General Equilibrium Impact and Comparison of BRICS without India and BRICS without China - A Structural Gravity Model Analysis

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Abstract

This research investigates the general equilibrium impacts of a hypothetical scenario where BRICS exists without India or China. Employing a structural gravity analysis, we explore trade relationships, volume shifts, and the ripple effects in global markets. The absence of either India or China from BRICS poses intriguing implications on trade dynamics within and outside the bloc, influencing global economic order. Leveraging the foundational work of Anderson and van Wincoop (2003) on gravity models, our study aims to discern the intricate interdependencies and power shifts within economic blocs. By conducting comparative analyses and counterfactual scenarios, we delve into potential repercussions, shedding light on the nuances of global trade dynamics and geopolitical shifts. The research draws from a rich array of data sources, including renowned databases such as the World Integrated Trade Solution, WTO, and IMF's World Economic Outlook Database. Methodologically, the study applies the Poisson Pseudo Maximum Likelihood (PPML) approach and integrates the General Equilibrium Pseudo Poisson Maximum Likelihood Estimator (GEPPML) to discern comprehensive general equilibrium effects. The expected results anticipate alterations in trade volumes, patterns, power dynamics, and economic welfare both within BRICS and among non-member states. Additionally, the analysis extends beyond economic realms, exploring geopolitical implications and potential shifts in alliances and diplomatic relations. This study seeks to contribute methodologically robust insights into the repercussions of the absence of India or China from the BRICS consortium, offering a deeper understanding of global trade dynamics and their broader implications.

Keywords- *Structural Gravity Analysis, BRICS, Counterfactual Scenarios, Multilateral Resistance , PPML Estimation, General Equilibrium, Counterfactual Analysis, Trade Dynamics*

1. Introduction

International trade allows nations to specialise in the production of goods and services in which they have a comparative advantage, leading to increased efficiency and productivity. This phenomenon, explained by David Ricardo in the 19th century through the theory of comparative advantage, results in mutual benefits for countries participating in trade. These benefits manifest as access to a wider variety of goods and services, economies of scale, technological diffusion, and an overall increase in global welfare. However, while the broad principles of trade are universally acknowledged, the intricacies of trade dynamics—especially when they involve major economic blocs—have profound implications for the global economic order.

Enter BRICS—an acronym for an association of five major emerging economies: Brazil, Russia, India, China, and South Africa. Established in the first decade of the 21st century, BRICS represents a powerful consortium, accounting for a significant portion of the world's population, land area, and GDP. These nations, while diverse in culture and economic structure, collectively challenge the traditional dominance of Western economies and financial institutions. By collaborating on various fronts, from economic policy coordination to development projects, BRICS nations aimed to reshape the contours of the global economy.

Yet, what if one of these giants were absent? India, with its vast population, burgeoning tech sector, and pivotal geographical location, is an indispensable pillar of BRICS. This research paper seeks to explore a hypothetical scenario: the impact on general equilibrium if BRICS existed without India. Employing a structural gravity analysis, we will delve into the trade relationships, volume shifts, and consequential ripple effects in global markets. Moreover, the absence of China, the economic powerhouse of BRICS, presents its own set of intriguing implications. China's remarkable economic growth, international investments, and technological advancements have elevated it to a position of global leadership. Within BRICS, China's role as an anchor for trade and investment is pivotal. Therefore, our research also endeavours to assess the hypothetical scenario of BRICS without China. By conducting a parallel analysis to our examination of BRICS without India, we aim to provide a comprehensive comparative view of the potential repercussions of the absence of these two economic giants from the consortium. This dual perspective allows for a deeper understanding of the nuances of global trade dynamics, power shifts within economic blocs, and the broader implications for the global economic order.

Understanding the role of each BRICS nation, particularly India and China, in the global trading system is imperative. The outcomes of this analysis not only shed light on the interconnectedness of these nations but also provide insights for policymakers, traders, and international relations scholars about the potential trajectory of the global economy in alternative scenarios.

2. Objective

The central objective of the current research endeavour is to employ the structural gravity model to investigate the general equilibrium impacts of the BRICS agreement on bilateral trade relationships among its member nations, coupled with a counterfactual analysis. Our more expansive aspiration is to enrich and further the existing academic discourse on the effects of trade liberalisation initiatives on welfare, with a specific lens on the BRICS dynamic. Specifically, the paper aims to:

1. Efficacy of the BRICS Agreement:
   - Gauge how effectively the agreement has promoted bilateral trade.
   - Assess its role in stimulating economic growth within the BRICS nations.

2. Counterfactual Analysis:
   - Project potential trade scenarios without India's participation in BRICS.
   - Project potential trade scenarios without China's participation in BRICS.
   - Determine and compare their anticipated influence on trade dynamics within the bloc.

3. Broadening the Perspective:
   - Incorporate an analysis of 10 significant non-BRICS nations with strong trade ties to India and China.
   - Purpose is to ascertain the overarching equilibrium effects on these nations when considering a BRICS framework excluding India and China.

3. Significance

Redefining Global Trade Dynamics: India and China are not only BRICS' largest economies but also are key global players. Assessing the general equilibrium impact of their hypothetical absence from BRICS can provide valuable insights into potential shifts in global trade dynamics, including alterations in trade volumes, flows, and regional imbalances.

Power Dynamics within BRICS: Understanding the potential scenarios without India or China can shed light on the power dynamics within BRICS. It offers a nuanced perspective on the influence of each member country and the resultant recalibrations that might ensue in their absence.

Policy Implications: Policymakers can glean potential strategies or areas of focus by understanding the role and influence of India and China within BRICS. Such insights can guide policy formulations, both within the BRICS nations and globally, especially concerning trade agreements, tariffs, and economic collaborations.

Strategic Implications for Non-BRICS Nations: For countries outside the BRICS consortium, especially major trading partners, understanding the potential trade and economic dynamics without India or China can inform their international trade strategies and alliances.

Economic Forecasting: By discerning the potential impacts on trade flows and economic interactions without India or China, economists and market analysts can make more informed forecasts regarding global economic trajectories and investment climates.

Academic Contributions: This topic offers a unique blend of theoretical and empirical analysis, contributing to academic discourse on international trade, economic bloc dynamics, and the applicability of structural gravity models in trade studies.

Welfare and Development Implications: Assessing the welfare effects on BRICS nations and their trading partners in the hypothetical scenarios can give insights into potential developmental challenges or opportunities that might emerge.

Regional Stability and Geopolitical Implications: Beyond the economic implications, understanding the equilibrium changes without India or China can also hint at potential geopolitical shifts, regional alliances, and changes in diplomatic relations.

4. Literature Review

The overarching theme of BRICS and its individual country dynamics has been a focal point for many economists, scholars, and policymakers. However, the novel perspective of analyzing the collective absence of either India or China has ushered a new dimension in this research arena. This literature review seeks to shed light on the existing body of knowledge around this niche topic.

BRICS as an Emerging Power Bloc: Since its inception, BRICS has been recognized as a coalition of emerging economies aiming to reshape global economic and political dynamics. Studies such as Looney (2013) and Armijo and Roberts (2014) have highlighted the collective economic power and influence of BRICS in global governance.

India in BRICS: India's role in BRICS has been notably significant due to its vast population and rapid economic progression. Ghosh (2016) emphasized India's importance in BRICS, especially in the areas of technology and services. While the potential repercussions of its absence from BRICS have been relatively under-researched, scholars like Majumdar (2017) have touched upon the hypothetical economic and geopolitical implications of such a Scenario.

China's Dominance in BRICS: China's unparalleled economic growth and its role as a global manufacturing hub have made it an influential player in BRICS. Zhang (2015) and Stuenkel (2015)

discussed China's leadership within the consortium and its broader implications for the BRICS nations. While speculations about the BRICS dynamics without China have been limited, papers such as Liu and Dunford (2016) have offered insights into how the absence of China might shift the power dynamics within the group.

Structural Gravity Analysis: The application of the gravity model in international trade studies has been widespread, with Anderson and van Wincoop (2003) providing foundational insights. In the context of BRICS, studies like Baier et al. (2014) have employed structural gravity models to understand trade flows and economic interdependencies. The integration of this approach to assess potential scenarios without India or China remains a novel frontier.

Comparative Studies: While many research papers have examined India and China's roles in BRICS individually, comparative analyses focusing on the simultaneous assessment of both nations' hypothetical absences are sparse. This presents a significant research gap, emphasizing the novelty and importance of the present study.

Conclusion: While a considerable amount of literature exists on the significance of BRICS and its member nations, specifically India and China, there remains a discernible gap in understanding the hypothetical absence of either country. This research, with its structural gravity analysis, seeks to contribute significantly to this realm, offering insights into the comparative general equilibrium impacts of BRICS without its two major pillars.

5. Methodology

The foundation of our study rests on the adoption and application of the structural gravity model, inspired and significantly influenced by the foundational work of Anderson and van Wincoop (2003). This choice provides us with a comprehensive and theoretically-grounded framework, essential for effectively analyzing the intricacies of bilateral trade flows.

5.1 Base Model: Anderson and van Wincoop (2003)

Our primary analytical foundation is the structural gravity model, a theoretical framework conceived and refined by Anderson and van Wincoop in 2003, which enhanced the empirical gravity model by introducing a sound theoretical foundation. Their pioneering work overcame many of the challenges faced by traditional gravity models and delivered a methodology that incorporates both direct bilateral trade resistances and indirect multilateral trade resistances.
The underlying premise is simple: trade between two countries is directly proportional to their economic sizes (often represented by their GDPs) and inversely proportional to the trade resistance between them. However, Anderson and van Wincoop's brilliance lies in the way they accounted for multilateral resistance, capturing a country's trade resistance with all its trading partners. The multilateral resistance

terms Pj and Πi are modeled as inward and outward resistance, incorporating variables like a country's remoteness, which is essentially the weighted average of its bilateral trade resistances with all its trading partners. These resistance terms offer a nuanced perspective, ensuring the model isn't overly simplistic and resonates with real-world dynamics.
The formulation is expressed as:

$$X_{ij} = \frac{Y_i E_j}{Y}\left(\frac{t_{ij}}{\Pi_i P_j}\right)^{1-\sigma} \qquad \Pi_i^{1-\sigma} = \sum_j \left(\frac{t_{ij}}{P_j}\right)^{1-\sigma} \frac{E_j}{Y} \qquad P_j^{1-\sigma} = \sum_i \left(\frac{t_{ij}}{\Pi_i}\right)^{1-\sigma} \frac{Y_i}{Y}$$

$$p_i = \left(\frac{Y_i}{Y}\right)^{\frac{1}{1-\sigma}} \frac{1}{\alpha_i \Pi_i}$$

$$E_i = \varphi_i Y_i = \varphi_i p_i Q_i$$

Where
Xij *- nominal trade flows from exporter i to destination j country*
Ej*- total expenditure in importer j*
Yi *- value of total production in exporter i*
Y *- value of world output*
tij *- denotes bilateral trade frictions between partners i and j*
σ >1*- elasticity of substitution among goods from different countries*
αi *- CES preference parameter*
$\boldsymbol{P_j}$ *- Structural term that denotes inward multilateral resistance terms*
Πi *- Structural term that denotes outward multilateral resistance terms*
pi *- factory-gate price for each variety of goods in the country of origin i*
Qi *-endowment or quantity supplied of each variety of goods in country i*
φi *-exogenous parameter, defining the relation between the value of output and aggregate expenditure,*
If ***φi*** *> 1, country i faces a trade deficit,*
*0<****φi****<1 country i runs a trade surplus*

Both structural terms defined by Anderson and van Wincoop (2003)

5.2 Method of Estimation: PPML

The choice of Poisson Pseudo-Maximum Likelihood (PPML) as our estimation technique is deliberate and strategic. In international trade data, it's common to find zero trade flows between certain country pairs. Ordinary Least Squares (OLS) regressions struggle with such zeroes. PPML, however, models the trade flows in a manner that seamlessly handles these zeroes. Moreover, PPML ensures consistent estimates even when faced with heteroscedasticity, a frequently encountered issue in trade data.

Equation Formulation:
For clarity, our study employs the following equation to represent the Structural Gravity Model with Fixed Effects:

$$X_{ij} = exp[\pi_{ij} + \chi_{ij} + \mu_{ij} + \beta_1 lnDIST_{ij} + \beta_2 Comlang_{ij} + \beta_3 Contiguity_{ij} + \beta_4 RTA_{ij} + \beta_5 Tariff_{ij} + \beta_6 BRDR_{ij}] * \varepsilon_{ij}$$

X_{ij} - exports from country i to country j
$DIST_{ij}$ - denotes the bilateral distance between countries i and j
$Tariff_{ij}$ - tariff rates between two countries
$Comlang_{ij}$ - dummy variable for the existence of a common official language between partners i and j
$Contiguity_{ij}$ - dummy variable takes 1 for contiguous borders between countries i and j, and 0 otherwise
$BRDR_{ij}$ - dummy variable takes 1 for international trade between countries i and j, and 0 otherwise
RTA_{ij} - dummy variable takes up value 1 when the countries have signed an RTA and is used for counterfactual purpose
π_{ij} - Exporter fixed effects
χ_{ij} - Importer fixed effects
μ_{ij} - Pair Fixed effects
ε_{ij} - Error term

Enhanced Estimation with GEPPML:

Our methodology incorporates the General Equilibrium Pseudo Poisson Maximum Likelihood Estimator (GEPPML) presented by Anderson, Larch, and Yotov (2017). This model not only builds upon the Constant Elasticity of Substitution (CES) function and the foundational structural gravity model but also leverages the PPML estimator, known for its efficacy with heteroscedastic trade data and its handling of zero values.

Gravity Model Estimation for Cross-Section Samples:

Building on the foundational gravity equation, this section delves deeper into a specific variant of the model suited for cross-section samples, with the estimation carried out using the Poisson Pseudo-Maximum Likelihood (PPML) approach.

$$lnX_{ij} = lnE_{ij} + lnY_i - lnY + (1-\sigma)t_{ij} - (1-\sigma)lnP_j - (1-\sigma)ln\pi_{ij} + \varepsilon_{ij}$$

X_{ij} - logarithm of trade flows from exporter i to destination j
Y_{ij} - logarithm of value of total production in exporter i
Y - logarithm of value of world output
t_{ij} - denotes bilateral trade frictions between partners i and j

σ >1 - elasticity of substitution among goods from different countries
P_{ij} - Structural term that denotes inward multilateral resistance terms
Π_{ij} - Structural term that denotes outward multilateral resistance terms
ε_{ij} - Error term

The steps of the GEPPML procedure discussed below follow closely the stages of the standard approach to general equilibrium analysis with the structural gravity model

Step I: Solve the baseline gravity model

Step I.a: Obtain estimates of RTA effects, pair fixed effects, and to create the bilateral trade costs matrix needed for calculating the baseline indexes of interest

$$X_{ij,t} = \exp\left[\pi_{i,t} + \chi_{j,t} + \mu_{ij} + \beta_1 RTA_{ij,t} + \beta_2 ES_{i,t} \times INTL_{ij} + \beta_3 MFN_{j,t} \times INTL_{ij}\right] \times \varepsilon_{ij,t}$$
$$= \exp\left[\pi_{i,t} + \chi_{j,t} + \mu_{ij} + \mathbf{T}_{ij,t}\boldsymbol{\beta}\right] \times \varepsilon_{ij,t}$$

β - Trade cost elasticities

Step I.b: Regress the estimates of pair fixed effects on gravity variables and country fixed effects.

$$\hat{t}_{ij}^{1-\sigma} = \exp\left[\hat{\pi}_i + \hat{\chi}_j + \hat{\beta}_1 \ln DIST_{ij} + \hat{\beta}_2 CNTG_{ij} + \hat{\beta}_3 LANG_{ij} + \hat{\beta}_4 CLNY_{ij}\right]$$

$$\exp\left[\hat{\mu}_{ij}\right] = \exp\left[\pi_i + \chi_j + \beta_1 \ln DIST_{ij} + \beta_2 CNTG_{ij} + \beta_3 LANG_{ij} + \beta_4 CLNY_{ij}\right] \times \varepsilon_{ij}$$

The (fitted) predicted bilateral trade costs from this second stage regression are computed
Then used to fill up the missing trade costs values in order to construct the complete set of bilateral trade costs that can then be used in counterfactual analysis.

Step II: Define a counterfactual scenario
The second step of the GEPPML procedure requires defining the hypothetical removal of India and removal of China from BRICS. This is done by re-defining the RTA dummy variable as by setting the original RTA indicator variable to be equal to zero for India and China and other non member countries when India and China leave the BRICS trade bloc.

Step III: Solve the counterfactual model
Baseline Multilateral resistances:

$$\left[\hat{\Pi}_{i,t}^{1-\sigma}\right]^{BLN} = \frac{Y_{i,t}}{\exp\left(\hat{\pi}_{i,t}\right)} \times E_{R,t}$$

$$\left[\hat{P}_{j,t}^{1-\sigma}\right]^{BLN} = \frac{E_{j,t}}{\exp\left(\hat{\chi}_{j,t}\right)} \times \frac{1}{E_{R,t}}$$

$\left[\hat{\Pi}_{i,t}^{1-\sigma}\right]^{BLN}$, and $\left[\hat{P}_{j,t}^{1-\sigma}\right]^{BLN}$

Step III.a: Obtain conditional general equilibrium effects.
(i) Estimate the "conditional" gravity model

$$X_{ij,t} = \exp\left[\pi_{i,t}^{CFL} + \chi_{j,t}^{CFL} + \bar{\mu}_{ij} + \mathbf{T}_{ij,t}^{CFL}\bar{\boldsymbol{\beta}}\right] \times \varepsilon_{ij,t}^{CFL}$$

(ii) Construct "conditional general equilibrium" indexes

$$\left[\hat{\Pi}_{i,t}^{1-\sigma}\right]_{CDL}^{CFL} = \frac{Y_{i,t}}{\exp\left(\hat{\pi}_{i,t}^{CFL}\right)} \times E_{R,t}$$

$$\left[\hat{P}_{j,t}^{1-\sigma}\right]_{CDL}^{CFL} = \frac{E_{j,t}}{\exp\left(\hat{\chi}_{j,t}^{CFL}\right)} \times \frac{1}{E_{R,t}}$$

Step III.b: Obtain "full endowment general equilibrium" effects.
(i) Allow for endogenous factory-gate prices

$$\Delta p_{i,t}^{CFL} = \frac{p_{i,t}^{CFL}}{p_{i,t}} = \left(\frac{\exp\left(\hat{\pi}_{i,t}^{CFL}\right) / E_{R,t}^{CFL}}{\exp\left(\hat{\pi}_{i,t}\right) / E_{R,t}}\right)^{\frac{1}{1-\sigma}}$$

(ii) Allow for endogenous income, expenditures and trade

$$X_{ij,t}^{CFL} = \frac{\left[\hat{t}_{ij,t}^{1-\sigma}\right]^{CFL}}{\hat{t}_{ij,t}^{1-\sigma}} \times \frac{Y_{i,t}^{CFL} E_{j,t}^{CFL}}{Y_{i,t} E_{j,t}} \times \frac{\Pi_{i,t}^{1-\sigma}}{\left[\Pi_{i,t}^{1-\sigma}\right]^{CFL}} \times \frac{P_{j,t}^{1-\sigma}}{\left[P_{j,t}^{1-\sigma}\right]^{CFL}} \times X_{ij,t}$$

(iii) Estimate the structural gravity model
(iv) Construct "full endowment general equilibrium" indexes

$$\left[\hat{\Pi}_{i,t}^{1-\sigma}\right]_{FULL}^{CFL} = \frac{Y_{i,t}^{FULL}}{\exp\left(\hat{\pi}_{i,t}^{FULL}\right)} \times E_{R,t}^{FULL}$$

$$\left[\hat{P}_{j,t}^{1-\sigma}\right]_{FULL}^{CFL} = \frac{E_{j,t}^{FULL}}{\exp\left(\hat{\chi}_{j,t}^{FULL}\right)} \times \frac{1}{E_{R,t}^{FULL}}$$

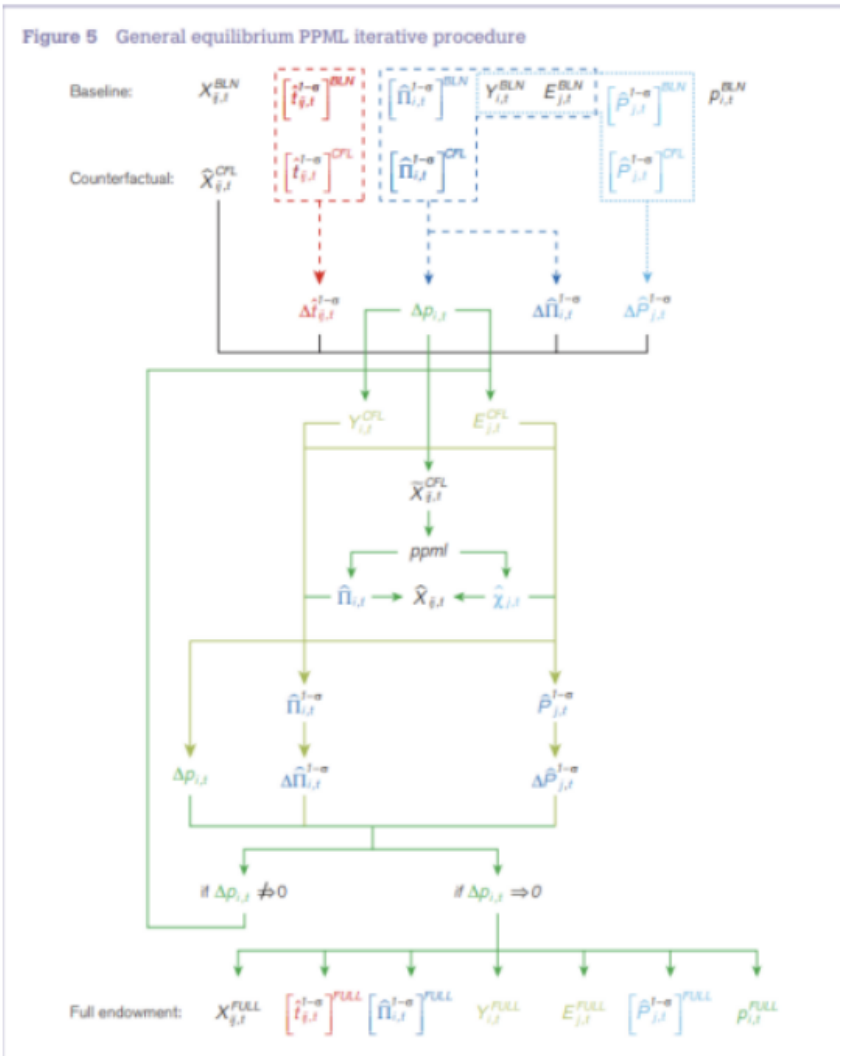
$$\frac{p_{i,t}^{FULL}}{p_{i,t}^{BLN}} = \left(\frac{\exp\left(\hat{\pi}_{i,t}^{FULL}\right) / E_{R,t}^{FULL}}{\exp\left(\hat{\pi}_{i,t}^{BLN}\right) / E_{R,t}^{BLN}}\right)^{\frac{1}{1-\sigma}}$$

$$Y_{i,t}^{FULL} = \frac{p_{i,t}^{FULL}}{p_{i,t}^{BLN}} \times Y_{i,t}^{BLN}$$

$$E_{i,t}^{FULL} = \varphi_i Y_{i,t}^{FULL}$$

$$X_{ij,t}^{FULL} = \frac{Y_{i,t}^{FULL} E_{j,t}^{FULL}}{Y^{FULL}} \frac{\left(\hat{t}_{ij,t}^{CFL}\right)^{1-\sigma}}{\left[\hat{\Pi}_{i,t}^{1-\sigma}\right]_{FULL}^{CFL}\left[\hat{P}_{j,t}^{1-\sigma}\right]_{FULL}^{CFL}}$$

General equilibrium PPML iterative procedure:



General Equilibrium Effects of Trade Policy

$$
\text{Full Endowment: GE} \begin{cases} \text{Conditional GE}: \begin{cases} \text{Direct (PE)}: \begin{cases} X_{ij} = \dfrac{Y_i E_j}{Y}\left(\dfrac{t_{ij}}{\Pi_i P_j}\right)^{1-\sigma} \\ \Pi_i^{1-\sigma} = \sum_j \left(\dfrac{t_{ij}}{P_j}\right)^{1-\sigma} \dfrac{E_j}{Y} \\ P_j^{1-\sigma} = \sum_i \left(\dfrac{t_{ij}}{\Pi_i}\right)^{1-\sigma} \dfrac{Y_i}{Y} \end{cases} \\ p_i = \left(\dfrac{Y_i}{Y}\right)^{\frac{1}{1-\sigma}} \dfrac{1}{\alpha_i \Pi_i} \\ E_i = \varphi_i Y_i = \varphi_i p_i Q_i \end{cases} \end{cases}
$$

Once we have estimated the trade cost elasticities, estimates of fixed effects along with output and expenditure data, then **GE analysis estimates** will be constructed. The process will be repeated for conditional and full endowment scenarios. Here we follow the works of Head and Mayer (2014) and Yotov (2016). For General Equilibrium (GE) analysis, we will evaluate four metrics: Partial Trade Impact (**PTI**), Modular Trade Impact **(MTI**), General Equilibrium Trade Impact (**GETI**), (as given by Head and Mayer, 2014) and Welfare(Anderson, Larch, Yotov, 2017).

PTI focuses on the 'partial' effects of changes in trade costs, capturing their direct impact without considering Multilateral Trade Resistance (MTR) terms or fluctuations in output and expenditure. MTI goes a step further by including the effects of changing inward and outward MTR terms due to trade cost alterations, offering a conditional GE perspective. GETI provides the most comprehensive view, taking into account changes in production, expenditure, MTR terms, and PTI, to measure the full equilibrium impact of variations in trade costs.

$$\mathrm{PTI}_{ni} = \hat{\phi}_{ni} = \phi'_{ni}/\phi_{ni} = \exp[\beta(B'_{ni} - B_{ni})].$$

$$\mathrm{MTI}_{ni} = \frac{X'_{ni}}{X_{ni}} = \underbrace{\exp[\beta(B'_{ni} - B_{ni})]}_{\text{PTI}} \times \underbrace{\frac{\Omega_i}{\Omega'_i}\frac{\Phi_n}{\Phi'_n}}_{\text{MR adjustment}}$$

$$\text{Welfare, } \widehat{W}_i = \frac{\hat{Y}_i^c/\hat{P}_i^c}{Y_i/\hat{P}_i} = \frac{\hat{P}_i}{\hat{P}_i^c}$$

$$\mathrm{GETI}_{ni} = \frac{X'_{ni}}{X_{ni}} = \underbrace{\exp[\beta(B'_{ni} - B_{ni})]}_{\text{PTI}} \times \underbrace{\frac{\Omega_i\Phi_n}{\Omega'_i\Phi'_n}}_{\text{MR adj.}} \times \underbrace{\frac{Y'_i X'_n}{Y_i X_n}}_{\text{GDP adj.}} = \frac{\hat{Y}_i\hat{X}_n}{\hat{\Omega}_i\hat{\Phi}_n}\hat{\phi}_{ni}.$$

Counterfactual Scenario Analysis

For performing the counterfactuals, we define the hypothetical removal of India and China from BRICS. This is done by re-defining the RTA dummy variable, RTA as by setting the original RTA indicator variable to be equal to zero for India and other non member countries when India leaves BRICS trade bloc and for China and other non member countries when China leaves.

Other estimation techniques that can be used

Abbrev.	Description	Introduced by
OLS	Linear-in-logs with GDPs	Tinbergen (1962)
SILS	Structurally Iterated Least Squares	Anderson and van Wincoop (2003)*
LSDV	Least squares w/ country dummies	Harrigan (1996)
DDM	Double-Demeaning of LHS & RHS	none
BVU	Bonus Vetus OLS, simple avgs.	Baier and Bergstrand (2010)
BVW	Bonus Vetus OLS, GDP-weighted	Baier and Bergstrand (2009)
Tetrads	Ratios of reference exporter & importer	Head et al. (2010)

6. Data Description and Sources

In this cross-country analysis, our study revolves around a focused set of countries: the BRICS member states and ten major non-member states. Their selection is based on their prominence in global trade and their intricate trade relations, especially with India and China.

BRICS Nations:
The BRICS bloc consists of five member countries, namely:
- Brazil
- Russia
- India
- China
- South Africa

These nations are bound by the BRICS agreement, fostering various economic collaborations and initiatives.

Top 10 Major Non-Member Countries:
Apart from the BRICS nations, our dataset incorporates ten significant non-member states, recognized for their substantial trade connections with both India and China. They are:
- United States
- Hong Kong
- Australia
- Germany
- Japan
- Malaysia
- Indonesia
- Singapore
- Netherlands
- Saudi Arabia

Formulating the Dataset:
Considering all 15 countries, there are 15P2 or 210 potential bilateral trading relationships. This captures the inter-trade relations. Adding to this the intra-trade relations within the 15 countries, we have 15 additional relations. Thus, our dataset consists of a total of 225 distinct trading relationships. It is essential to represent this as a square dataset, making it conducive for assessing general equilibrium effects.

6.1 Data Source

1. Trade, Internal Trade, and Tariff Data:

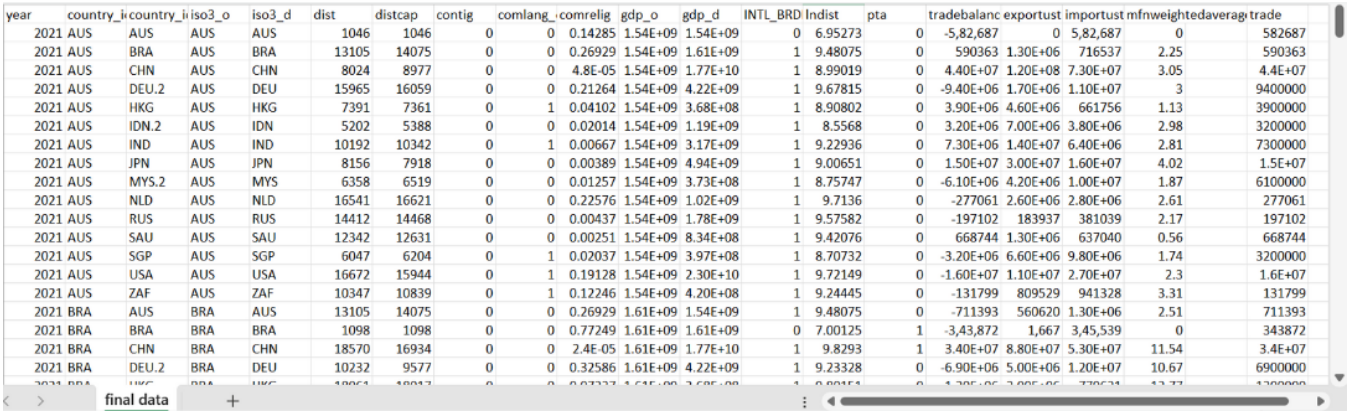
- World Integrated Trade Solution (WITS): Supplemental trade data, including intricate details on tariff structures, trade barriers, and related policy measures.
- Trade Map Database: Sourced data pertaining to global trade dynamics, encompassing both bilateral and internal trade.

2. Factor Variables and Additional Metrics:

- Centre for Prospective Studies and International Information (CEPII) Database: A primary resource for factor variables such as language, border, and additional metrics like geographical distance. CEPII's extensive datasets aided in providing context and nuance to the trade relationships and historical ties among the countries.

Leveraging these renowned databases ensures that the analysis will be rooted in data-driven insights, offering a robust foundation for the research's findings and conclusions.

6.2 Dataset



year	country_i	country_i	iso3_o	iso3_d	dist	distcap	contig	comlang_	comrelig	gdp_o	gdp_d	INTL_BRD	lndist	pta	tradebalanc	exportust	importust	mfnweightedaverag	trade
2021	AUS	AUS	AUS	AUS	1046	1046	0	0	0.14285	1.54E+09	1.54E+09	0	6.95273	0	-5,82,687	0	5,82,687	0	582687
2021	AUS	BRA	AUS	BRA	13105	14075	0	0	0.26929	1.54E+09	1.61E+09	1	9.48075	0	590363	1.30E+06	716537	2.25	590363
2021	AUS	CHN	AUS	CHN	8024	8977	0	0	4.8E-05	1.54E+09	1.77E+10	1	8.99019	0	4.40E+07	1.20E+08	7.30E+07	3.05	4.4E+07
2021	AUS	DEU.2	AUS	DEU	15965	16059	0	0	0.21264	1.54E+09	4.22E+09	1	9.67815	0	-9.40E+06	1.70E+06	1.10E+07	3	9400000
2021	AUS	HKG	AUS	HKG	7391	7361	0	1	0.04102	1.54E+09	3.68E+08	1	8.90802	0	3.90E+06	4.60E+06	661756	1.13	3900000
2021	AUS	IDN.2	AUS	IDN	5202	5388	0	0	0.02014	1.54E+09	1.19E+09	1	8.5568	0	3.20E+06	7.00E+06	3.80E+06	2.98	3200000
2021	AUS	IND	AUS	IND	10192	10342	0	1	0.00667	1.54E+09	3.17E+09	1	9.22936	0	7.30E+06	1.40E+07	6.40E+06	2.81	7300000
2021	AUS	JPN	AUS	JPN	8156	7918	0	0	0.00389	1.54E+09	4.94E+09	1	9.00651	0	1.50E+07	3.00E+07	1.60E+07	4.02	1.5E+07
2021	AUS	MYS.2	AUS	MYS	6358	6519	0	0	0.01257	1.54E+09	3.73E+08	1	8.75747	0	-6.10E+06	4.20E+06	1.00E+07	1.87	6100000
2021	AUS	NLD	AUS	NLD	16541	16621	0	0	0.22576	1.54E+09	1.02E+09	1	9.7136	0	-277061	2.60E+06	2.80E+06	2.61	277061
2021	AUS	RUS	AUS	RUS	14412	14468	0	0	0.00437	1.54E+09	1.78E+09	1	9.57582	0	-197102	183937	381039	2.17	197102
2021	AUS	SAU	AUS	SAU	12342	12631	0	0	0.00251	1.54E+09	8.34E+08	1	9.42076	0	668744	1.30E+06	637040	0.56	668744
2021	AUS	SGP	AUS	SGP	6047	6204	0	1	0.02037	1.54E+09	3.97E+08	1	8.70732	0	-3.20E+06	6.60E+06	9.80E+06	1.74	3200000
2021	AUS	USA	AUS	USA	16672	15944	0	1	0.19128	1.54E+09	2.30E+10	1	9.72149	0	-1.60E+07	1.10E+07	2.70E+07	2.3	1.6E+07
2021	AUS	ZAF	AUS	ZAF	10347	10839	0	1	0.12246	1.54E+09	4.20E+08	1	9.24445	0	-131799	809529	941328	3.31	131799
2021	BRA	AUS	BRA	AUS	13105	14075	0	0	0.26929	1.61E+09	1.54E+09	1	9.48075	0	-711393	560620	1.30E+06	2.51	711393
2021	BRA	BRA	BRA	BRA	1098	1098	0	0	0.77249	1.61E+09	1.61E+09	0	7.00125	1	-3,43,872	1,667	3,45,539	0	343872
2021	BRA	CHN	BRA	CHN	18570	16934	0	0	2.4E-05	1.61E+09	1.77E+10	1	9.8293	1	3.40E+07	8.80E+07	5.30E+07	11.54	3.4E+07
2021	BRA	DEU.2	BRA	DEU	10232	9577	0	0	0.32586	1.61E+09	4.22E+09	1	9.23328	0	-6.90E+06	5.00E+06	1.20E+07	10.67	6900000

final data

The structural gravity model utilized in this study encompasses a diverse set of variables designed to capture the intricate dynamics inherent in international trade. Both the exporting ('gdp_o') and importing ('gdp_d') nations' Gross Domestic Product (GDP) serves as a crucial metric, reflecting economic size and output essential for evaluating trade capacity. The 'mfnweightedaverage' variable indicates the average tariff rates applied by the reporting country, signifying the cost implications of trade barriers. 'tradebalanceusthousand' quantifies the total trade value between country pairs, offering a direct measure of trade volume. 'contig' identifies neighboring countries, hinting at potential heightened trade due to geographic proximity. The presence of a shared official language ('comlang_off') is anticipated to facilitate communication and thus impact trade positively. 'comrelig' denotes a shared religion between trading nations, a cultural aspect likely to influence trade through enhanced trust and mutual

understanding. The 'INTL_BRDR' variable differentiates international trade from domestic transactions. The presence of Free Trade Agreements (FTAs) is indicated by 'pta', taking the value of 1 for member countries and 0 for non-members, potentially reducing trade barriers and fostering increased trade flows. Lastly, 'dist' measures the physical distance between trading partners, a significant determinant of transport costs and trade feasibility. These variables collectively constitute the foundation of the gravity model analysis, offering insights into trade pattern determinants and the impact of trade agreements.

6.3 Analysis Procedure

The study employed both Stata and Google Colab to examine the comprehensive impact of trade cost variables using gravity analysis within a general equilibrium framework. The analysis utilized Peter Herman's gegravity package, specifically estimating structural gravity using the Poisson Pseudo-Maximum Likelihood (PPML) method. This approach was chosen for its effectiveness in handling heteroscedastic data common in trade datasets and its capacity to manage zero values.

The dataset included standard variables such as tariff rates, distance, shared language, religion, (comlang, comrelig), the Free Trade Agreement indicator, and an international border dummy. PPML estimation was performed to derive coefficients, crucial for assessing changes in GDP, trade costs, inward and outward resistance, and welfare concerning specific counterfactual scenarios—India and China exiting BRICS.

Concurrently, Stata codes were utilized to compute various indices like the Partial Trade Index (PTI), Multilateral Trade Index (MTI), General Equilibrium (GE) effects, and welfare impacts. This process followed the methodology outlined by Head and Mayer in 2014.

6.4 Variable Description

In the structural gravity model employed for this study, a range of variables are included to capture the complex dynamics of international trade. The Gross Domestic Product (GDP) of both the exporting ('gdp_o') and importing ('gdp_d') nations provides a measure of economic size and output, essential for assessing trade capacity. 'tariff' represents the average tariff rates applied by the reporter country, reflecting the cost impact of trade barriers. The 'TRADE' variable quantifies the total trade value between country pairs, serving as a direct indicator of trade volume. Contiguity ('Contig') identifies neighboring countries, suggesting potential for increased trade due to proximity. The presence of a common official language ('Comlang_off') is expected to facilitate communication and thereby trade. COMRELIG' denotes the commonality of religion between trading nations, a cultural dimension that can significantly influence trade by fostering trust and understanding. 'COMCOL' indicates a shared colonial history, which often establishes similar legal and business practices that can streamline trade interactions.The 'INTL_BRDER' variable serves as an identifier for international trade, distinguishing it from domestic transactions. The existence of Free Trade Agreements (FTAs) is signified by 'FTA'',

which typically signal reduced trade barriers and are hypothesized to boost trade flows. This variable takes 1 for member countries and 0 when they are non member, it is used for counterfactual analysis. Lastly, 'dist' measures the physical distance between trading partners, a significant determinant of transport costs and trade feasibility. Together, these variables form the basis of the gravity model analysis, providing insights into the determinants of trade patterns and the impact of trade agreements.

7. Empirical Results

The empirical findings from the structural gravity model shed light on the impacts of various factors in different hypothetical trade scenarios. The model, using trade flows from the exporter country as the dependent variable and factors like tariffs, contiguity, language similarity, distance, BRICS Free Trade Agreement status, and international borders as explanatory variables, was estimated using PPML.

Table:1 Generalized Linear Model Regression Results

	coef	std err	z	P>|z|	[0.025	0.975]
mfnweightedaverage	0.0532	0.029	1.815	0.069	-0.004	0.111
comlang_off	0.1395	0.177	0.788	0.430	-0.207	0.486
comrelig	-2.1658	0.638	-3.396	0.001	-3.416	-0.916
contig	0.4904	0.176	2.786	0.005	0.145	0.835
lndist	-0.7528	0.065	-11.546	0.000	-0.881	-0.625
pta	0.1299	0.271	0.479	0.632	-0.401	0.661
intl_brdr	13.8500	0.678	20.437	0.000	12.522	15.178

Source: Author's own computations

In the examination of the structural gravity model encompassing both BRICS member and non-member countries, the estimated coefficients provided meaningful insights. The positive coefficient for tariffs (0.0532) implies that heightened tariff rates are likely to increase trade flows, not aligning with established economic theory. Geographical contiguity (contig) yielded a positive and statistically highly significant effect (0.4904), signifying that countries sharing borders tend to engage in elevated trade volumes. The pta variable exhibited a positive coefficient (0.1299), indicating that FTAs increase trade volume, though statistical significance was not attained, possibly due to the omission of crucial variables such as the prevalence score. The lndist coefficient was negative, aligning with economic intuition, and was statistically highly significant. The international border dummy, however, had a highly significant positive coefficient (13.8500), suggesting that economic integration and global dynamics positively correlate with trade volumes and shape trade patterns.

Following this, the baseline model was solved, and baseline multilateral resistance terms were computed. The reference importer chosen was Saudi Arabia (SAU) to minimize the impact on counterfactual changes.

Table:2 Baseline model results when ARE is reference importer

country	baseline omr	baseline imr
AUS	0.194670	1.052962
BRA	0.199704	1.044365
CHN	0.152390	0.837689
DEU	0.166979	0.924187
HKG	0.158013	0.897676
IDN	0.163145	0.884985
IND	0.161294	0.843741
JPN	0.169455	0.948853
MYS	0.153643	0.847142
NLD	0.169711	0.939591
RUS	0.167032	0.874109
SAU	0.180961	1.000000
SGP	0.152644	0.865647
USA	0.197896	1.088716
ZAF	0.185105	0.970719

Source: Author's own computations

Baseline Outward Multilateral Resistance (OMR) and Inward Multilateral Resistance (IMR) were calculated. These terms, derived from the gravity model, aid in comprehending and predicting trade flow between two countries. OMR reflects the resistance a country encounters when exporting to other nations. A higher value implies greater resistance or costs associated with exporting. An OMR less than 1 indicates less resistance, while an OMR greater than 1 suggests more resistance.

Baseline IMR signifies the resistance a country faces when importing from other nations. A higher IMR indicates higher barriers to imports. Saudi Arabia, with a baseline IMR of 1.000000, serves as the benchmark. An IMR greater than 1 for a country implies higher resistance to imports compared to SAU, while an IMR less than 1 indicates lower resistance. For instance, India, as a member country, has a lower IMR (0.843741), indicating less import resistance, whereas the USA, a non-member, has a higher IMR (1.088716), signifying greater import resistance.

7.1 General equilibrium effects- India's Exit from BRICS

This part delineates the calculation of General Equilibrium (GE) effects, performed using Python code included in the appendix. These effects pertain to the theoretical scenario where India exits BRICS. The emphasis lies on specific country-level GE implications, including alterations in factory gate prices, changes in OMR and IMR, shifts in GDP, and welfare metrics, aiming to grasp their economic relevance.

Table3: GE Analysis Country Results

country	factory gate price change (percent)	omr change (percent)	imr change (percent)	GDP change (percent)	welfare statistic
AUS	-1.393656	1.413353	-2.207514	0.832229	0.991746
BRA	-3.627298	3.763823	0.204178	-3.823669	1.039757
CHN	-3.529225	3.658336	-0.038019	-3.492534	1.036189
DEU	-1.595055	1.620909	-2.257647	0.677896	0.993267
HKG	-1.592134	1.617893	-2.234638	0.657190	0.993471
IDN	-1.627554	1.654481	-2.351916	0.741810	0.992637
IND	-3.707284	3.850015	0.000000	-3.707284	1.038500
JPN	-1.605698	1.631901	-2.299856	0.710499	0.992945
MYS	-1.664670	1.692851	-2.246305	0.595000	0.994085
NLD	-1.573990	1.599161	-2.184948	0.624605	0.993793
RUS	-3.742414	3.887916	-0.245587	-3.505436	1.036328
SAU	-1.147392	1.160709	-2.381073	1.263773	0.987520
SGP	-1.648771	1.676411	-2.144341	0.506430	0.994961
USA	-1.453384	1.474818	-2.330665	0.898216	0.991098
ZAF	-3.887378	4.044607	-0.115884	-3.775870	1.039240

Source: Author's own computations

The factory gate prices in India exhibit a decrease of -3.707284%. This could imply that without the BRICS trade commitments, India might encounter decreased production expenses, or it could indicate a drop in domestic prices due to limited export opportunities. Across member countries, factory price changes show negative trends, indicating potentially more significant reductions compared to non-member nations. India's departure from BRICS might result in reduced demand for specific imported goods, prompting price decreases to stimulate sales. This exit could heighten competition among remaining BRICS members, driving prices down and reshaping trade dynamics.

The outward multilateral resistance (OMR) for IND has risen by 3.850015%, suggesting that after exiting, India faces increased trade barriers in terms of exports. This rise could stem from losing privileged access to BRICS markets or encountering elevated tariffs and non-tariff barriers. The increase in OMR is more pronounced for member countries compared to non-members. Should India exit, member nations would lose their advantageous market access, resulting in higher export barriers like tariffs and non-tariff obstacles. This effect would be notably more substantial for members than non-members, who initially lack such preferential access.

The departure of India leads to reduced Inward Multilateral Resistance (IMR) for non-member countries. This situation could encourage them to bolster trade ties with India, potentially initiating fresh trade agreements that might eventually decrease their IMR concerning India over time.

India's GDP is forecasted to contract by -3.707284%, indicating a marginal decline upon exiting BRICS, possibly stemming from reduced trade, investments, and economic interconnection. Despite being a robust economy, India may still face adverse effects due to altered trade dynamics. Member countries experience economic contractions, signifying the disruption in their established ties with India. The negative GDP change highlights the loss of benefits in economic integration, such as decreased trade, investments, and collaborative economic endeavors. Conversely, non-member countries exhibit positive changes, suggesting a potential pivot towards reinforcing bilateral trade relationships, potentially expanding trade beyond the BRICS sphere. Non-members might seize opportunities in markets where

Indian goods and services previously thrived due to preferential BRICS trade terms, which might no longer be applicable.

The welfare statistic is a probable indicator of the economic health of each country post-India's departure from BRICS. The slightly positive values in the welfare statistic column might suggest, within this model, that the listed countries see a minor uptick in their economic welfare if India exits BRICS. This could be attributed to potential trade redirection to these nations, a reallocation of resources from India to other markets, resulting in a marginal welfare gain. Furthermore, India's departure, being a major economy, might create new market openings for smaller countries, enhancing their opportunities.

Table4: Bilateral Trade Results

country	baseline modeled shipments	experiment shipments	shipments change (percent)
AUS	4.170800e+09	4.105501e+09	-1.565618
BRA	4.170800e+09	4.023336e+09	-3.535635
CHN	4.170800e+09	4.028474e+09	-3.412444
DEU	4.170800e+09	4.105886e+09	-1.556395
HKG	4.170800e+09	4.105855e+09	-1.557125
IDN	4.170800e+09	4.106372e+09	-1.544740
IND	4.170800e+09	4.018080e+09	-3.661641
JPN	4.170800e+09	4.106934e+09	-1.531254
MYS	4.170800e+09	4.105676e+09	-1.561425
NLD	4.170800e+09	4.105626e+09	-1.562615
RUS	4.170800e+09	4.014915e+09	-3.737534
SAU	4.170800e+09	4.106941e+09	-1.531090
SGP	4.170800e+09	4.105150e+09	-1.574046
USA	4.170800e+09	4.106376e+09	-1.544644
ZAF	4.170800e+09	4.007033e+09	-3.926512

Source: Author's own computations

The table exhibits trade flow data involving India and different nations, both pre and post the counterfactual enactment. It compares the baseline model's initial trade volumes with the simulated scenario of India's departure from a trade bloc or agreement. The negative percentage change in trade between India and member countries indicates a decline in trade flows following this event. This decline likely stems from higher tariffs, the loss of preferential treatment, and disruptions in existing trade pacts due to India exiting BRICS. The adverse trade changes with India might be due to economic contractions or shifts in the internal distribution of goods and services consequent to India's exit from BRICS.

Table5: Aggregate Trade Results

experiment foreign exports	foreign exports change (percent)	baseline modeled consumption	experiment consumption	consumption change (percent)
4.041353e+09	-1.529809	4.170800e+09	4.113949e+09	-1.363080
4.004758e+09	-3.475732	4.170800e+09	4.017753e+09	-3.669490
3.990208e+09	-3.274597	4.170800e+09	4.024131e+09	-3.516558
4.064021e+09	-1.535172	4.170800e+09	4.103382e+09	-1.616427
3.871980e+09	-1.437962	4.170800e+09	4.104523e+09	-1.589066
4.060336e+09	-1.517588	4.170800e+09	4.098047e+09	-1.744347
3.913297e+09	-3.299967	4.170800e+09	4.018299e+09	-3.656399
4.030577e+09	-1.488836	4.170800e+09	4.101168e+09	-1.669520
4.062502e+09	-1.541591	4.170800e+09	4.100982e+09	-1.673981
4.036061e+09	-1.531618	4.170800e+09	4.107359e+09	-1.521074
3.987268e+09	-3.637845	4.170800e+09	4.019896e+09	-3.618117
4.105309e+09	-1.529691	4.170800e+09	4.116819e+09	-1.294253
3.858402e+09	-1.480091	4.170800e+09	4.106011e+09	-1.553395
4.047138e+09	-1.505642	4.170800e+09	4.106214e+09	-1.548524
3.896000e+09	-3.548371	4.170800e+09	4.013624e+09	-3.768489

Source: Author's own computations

India's output witnesses a -3.2999671% decline, reflecting a contraction in economic production likely caused by reduced access to BRICS markets, leading to decreased production demand. Member countries uniformly display negative changes in output and expenditure, indicating substantial benefits derived from economic integration with India, such as trade efficiencies, investment, and shared production networks. These negative changes imply a reduction in production capacity and consumer spending within these economies, resulting in an overall economic slowdown. However, due to the global nature of trade and investment, these countries still experience economic repercussions, albeit to a lesser extent.

India encounters a -3.656399% shift in consumption, indicating a decline in domestic spending. This reduction might stem from lowered household income or increased savings in response to economic uncertainties post-exit. Member countries uniformly show negative changes in consumption, likely due to reduced consumer confidence, diminished disposable income, or increased prices due to potential trade cost escalations with India. These changes may arise from the loss of economic benefits linked to trade with India. Non-member countries display less negative consumption changes, lessening the impact of India's departure from BRICS.

Table6: Country Multilateral Resistance Terms

country	baseline imr	conditional imr	experiment imr	baseline omr	conditional omr	experiment omr
AUS	1.000121	0.978044	0.978044	1.643142	1.666366	1.666366
BRA	1.133521	1.135835	1.135835	1.738097	1.803516	1.803516
CHN	0.858810	0.858484	0.858484	1.462558	1.516063	1.516063
DEU	0.923208	0.902366	0.902366	1.597587	1.623483	1.623483
HKG	0.840520	0.821737	0.821737	1.522728	1.547364	1.547364
IDN	0.937812	0.915756	0.915756	1.559869	1.585677	1.585677
IND	1.000000	1.000000	1.000000	1.541831	1.601192	1.601192
JPN	0.858511	0.838766	0.838766	1.513874	1.538578	1.538578
MYS	0.897175	0.877022	0.877022	1.526699	1.552544	1.552544
NLD	0.934386	0.913971	0.913971	1.630506	1.656581	1.656581
RUS	0.882140	0.879974	0.879974	1.369003	1.422228	1.422228
SAU	0.848580	0.828375	0.828375	1.446413	1.463201	1.463201
SGP	0.843222	0.825141	0.825141	1.520984	1.546482	1.546482
USA	1.034222	1.010118	1.010118	1.769340	1.795434	1.795434
ZAF	1.045255	1.044044	1.044044	1.607464	1.672480	1.672480

Source: Author's own computations

The table illustrates the Inward Multilateral Resistance (IMR) and Outward Multilateral Resistance (OMR) before (baseline) and after (experiment) implementing the counterfactual scenario. Among ASEAN members, the experimental IMR slightly surpasses the baseline, indicating a heightened resistance to imports, possibly driven by efforts to explore new import sources or improve domestic conditions for imports in response to India's departure. Non-member countries exhibit relatively steady or marginally changed IMR values, suggesting that their import conditions have remained largely unaffected by India's exit. This stability might be due to a reduced reliance on imports from India or a diversified set of import sources.

India's OMR shows a slight increase, hinting at elevated export resistance, potentially arising from the loss of preferential access to BRICS markets. For BRICS member countries, the experimental OMR exceeds the baseline, indicating heightened export resistance after India's exit. This could be attributed to disrupted trade synergies, potentially leading to increased complexities and costs in exporting goods.

7.2 General equilibrium effects- China's Exit from BRICS

This part delineates the calculation of General Equilibrium (GE) effects, performed using Python code included in the appendix. These effects pertain to the theoretical scenario where China exits BRICS. The emphasis lies on specific country-level GE implications, including alterations in factory gate prices, changes in OMR and IMR, shifts in GDP, and welfare metrics, aiming to grasp their economic relevance.

Table7: GE Analysis Country Results

country	factory gate price change (percent)	omr change (percent)	imr change (percent)	GDP change (percent)	welfare statistic
AUS	-1.356153	1.374797	-2.170320	0.832229	0.991746
BRA	-3.590644	3.724373	0.242289	-3.823669	1.039757
CHN	-3.492534	3.618926	0.000000	-3.492534	1.036189
DEU	-1.557628	1.582274	-2.220472	0.677896	0.993267
HKG	-1.554706	1.579259	-2.197455	0.657190	0.993471
IDN	-1.590139	1.615833	-2.314777	0.741810	0.992637
IND	-3.670661	3.810532	0.038033	-3.707284	1.038500
JPN	-1.568275	1.593262	-2.262697	0.710499	0.992945
MYS	-1.627270	1.654188	-2.209126	0.595000	0.994085
NLD	-1.536555	1.560534	-2.147745	0.624605	0.993793
RUS	-3.705804	3.848419	-0.207647	-3.505436	1.036328
SAU	-1.109795	1.122249	-2.343945	1.263773	0.987520
SGP	-1.611365	1.637755	-2.107123	0.506430	0.994961
USA	-1.415903	1.436239	-2.293518	0.898216	0.991098
ZAF	-3.850823	4.005050	-0.077894	-3.775870	1.039240

Source: Author's own computations

The factory gate prices in China exhibit a decrease of -3.492534%. This could imply that without the BRICS trade commitments, China might encounter decreased production expenses, or it could indicate a drop in domestic prices due to limited export opportunities. Across member countries, factory price changes show negative trends, indicating potentially more significant reductions compared to non-member nations. India's departure from BRICS might result in reduced demand for specific imported goods, prompting price decreases to stimulate sales. This exit could heighten competition among remaining BRICS members, driving prices down and reshaping trade dynamics.

The outward multilateral resistance (OMR) for CHN has risen by 3.618926%, suggesting that after exiting, China faces increased trade barriers in terms of exports. This rise could stem from losing privileged access to BRICS markets or encountering elevated tariffs and non-tariff barriers. The increase in OMR is more pronounced for member countries compared to non-members. Should China exit, member nations would lose their advantageous market access, resulting in higher export barriers like tariffs and non-tariff obstacles. This effect would be notably more substantial for members than non-members, who initially lack such preferential access.

The departure of China leads to reduced Inward Multilateral Resistance (IMR) for non-member countries. This situation could encourage them to bolster trade ties with India, potentially initiating fresh trade agreements that might eventually decrease their IMR concerning India over time.

China's GDP is forecasted to contract by -3.492534%, indicating a marginal decline upon exiting BRICS, possibly stemming from reduced trade, investments, and economic interconnection. Despite being a robust economy, China may still face adverse effects due to altered trade dynamics. Member countries experience economic contractions, signifying the disruption in their established ties with China. The negative GDP change highlights the loss of benefits in economic integration, such as decreased trade, investments, and collaborative economic endeavors. Conversely, non-member countries exhibit positive changes, suggesting a potential pivot towards reinforcing bilateral trade relationships, potentially expanding trade beyond the BRICS sphere. Non-members might seize opportunities in

markets where Chinese goods and services previously thrived due to preferential BRICS trade terms, which might no longer be applicable.

The welfare statistic is a probable indicator of the economic health of each country post-China's departure from BRICS. The slightly positive values in the welfare statistic column might suggest, within this model, that the listed countries see a minor uptick in their economic welfare if China exits BRICS. This could be attributed to potential trade redirection to these nations, a reallocation of resources from China to other markets, resulting in a marginal welfare gain. Furthermore, China's departure, being a major economy, might create new market openings for smaller countries, enhancing their opportunities.

Table8: Bilateral Trade Results

country	baseline modeled shipments	experiment shipments	shipments change (percent)
AUS	4.170800e+09	4.107063e+09	-1.528180
BRA	4.170800e+09	4.024866e+09	-3.498946
CHN	4.170800e+09	4.030006e+09	-3.375709
DEU	4.170800e+09	4.107447e+09	-1.518954
HKG	4.170800e+09	4.107417e+09	-1.519684
IDN	4.170800e+09	4.107934e+09	-1.507294
IND	4.170800e+09	4.019608e+09	-3.625000
JPN	4.170800e+09	4.108496e+09	-1.493803
MYS	4.170800e+09	4.107238e+09	-1.523985
NLD	4.170800e+09	4.107188e+09	-1.525176
RUS	4.170800e+09	4.016442e+09	-3.700922
SAU	4.170800e+09	4.108503e+09	-1.493639
SGP	4.170800e+09	4.106711e+09	-1.536611
USA	4.170800e+09	4.107938e+09	-1.507198
ZAF	4.170800e+09	4.008557e+09	-3.889972

Source: Author's own computations

The table exhibits trade flow data involving China and different nations, both pre and post the counterfactual enactment. It compares the baseline model's initial trade volumes with the simulated scenario of China's departure from a trade bloc or agreement. The negative percentage change in trade between China and member countries indicates a decline in trade flows following this event. This decline likely stems from higher tariffs, the loss of preferential treatment, and disruptions in existing trade pacts due to India exiting BRICS. The adverse trade changes with India might be due to economic contractions or shifts in the internal distribution of goods and services consequent to China's exit from BRICS.

Table9: Aggregate Trade Results

experiment foreign exports	foreign exports change (percent)	baseline modeled consumption	experiment consumption	consumption change (percent)
4.042890e+09	-1.492357	4.170800e+09	4.115513e+09	-1.325565
4.006281e+09	-3.439020	4.170800e+09	4.019281e+09	-3.632852
3.991725e+09	-3.237809	4.170800e+09	4.025662e+09	-3.479862
4.065567e+09	-1.497722	4.170800e+09	4.104943e+09	-1.579008
3.873453e+09	-1.400476	4.170800e+09	4.106084e+09	-1.551637
4.061880e+09	-1.480132	4.170800e+09	4.099605e+09	-1.706977
3.914786e+09	-3.263189	4.170800e+09	4.019827e+09	-3.619756
4.032109e+09	-1.451369	4.170800e+09	4.102727e+09	-1.632122
4.064047e+09	-1.504144	4.170800e+09	4.102541e+09	-1.636584
4.037596e+09	-1.494167	4.170800e+09	4.108921e+09	-1.483619
3.988785e+09	-3.601195	4.170800e+09	4.021424e+09	-3.581459
4.106870e+09	-1.492239	4.170800e+09	4.118385e+09	-1.256711
3.859869e+09	-1.442620	4.170800e+09	4.107573e+09	-1.515952
4.048677e+09	-1.468181	4.170800e+09	4.107776e+09	-1.511080
3.897482e+09	-3.511687	4.170800e+09	4.015150e+09	-3.731889

Source: Author's own computations

China's output witnesses a -3.439020% decline, reflecting a contraction in economic production likely caused by reduced access to BRICS markets, leading to decreased production demand. Member countries uniformly display negative changes in output and expenditure, indicating substantial benefits derived from economic integration with China, such as trade efficiencies, investment, and shared production networks. These negative changes imply a reduction in production capacity and consumer spending within these economies, resulting in an overall economic slowdown. However, due to the global nature of trade and investment, these countries still experience economic repercussions, albeit to a lesser extent.

China encounters a -3.479862% shift in consumption, indicating a decline in domestic spending. This reduction might stem from lowered household income or increased savings in response to economic uncertainties post-exit. Member countries uniformly show negative changes in consumption, likely due to reduced consumer confidence, diminished disposable income, or increased prices due to potential trade cost escalations with China. These changes may arise from the loss of economic benefits linked to trade with China. Non-member countries display less negative consumption changes, lessening the impact of China's departure from BRICS.

Table10: Country Multilateral Resistance Terms

country	baseline imr	conditional imr	experiment imr	baseline omr	conditional omr	experiment omr
AUS	1.164543	1.139268	1.139268	1.411148	1.430548	1.430548
BRA	1.319873	1.323071	1.323071	1.492696	1.548289	1.548289
CHN	1.000000	1.000000	1.000000	1.256060	1.301516	1.301516
DEU	1.074985	1.051115	1.051115	1.372024	1.393734	1.393734
HKG	0.978703	0.957196	0.957196	1.307734	1.328387	1.328387
IDN	1.091990	1.066713	1.066713	1.339632	1.361278	1.361278
IND	1.164401	1.164844	1.164844	1.324141	1.374598	1.374598
JPN	0.999651	0.977032	0.977032	1.300130	1.320845	1.320845
MYS	1.044672	1.021594	1.021594	1.311145	1.332834	1.332834
NLD	1.088001	1.064633	1.064633	1.400296	1.422148	1.422148
RUS	1.027165	1.025032	1.025032	1.175714	1.220960	1.220960
SAU	0.988088	0.964927	0.964927	1.242194	1.256135	1.256135
SGP	0.981849	0.961160	0.961160	1.306237	1.327630	1.327630
USA	1.204250	1.176630	1.176630	1.519527	1.541351	1.541351
ZAF	1.217097	1.216149	1.216149	1.380507	1.435797	1.435797

Source: Author's own computation

The table illustrates the Inward Multilateral Resistance (IMR) and Outward Multilateral Resistance (OMR) before (baseline) and after (experiment) implementing the counterfactual scenario. Among ASEAN members, the experimental IMR slightly surpasses the baseline, indicating a heightened resistance to imports, possibly driven by efforts to explore new import sources or improve domestic conditions for imports in response to China's departure. Non-member countries exhibit relatively steady or marginally changed IMR values, suggesting that their import conditions have remained largely unaffected by China's exit. This stability might be due to a reduced reliance on imports from China or a diversified set of import sources.

China's OMR shows a slight increase, hinting at elevated export resistance, potentially arising from the loss of preferential access to BRICS markets. For BRICS member countries, the experimental OMR exceeds the baseline, indicating heightened export resistance after China's exit. This could be attributed to disrupted trade synergies, potentially leading to increased complexities and costs in exporting goods.

6. Comparison

Metric	India's Exit Impact	China's Exit Impact
Factory Gate Price Change	Decrease (Deflationary pressure due to excess supply)	More decrease
OMR Change	More positive	Positive (Increased resistance to exports, may suggest loss of trade efficiency)
GDP Change	Negative impact on member countries	Negative impact on member countries
Welfare Change	Marginally positive but mostly negative impact and loss in welfare	Marginally positive but mostly negative impact and loss in welfare

In summary, while both India and China's exits from BRICS demonstrate certain similarities in their impacts on various metrics, such as GDP changes and welfare implications, they also showcase nuanced differences. India's exit tends to display slightly more positive changes in some aspects, such as OMR, while China's exit reflects more significant decreases in factory gate prices. However, both scenarios primarily lead to negative outcomes, including adverse effects on GDP and overall welfare, signaling potential challenges and disruptions in the economic landscape.

7. Conclusion and Policy Implication

The analyses surrounding India and China's hypothetical exit from BRICS underscore the significant effects such events could have on global trade dynamics. The negative changes in GDP, trade volumes, and consumption signify the potential disruptions and economic contractions that could arise due to altered trade relationships. Member countries experience substantial economic contractions, indicating the disruption of established ties with India and China, while non-member countries exhibit more positive changes, indicating potential opportunities to strengthen bilateral trade relationships beyond the BRICS sphere.

Furthermore, the increase in multilateral resistance terms (IMR and OMR) for member countries following the exits of India and China suggests heightened trade barriers and complexities, potentially leading to increased costs in exporting and importing goods. This could substantially impact trade volumes and reshape trade dynamics within the BRICS bloc.

Policy Implications:

Diversification of Trade Partnerships: Member countries should strategize to diversify their trade partnerships and reduce reliance on a select few economies, such as India and China, to mitigate the risks associated with disruptions in specific trade relationships.

Bilateral Trade Strengthening: Non-member countries could explore opportunities to strengthen bilateral trade relations with India and China, leveraging potential gaps arising from their exit from BRICS and aiming to expand trade opportunities in markets where these countries previously held preferential trade terms.

Negotiating New Trade Agreements: The findings suggest the importance of engaging in fresh trade agreements that reduce barriers and foster smoother trade relationships. Both member and non-member countries could benefit from exploring new agreements to offset potential economic downturns resulting from India and China's exit.

Enhancing Economic Resilience: Member countries need to bolster their economic resilience to withstand potential shocks resulting from the exit of major economies like India and China. This could involve diversifying industries, fostering innovation, and increasing competitiveness in global markets.

In summary, these findings underscore the significance of carefully assessing the repercussions and formulating strategic policies to navigate the potential economic impacts resulting from the exit of major economies from trade blocs like BRICS. Policymakers and stakeholders need to prioritize diversification, bilateral relations, and strategic trade agreements to mitigate risks and capitalize on potential opportunities in the ever-evolving global trade landscape.

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Appendix

This part details the Python codes by Herman utilized for estimating the structural gravity model and obtaining the general equilibrium effects. The gegravity Python package is used for this task due to its comprehensive functionalities tailored for estimating structural gravity models and simulating scenarios for counterfactual analysis. The OneSectorGE model within the gegravity package is an adaptation of the structural model devised by Yotov et al. (2016). The relevant excerpts of the code are provided.

```
#installation
pip install gegravity
import gegravity as ge
import pandas as pd
# Increase number of columns printed for a pandas DataFrame
pd.set_option("display.max_columns", None)
pd.set_option('display.width', 1000)
import gme as gme


#Load the Gravity data
from google.colab import files
uploaded = files.upload()
```

```
gravity_data_location = "/content/DEBASHREE_FINALDATASET_200307.csv"
grav_data = pd.read_csv(gravity_data_location)
df = pd.read_csv('/content/DEBASHREE_FINALDATASET_200307.csv')
print(grav_data.head())


#preparing data for GE model
# Define GME Estimation Data
gme_data = gme.EstimationData(grav_data, # Dataset
                        imp_var_name="iso_d", # Importer column name
                        exp_var_name="iso_o", # Exporter column name
                        year_var_name = "year",  # Year column name
                        trade_var_name="trade")  # Trade column name


# Create Gravity Model
gme_model = gme.EstimationModel(gme_data, # Specify data to use
                         lhs_var="trade",                        # dependent, "left hand side" variable
                         rhs_var=["RTA","contiguity", # independent variables
                                "comcol","comlang","lndist","INTL_BRDR"],
                         fixed_effects=[["exporter"],["importer"]])     # Fixed effects to use

# Estimate gravity model with PPML
gme_model.estimate()

# Print econometric results table
print(gme_model.results_dict['all'].summary())

# Define GE model
ge_model = ge.OneSectorGE(gme_model,                # gme gravity model
                   year = "2021",             # Year to use for model
                   expend_var_name = "gdp_d",       # Expenditure column name
                   output_var_name = "gdp_o",       # Output column name
                   reference_importer = "IND",  # Reference importer
                   sigma = 5)                 # Elasticity of substitution



# Test that the model system of equations is computable from the supplied data and parameters
test_diagnostics = ge_model.test_baseline_mr_function()
# See what is returned:
print(test_diagnostics.keys())
# Check the values of the model parameters computed from the baseline data, which should be numeric
with no missing values
input_params = test_diagnostics['mr_params']
# Check one set of parameters, for example:
print(input_params['cost_exp_shr'])
```

```
# Check for OMR rescale factors that results in convergence
rescale_eval = ge_model.check_omr_rescale(omr_rescale_range=3)
print(rescale_eval)

# Solve the baseline model
ge_model.build_baseline(omr_rescale=100)
# Examine the solutions for the baseline multilateral resistances
print(ge_model.baseline_mr.head(12))

# Create a copy of the baseline data
exp_data = ge_model.baseline_data.copy()

#We develop an array of all member countries of BRICS.
member_countries = ["BRA", "RUS", "IND", "CHN", "ZAF"]

#For our counterfactual experiment, we set the value of the PTA dummy variable with all the member
countries as 0. We use 'for' loop for this iterative purpose.
for country in member_countries:
  exp_data.loc[(exp_data["iso3_d"] == "IND") | (exp_data["iso3_o"] == country), "pta"] = 0
  exp_data.loc[(exp_data["iso3_d"] == country) | (exp_data["iso3_o"] == "IND"), "pta"] = 0

# Define the experiment within the GE model
ge_model.define_experiment(exp_data)

# Examine the baseline and counterfactual trade costs
print(ge_model.bilateral_costs.head(56))
# Simulate the counterfactual model
ge_model.simulate()

# We can examine the counterfactual trade flows predicted by the model.
print(ge_model.bilateral_trade_results.head())

# A collection of many of the key country-level results (prices, total imports/exports, GDP, welfare, etc.)
country_results = ge_model.country_results
print(country_results)

# The bilateral trade results
bilateral_results = ge_model.bilateral_trade_results
print(bilateral_results)

# A wider selection of aggregate, country-level trade results
agg_trade = ge_model.aggregate_trade_results
print(agg_trade)

# country multilateral resistance (MR) terms
```

```
mr_terms = ge_model.country_mr_terms
# Get the solver diaganoistics, which is a dictionary containing many types of solver diagnostic info
solver_diagnostics = ge_model.solver_diagnostics
mr_terms = ge_model.country_mr_terms
print(mr_terms)

solver_diagnostics = ge_model.solver_diagnostics

# Export the results to a collection of spreadsheet (.csv) files and add trade values in levels to the
outputs.
from google.colab import drive
drive.mount('/content/drive')

import os
output_directory = "/content/drive/My Drive/"
os.makedirs(output_directory, exist_ok=True)
ge_model.export_results(directory=output_directory, name="GE_analysis1")

#For our counterfactual experiment, we set the value of PTA dummy variable with all the member
countries as 0. We use 'for' loop for this iterative purpose.
for country in member_countries:
  exp_data.loc[(exp_data["iso3_d"] == "CHN") | (exp_data["iso3_o"] == country), "pta"] = 0
  exp_data.loc[(exp_data["iso3_d"] == country) | (exp_data["iso3_o"] == "CHN"), "pta"] = 0


# Define the experiment within the GE model
ge_model.define_experiment(exp_data)

# Examine the baseline and counterfactual trade costs
print(ge_model.bilateral_costs.head(56))
# Simulate the counterfactual model
ge_model.simulate()

# We can examine the counterfactual trade flows predicted by the model.
print(ge_model.bilateral_trade_results.head())

# A collection of many of the key country-level results (prices, total imports/exports, GDP, welfare, etc.)
country_results = ge_model.country_results
print(country_results)

# The bilateral trade results
bilateral_results = ge_model.bilateral_trade_results
print(bilateral_results)

# A wider selection of aggregate, country-level trade results
agg_trade = ge_model.aggregate_trade_results
```

```
print(agg_trade)

# country multilateral resistance (MR) terms
mr_terms = ge_model.country_mr_terms
# Get the solver diaganoistics, which is a dictionary containing many types of solver diagnostic info
solver_diagnostics = ge_model.solver_diagnostics
mr_terms = ge_model.country_mr_terms
print(mr_terms)

solver_diagnostics = ge_model.solver_diagnostics

# Export the results to a collection of spreadsheet (.csv) files and add trade values in levels to the
outputs.
from google.colab import drive
drive.mount('/content/drive')

import os
output_directory = "/content/drive/My Drive/"
os.makedirs(output_directory, exist_ok=True)
ge_model.export_results(directory=output_directory, name="GE_analysis2")
```

Python Code File

India exit -

Codes

Results

China Exit-

Codes

Results

Plagiarism Report

https://drive.google.com/drive/folders/12jfuxqAzMFw_bCRsidf6ODmjiSDWAhfc?usp=drive_link