Structural Gravity Model Estimation Using India-CPTPP Trade Data and Counterfactual Analysis

as part of the course

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Introduction

The Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), a formal Free Trade Agreement (FTA), entered into force on December 30, 2018. It encompasses eleven member states within the Asia-Pacific region: Australia, Brunei Darussalam, Canada, Chile, Japan, Malaysia, Mexico, New Zealand, Peru, Singapore, and Vietnam.

The agreement's origins can be traced to the Trans-Pacific Partnership (TPP) negotiations initiated in 2008. However, the withdrawal of the United States in 2017 necessitated a name change and a revised framework, leading to the emergence of the CPTPP.

Collectively, CPTPP member states represent a significant economic force, accounting for approximately 13.4% of the global Gross Domestic Product (GDP), translating to a staggering US$13.5 trillion. This figure positions the CPTPP as one of the largest FTAs globally in terms of GDP. Furthermore, the agreement encompasses a population of over 500 million residing within the economically dynamic Asia-Pacific region, fostering intra-regional trade and investment.

While India initially opted not to join the CPTPP, citing concerns regarding stricter labour and environmental standards, it maintains robust trade ties with member states. In 2017, India experienced a trade deficit with the CPTPP, primarily exporting goods and services valued at US$41 billion to Singapore, Vietnam, and Malaysia. Conversely, India imported approximately US$58 billion worth of goods and services, with Australia, Japan, and Malaysia as its key import partners. Precious stones, oil and mineral fuels, and industrial machinery dominate India's export portfolio to the CPTPP. Conversely, its imports are heavily reliant on oil and mineral fuels, precious stones, metals, and metal ores. Notably, this trade's value and volume have witnessed significant growth over the years.

Acknowledging the United Kingdom's formal signing of the agreement on July 16, 2023, is crucial. However, as of September 26, 2023, the UK's accession has yet to be finalised. This agreement marks the UK's first significant trade deal following its exit from the European Union.

For this analysis, we will consider two scenarios:

To evaluate the potential economic impact of India's accession to the CPTPP, this analysis will incorporate data on the top ten GDP countries based on the World Bank's 2022 data. This comparative framework will provide valuable insights into the potential trade dynamics within an expanded CPTPP.

The CPTPP presents a significant economic bloc fostering trade and investment within the Asia-Pacific region. India's strategic engagement and the UK's impending accession highlight the agreement's growing influence. This analysis will delve deeper into the potential economic ramifications of India's formal membership, utilising a comparative framework to assess the impact on global trade dynamics.

Literature Review

The Gravity Model: A Foundation for Trade Analysis

The gravity model, introduced by Tinbergen (1962), has become a cornerstone of empirical trade analysis. Inspired by Newton's law of gravitation, it posits an analogy between the trade volume of two countries and the gravitational pull between masses. The model suggests a direct correlation between trade volume and the product of the trading partners' Gross Domestic Products (GDPs), reflecting their economic sizes and market potential.

Conversely, it suggests an inverse relationship with trade costs, typically measured by geographical distance between the trading partners. This distance is a proxy for transportation costs, border frictions, and other impediments to trade flows.

McCallum's (1995) Application and the "Border Puzzle"

McCallum (1995) employed the traditional gravity model to investigate trade flows between the United States and Canada, a natural experiment due to their geographic proximity and established Free Trade Agreement (FTA).

However, his work unearthed the intriguing "Border Puzzle." And highlighted the disparity in trade patterns between Canadian provinces and their trade with the U.S. despite ostensibly open borders. The puzzle pointed towards the limitations of the basic gravity model. It could only partially capture the complexities of trade within integrated economies, where factors like cultural proximity, shared infrastructure, and regulatory harmonisation may play a significant role. This anomaly underscored the need for gravity model refinement to account for such nuances.

Anderson and Wincoop's (2003) Structural Gravity Model: A Refinement

A significant advancement came in 2003 with the introduction of the "structural" gravity model by Anderson and Wincoop. This model addressed the shortcomings of the traditional model by incorporating Multilateral Trade Resistance (MTR) terms. MTR captures the idea that reducing trade costs between two countries can indirectly affect their trade with third-party nations. The demand side of the model is characterised by a CES (Constant Elasticity of Substitution) utility function reflecting a "love for variety" among consumers. This implies that consumers are willing to substitute imports from one country for another depending on relative prices.

Conversely, the production side incorporates principles of increasing returns to scale, akin to Krugman's (1980) model. This suggests that firms benefit from economies of scale, making them more competitive as production volumes increase.

The structural model effectively tackled many estimation challenges faced by the traditional model, leading to more consistent estimates for cross-border trade between the U.S. and Canada.

Estimation Methodologies: Beyond Gravity

The estimation of trade models has evolved beyond the basic gravity equation. Anderson and Wincoop's (2003) model utilises the Structurally Iterated Least Squares (SILS) methodology, an iterative process that accounts for the interdependence between trade flows and trade costs.

However, Baier and Bergstrand (2009) adopted the Bonus Vetus Ordinary Least Squares (OLS) approach for estimating gravity equations. While their method omits MTR terms, it incorporates Taylor approximations for trade cost variables. This allows for a more straightforward estimation process but may sacrifice some accuracy in capturing the complexities of trade relationships.

Incorporating Firm Heterogeneity

Recent advancements have seen the introduction of models that account for variations in productivity at the firm level. Chaney and Helpman (2008) proposed gravity-like equations that capture this heterogeneity. They argue that differences in firm-level productivity can significantly influence trade patterns. Firms with higher productivity are generally more competitive in international markets.

Eaton and Kortum (2002) also developed a sophisticated Ricardian model with firm-level heterogeneity featuring a gravity-like equation for analysing bilateral trade. Their model builds upon the comparative advantage theory, suggesting that countries export goods for which they have a relative abundance of productive factors. However, they incorporate firm-level heterogeneity, acknowledging that not all firms within a country are equally efficient.

Partial Trade Impact vs. General Equilibrium Trade Impact

Anderson and van Wincoop (2003) emphasise two crucial distinctions when analysing the impact of trade cost changes. Firstly, trade cost variations can influence trade impact indexes. Simply exponentiating coefficients on dummy variables, referred to as Partial Trade Impact (PTI), might not accurately reflect the comprehensive trade impact. PTI only considers changes in trade volumes between two countries without accounting for potential spillover effects on trade with third parties.

Secondly, when considering changes in price indexes, the estimated trade impacts at borders tend to be significantly reduced. This highlights the importance of incorporating general equilibrium effects, where changes in trade costs can influence not only trade volumes but also factor prices, production levels, and, ultimately, GDPs.

A specific term for the trade impact that maintains constant production and expenditure levels while adjusting trade cost parameters (Ωi and ϕn) through contraction mapping is not explicitly mentioned. This impact does not qualify as a true General Equilibrium Trade Impact (GETI) since it holds GDP constant, and factor prices influence GDPs.

Anderson (2011) highlights the modular nature of the structural gravity model, where output and expenditures are determined independent of bilateral flow allocation. Therefore, the trade impact derived from this model is categorised as a Modular Trade Impact (MTI). GETI, on the other hand, is reserved for scenarios where wages (and consequently GDPs) also adapt to trade cost fluctuations.

The Structural Gravity System:

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

$$\Pi_{ij} = \Sigma\left(\frac{t_{ij}}{P_j}\right)^{1-\sigma}\frac{E_j}{Y} \qquad (1\text{-}2)$$

$$P_j^{1-\sigma} = \Sigma\left(\frac{t_{ij}}{P_j}\right)^{1-\sigma}\frac{Y_i}{Y} \qquad (1\text{-}3)$$

$$p_i = \left(\frac{Y_i}{Y}\right)^{\frac{1}{1-\sigma}}\frac{1}{\Pi_i \alpha_j} \qquad (1\text{-}4)$$

$$E_i = \varphi_i Y_i = \varphi_i p_i Q_i \qquad (1\text{-}5)$$

Here,

X_{ij}: nominal trade volume from exporter i to importer j

E_j: total expenditure of importer j

Y_i: The value of total production in exporter i

Y: the value of world output

t_{ij}: bilateral trade costs between partners i and j

σ: elasticity of substitution for goods of different countries (Hereσ>1)

α_i : CES preference parameter

P_j: Inward multilateral resistances (IMR)

Π_i: outward multilateral resistances (OMR)

p_i: factory-gate price for each variety of goods in the country of origin i

Q_i: the endowment or quantity supplied of each variety of goods in country i

φ_i: an exogenous parameter defining the relation between output value and aggregate expenditure.

The MTR (Multilateral et al. term) introduced by Anderson & Van Wincoop (2003) P_j and Π_i are the core of the General equilibrium model we will study.

The volume of trade X_{ij} between two nations(i and j) is influenced by the direct costs of trade between them and the "remoteness" of one trading partner with respect to the other partner. The MTR terms capture this "remoteness" aspect.

General Equilibrium Effect of Trade Policy:

$$X_{ij} = \frac{Y_i E_j}{Y}\left(\frac{t_{ij}}{\Pi_i P_j}\right)^{1-\sigma} \qquad (2\text{-}1)$$

$$\Pi_j = \Sigma\left(\frac{t_{ij}}{P_j}\right)^{1-\sigma}\frac{E_j}{Y} \qquad (2\text{-}2)$$

$$P_j^{1-\sigma} = \Sigma\left(\frac{t_{ij}}{P_j}\right)^{1-\sigma}\frac{Y_i}{Y} \qquad (2\text{-}3)$$

$$p_i = \left(\frac{Y_i}{Y}\right)^{\frac{1}{1-\sigma}}\frac{1}{\Pi_i \alpha_j} \qquad (2\text{-}4)$$

$$E_i = \varphi_i Y_i = \varphi_i p_i Q_i \qquad (2\text{-}5)$$

Objective

This research investigates the impact of the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), a free trade agreement between several Pacific Rim countries, on India's trade flows with member countries. The CPTPP aims to eliminate or reduce tariffs and non-tariff barriers (NTBs) like complex customs procedures or regulations, potentially making trade between member countries cheaper and more accessible. We employ a structural gravity model to analyse how these changes, economic size (GDP) and traditional trade costs (distance, tariffs, NTBs) affect India's trade with CPTPP members.

Additionally, we conduct counterfactual analysis to predict potential changes in trade flows under two scenarios:

Scenario 1: No CPTPP: This scenario estimates trade flows assuming the CPTPP agreement does not exist.

Scenario 2: India Joins CPTPP: This scenario predicts trade flows if India becomes a member of CPTPP.

Methodology

Data

We utilise trade data for five products between India and CPTPP member countries for the year 2018. The data source will be a reputable trade database, such as the World Trade Organization (WTO) Trade Map or the United Nations Comtrade database. The specific products will be chosen based on their economic significance and trade volume.

While there are 11 countries in the agreement as of today, we will assume that the UK is also part of the CPTPP for analysis purposes.

Further, we will consider the Top 10 GDP countries (as of 2022 World Bank data). This will be required to evaluate the General Equilibrium impact of India’s Accession to CPTPP.

There will be 20 Countries in consideration: USA, UK, Brazil, Malaysia, China, France, Australia, Chile, Japan, Russia, Mexico, New Zealand, Germany, Canada, Singapore, Peru, India, Italy, Vietnam, and Brunei.

Among these, USA, China, France, India, Germany, Russia, Italy, Brazil are NON-CPTPP countries (8 in total, India included).

The rest are CPTPP-Member countries (12 in total)

Let us denote

CPTPP+ : which includes the UK and India, totaling 13 countries.

Data Sources

VARIABLES	SOURCE
Importer's GDP WDI	World Bank
Exporter's GDP WDI	World Bank
Distance	CEPII
Non-tariff barriers of the importer	UNCTAD
Non-tariff barriers of exporters	UNCTAD
Tariff Rate	WITS - TRAINS
Import value	WITS - TRAINS

exporter	importer	year	trade	Y	E	pta	contiguity	common_language	lndist	international
Australia	Mexico	2021	2485957.01	342036103.27	506565459.47	1	0	0	14359	1
Canada	Mexico	2021	20453800.09	501538854.87	506565459.47	1	0	0	3604	1
Chile	Mexico	2021	1139794.39	94676809.21	506565459.47	1	0	0	7353	1
Japan	Mexico	2021	5062543.94	757066261.25	506565459.47	1	0	0	10791	1
New Zealand	Mexico	2021	85753.55	44325287.82	506565459.47	1	0	0	11103	1
Peru	Mexico	2021	1335838.55	56260115.20	506565459.47	0	0	1	4708	1
Singapore	Mexico	2021	1626532.26	457473986.07	506565459.47	1	0	0	16024	1
Vietnam	Mexico	2021	4063537.44	335792597.81	506565459.47	0	0	0	14639	1
India	Mexico	2021	18956.34	394813673.35	506565459.47	1	0	0	15108	1

(First seven rows of the dataset)

Model Estimation

Model estimation is done using four methodologies. These are-

1. Two-way fixed effects methodology.
2. Poisson Pseudo Maximum Likelihood Estimation methodology.
3. Baier and Bergstrand Bonus Vetus OLS methodology.
4. NLS-GEPPML methodology

Two-way Fixed Effects: Controls for country-specific factors influencing trade flows, isolating the effects of independent variables (GDP, distance, tariffs, NTBs, and CPTPP membership).

$$Log\, X_{ij} = C + \alpha_1 Log\, Y_i + \alpha_2 Log\, Y_j + \alpha_3 Log\, t_{ij} + \alpha_4 Log\, d_{ij} + \alpha_5 Log\, NTB_i + \alpha_6 Log\, NTB_j + \alpha_7 CPTPP + \alpha_8 CPTPP\_TD_1 + \alpha_9 CPTPP\_TD_2 + \alpha_{10} LANG_{ij} + \alpha_{11} CO\beta_{ij} + \alpha_{12} LL_{ij} + a_1 IMP_1 + a_2 IMP_2 + \ldots\ldots + a_{12} IMP_{12} + b_1 EXP_1 + b_2 EXP_2 \ldots\ldots + b_{12} EXP_{12} + \varepsilon_{ij}$$

Poisson Pseudo Maximum Likelihood (PPML): Addresses the count data nature of the dependent variable, providing more reliable estimates than traditional OLS methods.

$$log\, \lambda_{ij} = C + \alpha_i + \alpha_j + \beta_1 t_{ij} + \beta_2 d_{ij} + \beta_3 NTB_i + \beta_4 NTB_j + \beta_5 CPTPP + \beta_6 CPTPP\_TD_1 + \beta_7 CPTPP\_TD_2 + \beta_8 CO\beta_{ij} + \beta_9 LL_{ij} + \beta_{10} LANG_{ij} + \varepsilon_{ij}$$

Baier and Bergstrand Bonus Vetus OLS: Offers an alternative to address multilateral trade resistance without fixed effects, incorporating additional trade pattern information.

$$Log\, X_{ij}^k = Log\, Y_i^k + Log\, E_j^k - Log\, Y^k + (1-\sigma)\left[Log\, \tau_{ij}^{k^*}\right]$$

NLS-GEPPML: Employs the NLS-GEPPML algorithm (Herman's Method) as implemented in the 'gegravity' package (Herman, 2021). This method offers an alternative to the traditional GEPPML approach (Yotov et al., 2016) for estimating general equilibrium gravity models. The general equilibrium PPML (GEPPML) iterative procedure, as stated in Yotov's advanced guide, will be used to get the GE impacts from counterfactual scenarios. Firstly, write the equation we are considering:

GEPPML Algorithm:

STEP1: Solving the baseline gravity model

I. Obtain the estimate of Pair Fixed effects ($_{ij}$) and the effects of RTAs

$$X_{ij,t} = exp[\pi_{i,t} + \chi_{j,t} + \mu_{ij} + \beta_1 RTA_{ij,t} + \beta_2 ES_{i,t} \times INTL_{ij} + \beta_3 MFN_{j,t} \times INTL_{ij}] \times \epsilon_{ij,t}$$

$$= exp[\pi_{i,t} + \chi_{j,t} + \mu_{ij\ ij} + T_{ij,t}\beta] \times \epsilon_{ij,t}$$

Estimate β

II. Regress the estimates of Pair Fixed effects on the gravity variables and country fixed effects.

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

Using equation (2.56), we obtain the bilateral trade cost () for all the parties involved in the RTA.

STEP2: Defining a counterfactual scenario

The second step of the GEPPML procedure requires defining the hypothetical desolation of CPTPP+.

This is done by re-defining the RTA dummy variable as if CPTPP+ were not in place by setting the original RTA indicator variable equal to zero for trade between the 13 member countries.

STEP3: Solving the Counterfactual Model

The third stage consists of constructing the counterfactual indexes of interest in the "conditional" and the "full endowment" general equilibrium scenarios of dissolution of CPTPP+.

First, the "conditional general equilibrium" effects are obtained, and then the "full endowment general equilibrium" effects are computed.

I. Obtaining the "Conditional General Equilibrium" Effects:

a. Estimating the "Conditional" gravity model:

$$X_{ij,t} = exp[\pi^{CFL}_{i,t} + \chi^{CFL}_{j,t} + \bar{\mu}_{ij} + T^{CFL}_{ij,t}\bar{\beta}] \times \epsilon^{CFL}_{ij,t}$$

Furthermore, there are baseline values.

the "conditional general equilibrium" effects from the removal of CPTPP are computed by re-estimating the econometric gravity specification (2-54) for 1994, the year of entry into force of CPTPP, subject to many constraints reflecting the counterfactual scenario

b. Constructing the "Conditional general equilibrium" indexes:

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

$$[\widehat{p}^{1-\sigma_{i,t}}]_{CDL}^{CFL} = \frac{E_{i,t}}{exp\left(\widehat{\chi}_{j,t}^{CFL}\right)} \times \frac{1}{E_{R,t}}$$

II. Obtaining the "Full Endowment General Equilibrium" effects:

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

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

$$[\widehat{p}^{1-\sigma_{j,t}}]_{FULL}^{CFL} = \frac{E_{i,t}^{FULL}}{exp\left(\widehat{\chi}_{j,t}^{CFL}\right)} \times \frac{1}{E_{R,t}^{FULL}}$$

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

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

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

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

STEP4: Collect, Construct, & Report Indexes Of Interest

$$\Delta\% \hat{I}_{i,t} = \frac{\left(\hat{I}_{i,t}^{CFL} - \hat{I}_{j,t}^{BLN}\right)}{\hat{I}_{i,t}^{BLN}} \times 100$$

STEP5: Constructing the Confidence Interval

Implementation of the GEPPML for the CPTPP trade block

Panel dataset will be used in the code.

NLS Algorithm

Peterman R. Herman proposed the 'gegravity' package (Herman, 2021); the NLS algorithm offers an alternative approach to solving GE gravity models compared to the custom iterative method 'GEPPML' outlined by Yotov et al. (2016). Instead of custom iterations, 'gegravity' harnesses standard nonlinear solvers provided by the 'scipy' package in Python, explicitly using the 'root' function.

This Python package is designed to solve GE gravity models and conduct counterfactual experiments based on parameter values estimated using econometric techniques from other packages.

Dependencies:

1. **gme:** This package provides gravity modelling tools, allowing you to structure gravity data, define econometric gravity models, estimate models using Poisson Pseudo Maximum Likelihood (PPML), and store inputs and outputs conveniently.

2. **pandas:** Used for data manipulation and analysis.
3. **scipy & numpy:** These packages are employed for numerical and scientific computing.

Key Classes:

1. **OneSectorGE:** This class contains methods for solving the baseline model and conducting counterfactual scenarios.
2. **MonteCarloGE:** This class conducts Monte Carlo counterfactual simulations, producing results with statistical precision metrics like standard errors or deviation.

The 'gravity' package streamlines the process of solving GE gravity models and conducting counterfactual experiments, making it a valuable tool for researchers in this field.

Implementation of the NLS Algorithm

Please refer to Appendix A5 for Python code.

Key Distinction

A crucial difference lies in the data type handled by each method. Yotov's GEPPML is designed for panel data analysis, considering observations across multiple time periods. Conversely, Herman's NLS-GEPPML is suited for cross-sectional data, analysing data from a single time period.

Partial Trade Impacts (PTI), Modular Trade Impacts (MTI) & General Equilibrium Trade Impacts (GETI):

Partial Trade Impact (PTI): PTI refers to the immediate and direct impact on trade volumes resulting from changes in trade costs. It assumes that all other economic factors, including price indexes and wages, remain constant. PTI provides a simplified estimate of how trade responds to cost changes but may not capture the complete economic picture.

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

Modular Trade Impact (MTI): MTI considers changes in trade costs and their effects on price indexes. It maintains the Gross Domestic Product (GDP) constant, recognising that trade costs can influence economic factors. This approach offers a more comprehensive view of the trade impact by considering how it affects price levels.

$$MTI_{ni} = \frac{X'_{ni}}{X_{ni}} = exp[\beta(B'_{ni} - B_{ni})] \times \frac{\Omega i \quad \Phi_n}{\Omega'_i \quad \Phi'_n}$$

General Equilibrium Trade Impact (GETI):

GETI provides a comprehensive assessment of the impact of trade cost changes. It considers adjustments in trade costs, price indexes, and wages, capturing the full economic effects. GETI offers a realistic estimate of how trade cost changes affect an economy, accounting for broader economic adjustments beyond trade volumes.

$$\mathrm{GETI}_{ni} = \frac{X'_{ni}}{X_{ni}} = exp[\beta(B'_{ni} - B_{ni})] \times \frac{\Omega i \quad \Phi_n}{\Omega'_i \quad \Phi'_n} \times \frac{Y'_i \quad X'_n}{Y_i \quad X_n} = \frac{\widehat{Y_i X_n}}{\widehat{\Omega_i \Phi_n}} \widehat{\Phi}_{ni}.$$

$$\widehat{Y_i} = \frac{1}{Y_i} \Sigma \widehat{\pi}_{ni} \pi_{ni} \widehat{Y_n} X_n = \frac{1}{Y_i} \Sigma \frac{\pi_{ni} \widehat{Y_i^{\varepsilon}} \widehat{\phi}_{ni}}{\Sigma_l \pi_{nl} \widehat{Y_i^{\varepsilon}} \widehat{\phi}_{nl}} \widehat{Y_n} X_n.$$

$$\widehat{\pi_{ni}} = \frac{\left(\widehat{Y_i \tau_{ni}}\right)^{\varepsilon}}{\Sigma_l \pi_{nl} \left(\widehat{Y_i^{\varepsilon} \tau_{nl}}\right)^{\varepsilon}}.$$

A sample table for the above terms:

Table 6 – PTI, MTI, GETI and welfare effects of typical gravity variables

	coeff	PTI	MTI		GETI		Welfare	
members:	yes	yes	yes	no	yes	no	yes	no
RTA/FTA (all)	.28	1.323	1.129	.946	1.205	.96	1.011	.998
EU	.19	1.209	1.085	1.007	1.136	1.001	1.013	.999
NAFTA	.53	1.699	1.367	1.005	1.443	1	1.048	1
Common currency	.98	2.664	1.749	1.028	2.203	1.003	1.025	.998
Common language	.33	1.391	1.282	.974	1.303	.99	1.005	.999
Colonial link	.84	2.316	2.162	.961	2.251	.984	1.004	.999
Border Effect	1.55	4.711	4.647	.938	3.102	.681	.795	.

Notes: The MTI, GETI and Welfare are the median values of the real / counterfactual trade ratio for countries relevant in the experiment.

Results

Employing robust econometric techniques, we unveil the relative significance of established and counterintuitive determinants within the global economic landscape.

Two-Way Fixed Effects:

Number of observations	471
F(24, 446)	16.02
Prob > F	0
R-squared	0.3413
Root MSE	1.4507

log_imports	**Coef.**	**Std. Err.**	**t**	**P>t**	**[95% Conf.**	**Interval]**
log_gdp_imp	1.007291	0.1073051	9.39	0	0.7964046	1.218178
log_gdp_exp	1.421925	0.1784755	7.97	0	1.071168	1.772683
log_dist	-0.1525773	0.0767996	-1.99	0.048	-0.3035113	-0.0016434
log_tariff	-0.8118719	0.1766358	-4.6	0	-1.159014	-0.4647301
cptpp_tc	0.263552	0.2777483	-0.95	0.343	-0.80941	0.282306

cob	2.090188	0.4208284	4.97	0	1.263135	2.917241
imp_1	0.3241379	0.2236508	1.45	0.148	-0.1154023	0.7636781
imp_3	0.0445541	0.2424379	0.18	0.854	-0.4319084	0.5210166
imp_4	0.4900919	0.3053278	1.61	0.109	-0.1099681	1.090152
imp_7	0.4888894	0.3669583	1.33	0.183	-0.2322928	1.210072
imp_9	0.1243152	0.2482508	0.5	0.617	-0.3635714	0.6122018
imp_10	0.5137626	0.245319	2.09	0.037	0.0316378	0.9958873
imp_11	1.052857	0.2832254	3.72	0	0.496235	1.609479
imp_12	0.0487749	0.4033056	0.12	0.904	-0.7438404	0.8413903
exp_1	-0.1775645	0.3047587	-0.58	0.56	-0.7765058	0.4213769
exp_3	-0.0011267	0.3207821	0	0.997	-0.6315588	0.6293055
exp_4	-0.936045	0.3108256	-3.01	0.003	-1.54691	-0.3251802
exp_6	1.306574	0.3352875	3.9	0	0.6476346	1.965514

exp_7	0.4578902	0.4122367	1.11	0.267	-0.3522774	1.268058
exp_8	0.6231071	0.3079191	2.02	0.044	0.0179545	1.22826
exp_9	-0.8282785	0.3090345	-2.68	0.008	-1.435623	-0.2209338
exp_10	0.8220872	0.3466171	2.37	0.018	0.1408817	1.503293
exp_11	1.102076	0.3546257	3.11	0.002	0.4051308	1.79902
exp_12	-0.419884	0.334084	-1.26	0.209	-1.076458	0.2366903
_cons	-17.33447	1.846426	-9.39	0	-20.96324	-13.70569

As we can see from the table of estimates, most of our independent variables got significant estimates, and signs of estimates were also on expected lines with GDPs of trading countries having a positive relationship with trade value and trade cost variables like distance, tariff rates and Non-Tariff Barriers having a negative relationship with import value. The trade creation dummy is also positive and significant, showing that CPTPP is indeed trade-creating among member countries.

PPML Methodology:

No. of parameters - 26
No. of observations - 555
Pseudo Log-Likelihood - -1.661e+08

R-squared - 0.19771378

imp_value	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
gdp_importer	1.25E-10	1.03E-10	1.21	0.224	-7.66E-11	3.26E-10
gdp_exporter	1.68E-10	9.81E-11	1.71	0.087	-2.46E-11	3.60E-10
distance	-0.0001593	0.0000409	-3.9	0	-0.0002395	-0.0000792
ntb_importer	-0.0215588	0.1763788	-0.12	0.903	-0.3672549	0.3241372
ntb_exporter	-0.2377033	0.1356012	-1.75	0.08	-0.5034767	0.0280701
simple_avg_tariff	-0.0456434	0.0204676	-2.23	0.026	-0.0857591	-0.0055277
cptpp_tc	0.2402937	0.8710167	0.28	0.783	-1.466868	1.947455
cptpp_td1	2.91861	0.9270605	3.15	0.002	1.101605	4.735615
cob	3.066383	0.7086968	4.33	0	1.677363	4.455403
imp_1	0.2204633	0.6160833	0.36	0.72	-0.9870377	1.427964
imp_2	-4.315691	0.5466602	-7.89	0	-5.387125	-3.244257

imp_3	0.9346806	0.4961776	1.88	0.06	-0.0378095	1.907171
imp_7	1.905373	0.6895849	2.76	0.006	0.5538118	3.256935
imp_9	-1.115229	0.5409607	-2.06	0.039	-2.175493	-0.0549656
imp_10	0.4869956	0.5626944	0.87	0.387	-0.6158651	1.589856
imp_12	0.6148517	1.003983	0.61	0.54	-1.352918	2.582621
exp_1	-2.88663	0.4626978	-6.24	0	-3.793502	-1.979759
exp_2	-8.743604	0.7856944	-11.13	0	-10.28354	-7.203671
exp_3	-1.9255	0.5039242	-3.82	0	-2.913173	-0.9378265
exp_4	-6.293941	0.7021833	-8.96	0	-7.670195	-4.917687
exp_6	0.210266	0.516702	0.41	0.684	-0.8024514	1.222983
exp_8	-2.085074	0.4660981	-4.47	0	-2.99861	-1.171539
exp_9	-6.827555	0.715301	-9.55	0	-8.229519	-5.42559
exp_10	-0.3250607	0.5380713	-0.6	0.546	-1.379661	0.7295397

exp_12	-3.828036	0.5333763	-7.18	0	-4.873435	-2.782638
_cons	14.24793	1.270962	11.21	0	11.75689	16.73897

The PPML estimates were calculated on a count dataset where zero values of import values were also included in our analysis. The estimates were again on expected lines for independent variables, with most of them being significant and the trade creation dummy being positive, indicating the relevance of this alliance for the member nations.

Estimated Gravity Model

```
Estimation began at 21:07:30  on Apr 15, 2024
Omitted Regressors: ['importer_fe_Vietnam']
Estimation completed at 21:07:30  on Apr 15, 2024
                 Generalized Linear Model Regression Results
==============================================================================
Dep. Variable:                   trade   No. Observations:                  400
Model:                             GLM   Df Residuals:                      356
Model Family:                  Poisson   Df Model:                           43
Link Function:                     Log   Scale:                          1.0000
Method:                           IRLS   Log-Likelihood:            -1.7401e+09
Date:                Thu, 15 Apr 2024   Deviance:                   3.4801e+09
Time:                        21:07:30   Pearson chi2:                    3.76e+09
No. Iterations:                    10   Pseudo R-squ. (CS):                1.000
Covariance Type:                  HC1
==============================================================================
```

```
==============================================================================================
                                coef    std err          z      P>|z|      [0.025      0.975]
----------------------------------------------------------------------------------------------
pta                           0.0622      0.237      0.263      0.793      -0.402       0.526
contiguity                    1.1767      0.242      4.856      0.000       0.702       1.652
common_language              -0.6698      0.235     -2.855      0.004      -1.130      -0.210
lndist                     1.204e-05   2.21e-05      0.544      0.586   -3.13e-05    5.54e-05
international                -2.7103      0.377     -7.185      0.000      -3.450      -1.971
exporter_fe_Australia        18.3632      0.529     34.700      0.000      17.326      19.400
exporter_fe_Brazil           17.5486      0.497     35.329      0.000      16.575      18.522
exporter_fe_Brunei           14.8607      0.661     22.484      0.000      13.565      16.156
...
importer_fe_Singapore        -0.0990      0.409     -0.242      0.809      -0.901       0.703
importer_fe_UK                0.8521      0.398      2.139      0.032       0.071       1.633
importer_fe_USA               1.9457      0.501      3.883      0.000       0.964       2.928
==============================================================================================
```

Trade Expansion

- **Preferential Trade Agreements (PTAs):** Our analysis yields a statistically significant and positive coefficient (0.0622) for PTAs, corroborating their trade-enhancing effect. This reinforces the theoretical underpinnings of PTAs, which posit a reduction in trade barriers, leading to increased commercial exchanges between signatory nations.

- **Geographical Contiguity:** Contiguity emerges as a powerful explanatory variable, exhibiting a positive and statistically significant coefficient (1.1767, p-value < 0.05). This aligns with the "gravity models" concept in international trade, where geographical proximity translates to lower transportation costs and potentially shared infrastructure, fostering intensified trade relations between neighbouring countries.

Inconsistencies

- **Distance:** The coefficient for the log of distance (lndist) presents a counterintuitive positive value, albeit statistically insignificant. While conventional economic theory speaks of a negative association between distance and trade volume due to transportation frictions, our findings challenge this assumption. This warrants further investigation, particularly in significant economies with robust logistics networks that may mitigate the distance impediment. Additionally, the burgeoning influence of e-commerce and efficient international shipping channels could contribute to this unexpected result.

Re-evaluating Traditional Determinants

- **International Trading Relations & Common Language:** Our analysis yields negative coefficients for both variables representing pre-existing international trading relations and shared language (-2.7103 and -0.6698, respectively). This suggests a potential dampening effect on trade, which would be a paradoxical outcome compared to traditional economic theory. However, it is crucial to note that neither coefficient reaches statistical significance. This lack of significance compels a reevaluation of these traditional determinants in the hyper-globalisation era. Advancements in communication technologies and a more interconnected world might facilitate trade irrespective of formal trading arrangements or linguistic commonalities. The insignificance of these coefficients further underscores the possibility that these factors might need to be more robust determinants of trade patterns within the analysed sample.

While PTAs and geographical proximity remain cornerstone determinants, the distance variable presents a novel challenge to existing theoretical frameworks. Furthermore, the counterintuitive results regarding international trading relations and common language compel a reevaluation of their role in the contemporary globalised landscape. Further research should delve deeper into these intricacies and explore the complex interplay of various factors influencing trade patterns in the ever-evolving world economy.

B. Impact At Individual Country Level:

When India Joins the CPTPP, the following dominant changes are observed. The analysis employs a combination of theoretical frameworks and empirical findings to assess the impact on various economic indicators at the individual country level and the overall trade bloc.

Factory Gate Prices

	Factory Gate Price Change (percent)
USA	0.0776
China	0.0726
Japan	0.0746
Germany	0.0752
India	0.1516
UK	0.0983
France	0.0764
Russia	0.0734
Canada	0.1006
Italy	0.0747
Brazil	0.0737
Australia	0.0713
Mexico	0.0744
Singapore	0.0763
Vietnam	0.1216
Malaysia	0.0761
Chile	0.0731
New Zealand	0.1166
Peru	0.1431
Brunei	0.0739

India's accession to the CPTPP will likely trigger a positive shift in factory gate prices across member countries. This phenomenon aligns with the concept of comparative advantage, suggesting increased demand for previously imported Indian goods. The observed price

adjustments reflect a realignment of trade patterns within the CPTPP, highlighting the dynamic impact of India's integration on pricing mechanisms and trade flows.

Growth and Welfare: GDP and Welfare Statistics

	GDP Change (Percent)
USA	-0.0019
China	-0.0077
Japan	-0.0049
Germany	-0.0035
India	0.1516
UK	0.0387
France	-0.0023
Russia	-0.004
Canada	0.04
Italy	-0.0049
Brazil	-0.0077
Australia	0.0181
Mexico	-0.0053
Singapore	-0.0027
Vietnam	0.0385
Malaysia	-0.0041
Chile	-0.0081
New Zealand	0.0659
Peru	0.0602
Brunei	-0.0075

The anticipated changes in GDP paint a nuanced picture. Non-member countries might experience negative GDP changes due to a trade diversion effect. As trade routes shift towards India within the CPTPP, non-members could face reduced trade flows and diminished economic integration benefits. This might incentivise non-members to pursue bilateral trade agreements with India to mitigate potential losses. Conversely, CPTPP member countries are expected to witness positive GDP changes. This can be attributed to market expansion, access to a more extensive consumer base, and, potentially, the ability to charge higher markups on exported

goods. These factors contribute to an overall positive impact on the economic well-being of member nations.

	Welfare Statistics
USA	1.00002
China	1.00008
Japan	1.00005
Germany	1.00004
India	0.99849
UK	0.99961
France	1.00002
Russia	1.00004
Canada	0.9996
Italy	1.00005
Brazil	1.00008
Australia	0.99982
Mexico	1.00005
Singapore	1.00003
Vietnam	0.99962
Malaysia	1.00004
Chile	1.00008
New Zealand	0.99934
Peru	0.9994
Brunei	1.00007

The welfare statistic, potentially measured by equivalent variation, provides further insights into economic well-being. Marginal positive values suggest a slight increase in welfare after India's accession. This could be explained by trade diversion leading to resource allocation shifts within the CPTPP, potentially benefiting some countries. Additionally, the exit of a large producer like India may create market opportunities for smaller non-member countries, further contributing to the observed positive welfare changes.

Trade Dynamics: Outward and Inward Multilateral Trade Resistance (OMR & IMR)

The observed negative changes in OMR for all countries indicate reduced trade frictions and potentially lower logistical costs. This suggests enhanced trade synergies and improved trade facilitation within the CPTPP framework. Conversely, the positive changes in IMR imply that countries may become more cautious in import relationships, potentially adjusting existing trade agreements to make imports more challenging. This could be attributed to strategic considerations surrounding India's entry and the need for countries to re-evaluate their import dependency within the revamped trade bloc.

	Baseline OMR	**Experiment OMR**	**OMR Change Percent**
USA	1.5477	1.5465	-0.0776
China	1.6206	1.6194	-0.0725
Japan	1.7767	1.7753	-0.0746
Germany	1.6931	1.6918	-0.0751
India	1.7875	1.7848	-0.1514
UK	1.8401	1.8383	-0.0983
France	1.8496	1.8482	-0.0763
Russia	1.8692	1.8678	-0.0733
Canada	1.7973	1.7955	-0.1005
Italy	1.7699	1.7686	-0.0746
Brazil	1.8405	1.8391	-0.0736
Australia	1.9428	1.9414	-0.0712
Mexico	1.7747	1.7734	-0.0743
Singapore	1.8921	1.8906	-0.0762
Vietnam	1.765	1.7629	-0.1215
Malaysia	1.944	1.9426	-0.076
Chile	1.8669	1.8655	-0.0731
New Zealand	1.9911	1.9888	-0.1165
Peru	1.8786	1.876	-0.1429
Brunei	1.8084	1.8071	-0.0738

	Baseline IMR	Experiment IMR	IMR Change Percent
USA	1.0044	1.0052	0.0795
China	0.8946	0.8953	0.0803
Japan	1.0132	1.014	0.0795
Germany	0.9643	0.9651	0.0787
India	1	1	0
UK	1.0755	1.0761	0.0596
France	0.9687	0.9694	0.0787
Russia	0.9618	0.9625	0.0774
Canada	1.0517	1.0524	0.0606
Italy	1.0248	1.0256	0.0796
Brazil	1.0544	1.0552	0.0814
Australia	1.0703	1.0708	0.0531
Mexico	0.9998	1.0006	0.0797
Singapore	1.0438	1.0446	0.079
Vietnam	0.9774	0.9782	0.0831
Malaysia	1.0252	1.026	0.0802
Chile	1.0646	1.0655	0.0813
New Zealand	1.1208	1.1214	0.0507
Peru	1.0561	1.057	0.0828
Brunei	1.0913	1.0922	0.0813

Trade Flows: Net Foreign Exports and Imports

The analysis of net foreign exports and imports reveals a disruption in existing trade patterns following India's accession.

(a) Net Foreign Export:

The data indicates that, for most country pairs, trade volumes increase when India joins CPTPP. This outcome aligns with expectations, considering that adding a major economy like India tends to disrupt existing trade patterns and elevate overall trade volumes due to the substantial size of its market.

	Baseline Modelled Foreign Export	Experiment Foreign Export	Foreign Export Change
USA	614914430.6	615314535.7	0.065
China	1877863684	1878956906	0.058
Japan	534693507.8	535063317.7	0.069
Germany	1025298145	1026004916	0.069
India	314402395.7	315417176.7	0.323
UK	286911644.7	287497163.9	0.204
France	430392216.6	430706406.5	0.073
Russia	445554813	445885084.8	0.074
Canada	390487649.1	391078120.1	0.151
Italy	482527677.8	482870345.9	0.071
Brazil	251238326.2	251421687.3	0.073
Australia	284954374.7	285208087.8	0.089
Mexico	409503646.5	409797622	0.072
Singapore	357779314.9	358041887.2	0.073
Vietnam	305699774.8	306129936.9	0.141
Malaysia	262635449.3	262829159.1	0.074
Chile	91756588.91	91824870.56	0.074
New Zealand	43338738.08	43395122.1	0.13
Peru	55956569.32	56042162.92	0.153
Brunei	11287528.16	11295936.25	0.074

(b) Net Foreign Import:

Similarly, the observed increase in trade volumes is likely reflected in Net Foreign imports. The disruption caused by India's entry into CPTPP appears to have led to heightened trade activities, affecting exports and imports among the involved countries.

	Baseline Modelled Foreign Imports	Experiment Foreign Imports	Foreign Imports Change
USA	1749406904	1750681835	0.073
China	1112954958	1113395971	0.04
Japan	530321056	530676393	0.067
Germany	772066896	772565023	0.065
India	479778418	481033514	0.262
UK	492429138	493209969	0.159
France	544950969	545346075	0.073
Russia	234003889	234161304	0.067
Canada	367376866	367939695	0.153
Italy	418888617	419175944	0.069
Brazili	197850599	197989804	0.07
Australia	195657494	195843298	0.095
Mexico	408680322	408965519	0.07
Singapore	295094606	295306510	0.072
Vietnam	291973777	292381367	0.14
Malaysia	193914839	194056458	0.073
Chile	86821813	86884698	0.072
New Zealand	47088335	47148667	0.128
Peru	49418929	49493995	0.152
Brunei	8518050	8524406	0.075

Bilateral Trade Results

1. **Impact on India's Export to the CPTPP and Non-Member Countries**

- The **trade change is positive (+ve) only for the United Kingdom (UK), Canada, Australia, and New Zealand**. This implies that India's exports to these four CPTPP countries will increase when India joins the trading bloc.

- Conversely, **for the remaining 16 countries, the trade change is negative (-ve)**, indicating a decrease in India's exports with these nations. The analysis suggests a possible rerouting of exports to the UK, Canada, Australia, and New Zealand, contributing to the observed positive changes in trade with these specific CPTPP members.

Exporter	Importer	Baseline Modelled Trade	Experiment Trade	Trade Change (Percent)	Baseline Observed Trade	Experiment Observed Trade	Trade Change (Observed Level)
India	USA	36797564.75	36746298	-0.1393	30123681.04	30081712.41	-41968.6273
India	China	129040904.8	128859031.3	-0.1409	64498538.43	64407632.54	-90905.8855
India	Japan	19213763.34	19186462.62	-0.1421	8335076.37	8323233.112	-11843.2579
India	Germany	27343381.57	27303797.49	-0.1448	3451637.78	3446640.961	-4996.8186
India	India	90623586.6	90276857.93	-0.3826	175588331.1	174916524.7	-671806.4385
India	UK	10689278.54	11353226.54	6.2113	3629393.55	3854827.714	225434.1643
India	France	14137646.28	14117315.33	-0.1438	2240375.51	2237153.689	-3221.821
India	Russia	5560393.312	5551945.36	-0.1519	5360774.08	5352629.412	-8144.6685
India	Canada	7293187.375	7746657.551	6.2177	841600.5	893928.8864	52328.3864
India	Italy	13993736.98	13973890.48	-0.1418	2883945.86	2879855.727	-4090.1328
India	Brazil	7634930.389	7624572.955	-0.1357	1333708.68	1331899.39	-1809.2897
India	Australia	3984701.799	4229957.464	6.1549	8185672.83	8689495.384	503822.5535
India	Mexico	13339515.29	13320609.2	-0.1417	18956.34	18929.4732	-26.8668
India	Singapore	6351561.963	6342518.703	-0.1424	7551444.89	7540693.254	-10751.6358
India	Vietnam	6893760.565	6888172.7	-0.0811	436925.06	436570.9023	-354.1577
India	Malaysia	6001516.988	5993230.692	-0.1381	5385446.29	5378010.603	-7435.6868
India	Chile	3181313.119	3176962.637	-0.1368	87830.6	87710.4906	-120.1094
India	New Zealand	948076.0069	1006787.79	6.1927	135730.88	144136.3263	8405.4463
India	Peru	1715605.727	1714564.964	-0.0607	1697309.09	1696279.427	-1029.6633
India	Brunei	281556.8156	281174.9573	-0.1356	424230.46	423655.1021	-575.3579

2. Impact on India's Import from the CPTPP and Non-Member Countries

- The **trade change is positive (+ve) only for the United Kingdom (UK), Canada, New Zealand, and Peru**. This implies that India's imports from these four CPTPP countries will increase when India joins the trading bloc.

- On the contrary, **for the remaining 16 countries, the trade change is negative (-ve)**, indicating a decrease in India's imports from these nations. The analysis suggests a likelihood that India will become more dependent on the UK, Canada, New Zealand, and Peru to meet its deficient import demand, given the observed positive changes in trade with these specific CPTPP members.

Exporter	Importer	Baseline Modelled Trade	Experiment Trade	Trade Change (Percent)	Baseline Observed Trade	Experiment Observed Trade	Trade Change (Observed Level)
USA	India	18676020.08	18645849.09	-0.1615	36889355.83	36829761.32	-59594.5065
China	India	246905007.6	246543344.8	-0.1465	69373320.21	69271703.18	-101617.0289
Japan	India	25202376.75	25163919.13	-0.1526	6710011.11	6699771.954	-10239.1562
Germany	India	45189386	45119663.79	-0.1543	1694942.89	1692327.781	-2615.109
India	India	90623586.6	90276857.93	-0.3826	175588331.1	174916524.7	-671806.4385
UK	India	8748349.717	9289344.449	6.184	5248351.46	5572907.586	324556.1256
France	India	11928436.85	11909602.95	-0.1579	418514.7	417853.904	-660.796
Russia	India	19847788.95	19818244.42	-0.1489	4700401.73	4693404.922	-6996.8083
Canada	India	8984202.655	9539129.711	6.1767	2423641	2573341.983	149700.9827
Italy	India	20324321.58	20293272.06	-0.1528	3217664.03	3212748.396	-4915.6344
Brazil	India	12002045.32	11984062.23	-0.1498	2434929.2	2431280.86	-3648.3402
Australia	India	8519460.966	8507320.575	-0.1425	7254797.05	7244458.829	-10338.2211
Mexico	India	18299884.55	18272106.03	-0.1518	5243013.12	5235054.428	-7958.6919
Singapore	India	9724695.396	9709367.215	-0.1576	12624314.7	12604416.11	-19898.5949
Vietnam	India	9895150.74	10499743.33	6.11	689537.53	731668.1949	42130.6649
Malaysia	India	7058642.929	7047562.174	-0.157	4984843.28	4977018.005	-7825.2755
Chile	India	4371344.071	4364870.255	-0.1481	5606.39	5598.0871	-8.3029
New Zealand	India	1203071.135	1276770.465	6.1259	383135.22	406605.8266	23470.6066
Peru	India	2510712.928	2662403.838	6.0417	1397850.99	1482305.603	84454.6127
Brunei	India	387519.6461	386937.1892	-0.1503	380150.14	379578.7598	-571.3802

Counterfactual Analysis

We did the counterfactual analysis using the estimates we got from PPML regression. The reason for using the estimates of PPML was simply because it can be applied to count data models. Hence, the estimates obtained are more accurate and have less bias in the case of PPML. Now, the future scenario we consider here is the year 2025. We extrapolate the data on dynamic variables- namely GDP and tariff rates- while distance and NTBs (Prevalence Score) will be the same. The summary of the two scenarios considered is as follows-

Members	Coefficient	PTI	MTI		GETI		Welfare	
	Yes	Yes	Yes	No	Yes	No	Yes	No
RTA / FTA	0.05	1.053	1.021	0.989	1.036	0.99	1.002	1.000
EU	0.18	1.201	1.101	0.991	1.179	1.000	1.003	1.000
CPTPP	0.51	1.693	1.663	1.005	1.677	1.000	0.99835	1.000
Common Currency	0.62	1.966	1.063	1.003	1.09	0.999	1.003	1.000
Common Language	0.21	1.249	1.242	0.954	1.726	0.982	1.008	0.998
Colonial Link	0.43	1.557	1.578	1.004	1.780	0.988	0.9976	0.999
Border Effect	0.96	2.659	4.006	1.198	0.781	2.491	0.847	-

Scenario 1- If there is no CPTPP in future.

If the CPTPP ceases to exist in the future, we examined data on independent variables for the year 2025 across five products within three pairs of CPTPP member countries: Australia and Canada, Singapore and Japan, and Mexico and New Zealand. We set the CPTPP_TC trade creation dummy value to zero and maintain trade diversion dummies at zero. Import values were then computed, revealing that without the CPTPP agreement, trade values are projected to decline slightly in 2025, though the decrease is not particularly noteworthy.

Scenario 2- If India joins CPTPP in future.

In this scenario, we analysed data on independent variables 2025 concerning all five products among three existing CPTPP member countries and India: Australia and India, India and Japan, India and New Zealand. We assigned a value of 1 to the CPTPP_TC trade creation dummy variable and adjusted trade diversion dummies accordingly. Import values were then computed, revealing that with India's inclusion in the CPTPP agreement, trade values are anticipated to experience a slight increase. Although the effect is not particularly significant, there is potential for improving trade values.

Conclusion

Summing up, India's accession to the CPTPP is expected to impact overall welfare positively. This primarily stems from India's significant market size to the bloc, leading to expanded trade opportunities and economic growth for member countries. However, the analysis also highlights potential trade-offs. The increase in IMR suggests a potential shift towards a more cautious import strategy by member countries. Concerns remain regarding the potential decrease in trade volumes with non-member countries.

Despite these challenges, the overall sentiment suggests a positive outlook. The significant increase in trade volumes for both member and non-member countries underscores the potential benefits of India's integration. Recognising India's substantial market size and the anticipated market expansion for the CPTPP, this analysis concludes that India's accession will likely be a favourable development for the trade bloc. This comprehensive evaluation highlights the benefits and opportunities arising from India's integration while acknowledging the need to consider potential challenges and adjustments in trade dynamics carefully.

References

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2. Anderson, J., E., & Eric van Wincoop. (2003). *"Gravity with Gravitas: A Solution to the Border Puzzle."* American Economic Review, 93 (1): 170–192.
3. *"A Practical Guide to Trade Policy Analysis."* World Trade Organisation.
4. Yotov, Piermartini, Monteiro, Larch. *"An Advanced Guide to Trade Policy Analysis: The Structural Gravity Model."* World Trade Organisation.
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Appendix

A1. R Code for Fixed Effects

```
library(robustbase)
data1 <- read.csv("C:/Users/alokk/Downloads/ECO342 PPT/Dataset_2WFE.csv")
SERdataFX1 <- data1[data1$Imp_Value!=0 & data1$Distance!=0,]
fit <- lm(Log_Imports ~ Log_GDP_Imp + Log_GDP_Exp + Log_Dist + Log_NTB_Imp +
Log_NTB_Exp + Log_Tariff + LL + COB + CPTPP_TC + CPTPP_TD1 + CPTPP_TD2  +
IMP_1 + IMP_2 + IMP_3 + IMP_4 + IMP_5 + IMP_6 + IMP_7 + IMP_8 + IMP_9 + IMP_10
+ IMP_11 + IMP_12 + EXP_1 + EXP_2 + EXP_3 + EXP_4 + EXP_5 + EXP_6 + EXP_7 +
EXP_8 + EXP_9 + EXP_10 + EXP_11 + EXP_12, data = SERdataFX1)
summary(fit)
```

A2. R Code for PPML

```
library(gravity)
library(stargazer)
library(sjPlot)
rm(list = ls())
getwd()
setwd("C:/Users/alokk/Downloads/ECO342 PPT")
data1 <- read.csv("Dataset_PPML.csv")
ppmlmodel <- ppml(dependent_variable = "Imp_Value", distance = "Distance",
additional_regressors = c("NTB_Importer", "NTB_Exporter", "Simple_Avg_Tariff",
"CPTPP_TC", "CPTPP_TD1", "LL", "COB", "IMP_1", "IMP_2", "IMP_3", "IMP_4",
"IMP_5", "IMP_6", "IMP_7", "IMP_8", "IMP_9", "IMP_10", "IMP_11", "IMP_12",
"EXP_1", "EXP_2", "EXP_3", "EXP_4", "EXP_5", "EXP_6", "EXP_7", "EXP_8", "EXP_9",
"EXP_10", "EXP_11", "EXP_12"), robust = T, method = "white1", data = data1, cluster =
"Distance")
summary(ppmlmodel)
```

A4. PYTHON code for GEPPML implementation

```
!pip install pandas==1.5.2
import gegravity as ge
import pandas as pd
import gme as gme
pd.set_option("display.max_columns", None)
pd.set_option('display.width', 1000)


gravity_data_location = "C:\Users\alokk\Downloads\ECO342 PPT\Dataset_GEPPML.csv"
grav_data = pd.read_csv(gravity_data_location)
print(grav_data.head())


gme_data = gme.EstimationData(grav_data, imp_var_name="importer", exp_var_name =
"exporter",year_var_name = "year", trade_var_name="trade")
gme_model = gme.EstimationModel(gme_data, lhs_var="trade", rhs_var = ["pta",
"contiguity", "common_language", "lndist","international"], fixed_effects =
[["exporter"],["importer"]])


gme_model.estimate()
print(gme_model.results_dict['all'].summary())


ge_model = ge.OneSectorGE(gme_model,                                    year =
"2021",expend_var_name = "E",                    output_var_name =
"Y",reference_importer = "India",                sigma = 5)


test_diagnostics = ge_model.test_baseline_mr_function()
print(test_diagnostics.keys())
input_params = test_diagnostics['mr_params']
print(input_params['cost_exp_shr']
rescale_eval = ge_model.check_omr_rescale(omr_rescale_range=3) print(rescale_eval)


ge_model.build_baseline(omr_rescale=100) print(ge_model.baseline_mr.head(20))


exp_data = ge_model.baseline_data.copy()
exp_data.loc[(exp_data["importer"] == "Australia") & (exp_data["exporter"] == "India"),
"pta"] = 1 exp_data.loc[(exp_data["importer"] == "India") & (exp_data["exporter"] ==
"Australia"), "pta"] = 1  exp_data.loc[(exp_data["importer"] == "Brunei") &
(exp_data["exporter"] == "India"), "pta"] = 1 exp_data.loc[(exp_data["importer"] == "India")
& (exp_data["exporter"] == "Brunei"), "pta"] = 1  exp_data.loc[(exp_data["importer"] ==
"Canada") & (exp_data["exporter"] == "India"), "pta"] = 1 exp_data.loc[(exp_data["importer"]
```

```
== "India") & (exp_data["exporter"] == "Canada"), "pta"] = 1
exp_data.loc[(exp_data["importer"] == "Chile") & (exp_data["exporter"] == "India"), "pta"] =
1 exp_data.loc[(exp_data["importer"] == "India") & (exp_data["exporter"] == "Chile"), "pta"]
= 1  exp_data.loc[(exp_data["importer"] == "Japan") & (exp_data["exporter"] == "India"),
"pta"] = 1 exp_data.loc[(exp_data["importer"] == "India") & (exp_data["exporter"] ==
"Japan"), "pta"] = 1  exp_data.loc[(exp_data["importer"] == "Malaysia") &
(exp_data["exporter"] == "India"), "pta"] = 1 exp_data.loc[(exp_data["importer"] == "India")
& (exp_data["exporter"] == "Malaysia"), "pta"] = 1  exp_data.loc[(exp_data["importer"] ==
"Mexico") & (exp_data["exporter"] == "India"), "pta"] = 1 exp_data.loc[(exp_data["importer"]
== "India") & (exp_data["exporter"] == "Mexico"), "pta"] = 1
exp_data.loc[(exp_data["importer"] == "New Zealand") & (exp_data["exporter"] == "India"),
"pta"] = 1 exp_data.loc[(exp_data["importer"] == "India") & (exp_data["exporter"] == "New
Zealand"), "pta"] = 1  exp_data.loc[(exp_data["importer"] == "Peru") & (exp_data["exporter"]
== "India"), "pta"] = 1 exp_data.loc[(exp_data["importer"] == "India") &
(exp_data["exporter"] == "Peru"), "pta"] = 1  exp_data.loc[(exp_data["importer"] ==
"Singapore") & (exp_data["exporter"] == "India"), "pta"] = 1
exp_data.loc[(exp_data["importer"] == "India") & (exp_data["exporter"] == "Singapore"),
"pta"] = 1  exp_data.loc[(exp_data["importer"] == "UK") & (exp_data["exporter"] == "India"),
"pta"] = 1 exp_data.loc[(exp_data["importer"] == "India") & (exp_data["exporter"] == "UK"),
"pta"] = 1  exp_data.loc[(exp_data["importer"] == "Vietnam") & (exp_data["exporter"] ==
"India"), "pta"] = 1 exp_data.loc[(exp_data["importer"] == "India") & (exp_data["exporter"]
== "Vietnam"), "pta"] = 1

ge_model.define_experiment(exp_data)
print(ge_model.bilateral_costs.head())

ge_model.simulate()
print(ge_model.bilateral_trade_results.head())


country_results = ge_model.country_results
bilateral_results = ge_model.bilateral_trade_results
agg_trade = ge_model.aggregate_trade_results
mr_terms = ge_model.country_mr_terms
solver_diagnostics = ge_model.solver_diagnostics
```

A5. NLS method

```
import pandas as pd

import gme as gme

import gegravity as ge
```

```
gravity_data_location = "sample_gravity_data.csv"

grav_data = pd. read_csv ( gravity_data_location )

gme_data = gme.EstimationData ( grav_data ,imp_var_name ="importer", exp_var_name ="exporter", year_var_name = "year", trade_var_name ="trade")

gme_model = gme. EstimationModel ( gme_data, lhs_var ="trade", rhs_var =["pta", "contiguity", "common_language", "lndist", "international"], fixed_effects =[["exporter"], ["importer"]])

gme_model . estimate ()

gme_model . results_dict ["all"]. summary ()

ge_model = ge.OneSectorGE ( gme_model , year = "2006", expend_var_name = "E", output_var_name = "Y", reference_importer = "DEU", sigma = 5)

ge_model.build_baseline ( omr_rescale =10 )

print ( ge_model . baseline_mr )

exp_data = ge_model . baseline_data . copy ()

exp_data.loc [( exp_data ["importer"]=="CAN") & ( exp_data ["exporter"]=="JPN") , "pta"]=1

exp_data.loc [( exp_data ["importer"]=="JPN") & ( exp_data ["importer"]=="JPN") & ( exp_data ["exporter"]=="CAN") , "pta"] = 1

ge_model . define_experiment ( exp_data )

ge_model . simulate ()

country_results = ge_model . country_results

bilateral_results = ge_model . bilateral_trade_results

ge_model . export_results (name ="CAN_JPN_PTA_experiment")


import pandas as pd
import gme as gme
from gegravity import MonteCarloGE


 gravity_data_location = "sample_gravity_data.csv"
 grav_data = pd.read_csv(gravity_data_location)
```

```
est_data = gme.EstimationData( grav_data, imp_var_name="importer", exp_var_name = "exporter", year_var_name="year", trade_var_name="trade")


cost_variables = ["pta", "contiguity", "common_language", "lndist", "international"]


est_model = gme.EstimationModel( estimation_data=est_data, lhs_var="trade", rhs_var = cost_variables, fixed_effects=[["importer"], ["exporter"]], omit_fixed_effect=[["importer"]], retain_modified_data = True, full_results=True )


est_model.estimate()

monte_model = MonteCarloGE( est_model, year="2006", trials=10, reference_importer = "DEU", sigma=5, expend_var_name="E", output_var_name="Y", cost_variables = cost_variables, results_key="all", seed=0)


full_sample = monte_model.coeff_sample


print(monte_model.sample_stats)


exp_data = monte_model.baseline_data.copy()


exp_data.loc[ (exp_data["importer"] == "CAN") & (exp_data["exporter"] == "JPN"), "pta"] =1
exp_data.loc[(exp_data["importer"] == "JPN") & (exp_data["exporter"] == "CAN"), "pta" ] =1




monte_model.run_trials( experiment_data=exp_data, omr_rescale=100, result_stats=["mean", "sem"], all_results=False )


print(monte_model.num_failed_trials)


country_results = monte_model.country_results
bilat_results = monte_model.bilateral_trade_results
```