively associated with trade (0.0702). The exchange rate of Nepal (–0.0189) has a significant negative effect, indicating that depreciation reduces trade, whereas the exchange rate of partners is insignificant. Common borders (2.465) and BIMSTEC membership (0.464) significantly boost trade. The India blockade is insignificant here, while the COVID-affected period (–0.0627) is significantly negative.

Similarly, in model (3), the distance effect decreases to –2.334, and the coefficients for partner GDP (0.961) and Nepal's GDP (1.792) remain positive and significant. Notably, the direct effect of tariffs turns positive (1.524), which may seem counterintuitive, but the negative and significant interaction term (–0.0299) clarifies that in countries with higher economic freedom, the negative impact of tariffs is mitigated. Economic freedom now has a stronger independent effect (0.252), suggesting that liberal institutions significantly promote trade. Nepal's exchange rate (–0.0147) continues to harm trade significantly. Common borders (2.321) and BIMSTEC (0.561) retain strong, positive significance. Importantly, the India blockade (–0.0170) becomes significant in this model, implying a delayed or compounded negative impact once institutional interaction is considered.

This interaction is theoretically grounded in the notion that stronger institutional environments can mitigate

the restrictive effects of protectionist policies. The significance of the interaction term is statistically confirmed by a Wald test, which yields a chi-squared value of 99.28 and a p-value of 0.0000, leading to a strong rejection of the null hypothesis. Moreover, model fit comparisons using the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) reveal that the model including the interaction term outperforms the one without it, with lower AIC and BIC values (7.99×10^8 vs. 8.78×10^8). These diagnostics underscore the importance of accounting for institutional context when evaluating the trade effects of tariffs, affirming that trade policy effectiveness is conditioned by the quality of economic governance.

Table 5: Akaike's information criterion and Bayesian information criterion

Model	N	ll(null)	ll(model)	df	AIC	BIC
Trade with no interaction term	84	-1.59e+11	-4.39e+08	11	8.78e+08	8.78e+08
Trade with interaction term	84	-1.59e+11	-3.99e+08	12	7.99e+08	7.99e+08

Source: Author's calculation using STATA17

Empirical Analysis of Nepal's exports to SAARC Countries

Understanding the drivers of Nepal's export performance is essential for informing trade policy and enhancing the country's integration into global markets. This section presents empirical evidence on the determinants of Nepal's exports, drawing on gravity model specifications that progressively incorporate economic, policy, and institutional variables. Unlike the earlier analysis of overall trade, the focus is on isolating export-specific dynamics and identifying factors that uniquely facilitate or hinder outbound trade from Nepal.

The analysis pays particular attention to how institutional quality interacts with tariff structures, aiming to uncover whether stronger economic governance can mitigate the restrictive effects of trade barriers. Additionally, including geopolitical events such as the India blockade and the COVID-19 pandemic provides a contextual lens to evaluate the resilience and adaptability of Nepal's export sector under external shocks. By highlighting the sensitivity of export flows to structural and policy-level variables, Table 6 presents a nuanced understanding of Nepal's export competitiveness in a rapidly evolving regional and global landscape.

Table 6: Regression Results for Nepal's Exports Determinants Using Gravity Model Specifications

VARIABLES	Model (1)	Model (2)	Model (3)
	Export (pure gravity)	Export (Without interaction term)	Export (With interaction term)
lndis	-5.081***	-4.324**	-3.197***
	(1.426)	(2.116)	(0.878)
lnGDP of the partner country	1.617***	0.745***	0.836***
	(0.169)	(0.139)	(0.0837)
lnGDP of Nepal	-1.270***	0.675	1.017***
	(0.460)	(0.558)	(0.0807)
Exchange_partner		0.0183	0.00945
		(0.0179)	(0.0120)
Exchange_Nepal		-0.0344***	-0.0336***
		(0.00954)	(0.00983)

Weighted Tariff		0.00419	3.639***
		(0.0210)	(0.311)
Econ_freedom		0.0137	0.481***
		(0.0736)	(0.0512)
Tariff*freedom			-0.0676***
			(0.00579)
Common border		2.741***	2.336***
		(0.663)	(0.356)
BIMSTEC		1.108***	1.226***
		(0.378)	(0.0558)
India blockade		-0.188***	-0.161***
		(0.0235)	(0.0332)
COVID 19		0.669***	0.594***
		(0.0801)	(0.0344)
Constant	38.70***	9.385	-33.33***
	(12.22)	(26.34)	(5.005)
Observations	84	84	84

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

Source: Author's calculation using STATA17

Table 6 presents the estimation results from three gravity models of Nepal's exports to its trading partners. Model 1 represents a basic gravity framework that includes only the traditional gravity variables: distance and GDP. Model 2 expands the specification to include macroeconomic and institutional covariates, while Model 3 further introduces an interaction term between tariffs and economic freedom (*Tariff* × *Econ_freedom*) to test for the moderating role of institutional quality in shaping trade outcomes.

Across all three models, the coefficient for the log of distance (lndis) remains negative and statistically significant. Specifically, the magnitude decreases from -5.081 in Model 1 to -4.324 in Model 2 and -3.197 in Model 3, suggesting that distance acts as a strong barrier to exports, but its impact slightly diminishes once other macro-institutional factors are introduced. The coefficient on the GDP of Nepal's trading partners is positive and highly significant across all models, with values of 1.617 (Model 1), 0.745 (Model 2), and 0.836 (Model 3). This supports the gravity model's prediction that countries with larger economies tend to import more from Nepal. Nepal's own GDP displays a negative and significant effect in Model 1 (-1.270), becomes statistically insignificant in Model 2 (0.675), and turns positive and significant in Model 3 (1.017), suggesting that the inclusion of institutional and policy variables changes the nature of the domestic economy's role in promoting exports.

Among the additional covariates, Nepal's exchange rate (Exchange_Nepal) consistently exhibits a significant negative effect, with coefficients of -0.0344 (Model 2) and -0.0336 (Model 3), indicating that currency depreciation may reduce export performance, potentially due to input cost inflation or macroeconomic uncertainty. The partner country's exchange rate is not statistically significant in either model. The effect of tariffs is statistically insignificant in Model 2 (0.00419) but becomes strongly positive and significant in Model 3 (3.639), while economic freedom (Econ_freedom) also becomes significant only in Model 3 (0.481). This shift suggests that their influence becomes meaningful only when combined.

The interaction term between tariffs and economic freedom (Tariff × Econ_freedom) in Model 3 is -0.0676 and statistically significant at the 1% level, confirming a negative moderating effect. This

implies that higher levels of economic freedom reduce the adverse impact of tariffs on export flows. In institutional environments with greater economic freedom, tariff barriers are less obstructive, highlighting the importance of institutional quality in mitigating policy-related trade distortions. Geopolitical and institutional dummies align with theoretical expectations. A common border has a strong positive effect, as does BIMSTEC membership. The India blockade has a significant negative impact, with coefficients of -0.188 and -0.161 in Models 2 and 3. Interestingly, the coefficient for COVID-19 is significantly positive, potentially reflecting trade shifts toward essential goods or regional adaptation during the pandemic period.

Overall, Model 3 presents the most comprehensive understanding of Nepal's export dynamics by capturing the interaction between tariffs and institutional quality, with lower AIC and BIC values supporting its statistical superiority. These results underscore the importance of strengthening economic institutions to sustain trade performance, particularly in policy-induced trade frictions.

Table 7: Akaike's information criterion and Bayesian information criterion

Model	N	ll(null)	ll(model)	df	AIC	BIC
Export with no interaction variable	84	-1.52e+10	-3.05e+08	11	6.09e+08	6.09e+08
Export with interaction variable	84	-1.52e+10	-2.14e+08	12	4.29e+08	4.29e+08

Source: Author's calculation using STATA17

5. Discussion

The theoretical foundation of the gravity model of trade, rooted in Newtonian physics by analogy, posits that bilateral trade flows between two countries are directly proportional to their economic sizes (GDP) and inversely proportional to the distance between them, with institutional quality, trade policies, and cultural ties acting as key moderators (De Benedictis & Taglioni, 2011; Kabir et al., 2017). This study's empirical findings align with these theoretical propositions while revealing nuanced interactions specific to Nepal's trade dynamics within the SAARC region (Martinez-Zarzoso, 2003; Yotov, 2022). The robust negative coefficient for geographic distance confirms the gravity model's core prediction about trade-impeding effects of distance, particularly acute for Nepal due to its landlocked geography. However, the observed reduction of this effect in models incorporating institutional variables supports the theory's emphasis on moderating factors—demonstrating how improvements in trade-related infrastructure and governance can partially overcome geographical disadvantages, consistent with recent literature on institutional mitigation of the "tyranny of distance" (Abebe et al., 2016; Harcourt, 2012; Lemke, 1995; Robertson and Robitaille, 2017).

The economic size variables further validate the gravity model's theoretical expectations (Capoani, 2021). Partner country GDP exhibits the predicted positive relationship, while Nepal's GDP coefficient evolves from negative to positive across specifications. This aligns with the theory's proportionality principle while revealing a developmental nuance: initial import dependence at low income levels (yielding a negative coefficient) gradually gives way to export-capable production as Nepal's economy grows—a path mirroring the model's theoretical flexibility to accommodate structural transformation (Markusen, 2002). The exchange rate results present a theoretical paradox. Contrary to conventional expectations that depreciation boosts exports (Blecker, 2023), Nepal's experience reflects the gravity model's broader theoretical scope, accommodating contextual factors like import-dependent export production and institutional informality. These findings reinforce the theory's capacity to explain deviations when moderated by developing-economy realities (Bahmani-Oskooee and Hegerty, 2007; Mesagan et al., 2022).

Most critically, the institutional interactions empirically validate the gravity model's theoretical premise that non-geographic moderators fundamentally reshape trade outcomes (Capoani, 2021; Shahriar et al., 2019). The significant dampening effect of economic freedom on tariff impacts directly aligns with the theory's allowance for institutional quality to alter policy effectiveness—demonstrating how

governance quality (e.g., efficient customs administration, contract enforcement) can redefine the gravity equation's parameters in practice (Caliendo et al., 2015; Findlay and Wellisz, 1982; Head and Ries, 1999). Additional findings on dummy variables further illustrate the theory's contextual adaptability and capacity to account for real-world contingencies beyond static economic fundamentals. The strong positive and statistically significant effect of common border and BIMSTEC membership reflects the importance of regional integration and geographic proximity in facilitating trade. A shared border reduces both physical transportation costs and bureaucratic friction—such as customs clearance and logistics coordination—thus reinforcing the gravity model's assumption that lower transaction costs enhance bilateral trade flows. Similarly, BIMSTEC membership appears to serve as a proxy for institutional cooperation and preferential trade arrangements, enabling smoother intergovernmental coordination, harmonized trade regulations, and lower tariff and non-tariff barriers (Chacha, 2014). These findings support the model's theoretical flexibility to incorporate political and institutional arrangements as mechanisms that amplify trade beyond what standard economic variables can explain (Hettne and Söderbaum, 2006).

In contrast, the India blockade had a statistically significant and negative impact on trade, highlighting how political frictions and unilateral border disruptions can abruptly constrict trade flows (Karki, 2022). This is especially salient for landlocked countries like Nepal, whose trade routes depend highly on neighbouring countries' infrastructure and policies (Bhatnagar and Shahab Ahmed, 2021). The blockade's impact underscores the gravity model's responsiveness to exogenous geopolitical events, suggesting that bilateral trade flows, even when driven by strong economic fundamentals, remain vulnerable to strategic or diplomatic shocks (Adhikari and Ma, 2022). Such disruptions operate outside the traditional variables of the model, yet their inclusion through dummy variables demonstrates the gravity model's structural openness to temporal and political disturbances, thereby improving its explanatory power in real-world settings (Subramanian and Wei, 2005).

Likewise, the COVID-19 pandemic introduced significant global supply chain disruptions, reduced production and consumption, and increased uncertainty, negatively affecting Nepal's trade (Saif et al., 2021). The observed reduction in trade flows during the COVID-19 period confirms the model's sensitivity to global macroeconomic shocks (Liu et al., 2022). The gravity model adapts to temporary but impactful shocks by incorporating time-specific dummy variables, capturing short-term deviations from expected patterns. These results validate the model's utility as a predictor of long-term trade trends and a diagnostic tool for identifying the effects of abrupt, crisis-induced deviations from normalcy (Vidya & Prabheesh, 2021).

6. Conclusion

This study analysed the determinants of Nepal's trade with SAARC partners using an augmented gravity model estimated through the Poisson Pseudo-Maximum Likelihood (PPML) method. The analysis confirmed that economic size and geographic distance are key trade drivers, consistent with gravity theory. Nepal's landlocked geography significantly hinders trade, but including institutional variables such as economic freedom and governance quality showed that improved institutional frameworks can mitigate distance-related barriers and foster trade. A structural shift in Nepal's trade dynamics was observed as the initially negative association between Nepal's GDP and trade became positive with economic growth, indicating a transition toward export-oriented production. The negative impact of currency depreciation reflects Nepal's vulnerability due to import-dependent exports and macroeconomic imbalances, underscoring the need for coordinated industrial and trade policies. Importantly, the study found that stronger institutions reduce the negative effects of tariffs, highlighting the importance of governance in enhancing trade outcomes. Dummy variables—such as BIMSTEC membership, shared borders, the India blockade, and COVID-19—demonstrated the gravity model's adaptability to geopolitical and temporal shocks. Nepal should invest in trade infrastructure, streamline regulatory processes, and diversify exports to deepen regional integration. Future research could focus on digital trade and sector-specific dynamics to inform more targeted policies.

A comprehensive and multidimensional policy approach is essential to enhance Nepal's trade performance. Improving cross-border infrastructure—such as transport networks, customs efficiency, and digital trade facilitation—can significantly reduce the costs associated with geographic distance. Strengthening institutional quality, including regulatory transparency and export promotion mechanisms, is equally critical, as it enhances the effectiveness of trade policies and mitigates the adverse effects of tariffs. Export diversification beyond primary goods would reduce vulnerability to external shocks, particularly exchange rate fluctuations, while bolstering competitiveness. Nepal should also deepen regional integration by prioritising bilateral agreements within SAARC—especially with India—and advocating for reforms in frameworks like SAFTA to address non-tariff barriers. Investments in domestic industrial capacity through technology, skills, and governance will further enable firms to thrive in open markets. The positive trade response during COVID-19 underscores the importance of flexible, crisis-responsive policies. Nepal's trade strategy must align with institutional reform, infrastructure development, and regional cooperation to unlock its full potential.

Future studies should delve into sector-specific trade dynamics, particularly in agriculture and manufacturing, to design more targeted and effective policy interventions. Further, examining the long-term effects of regional cooperation initiatives and institutional reforms would offer valuable insights into strategies for sustaining and enhancing Nepal's trade performance over time.

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