Estimating Structural Gravity Model to Analyse a Potential Trading Opportunity between India and CPTPP

Course Project
ECO342A: Econometrics-II
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Introduction

There are ample papers available on different estimation methods for gravity models. Through this project we want to use different methods such as **structural iterated least squares, poissons maximum likelihood estimation, two way fixed effects estimator** and **non-linear least squares** to estimate the structural gravity model given by Anderson and Wincoop to evaluate the situation in which India joins CPTPP. CPTPP(Comprehensive and Progressive Agreement for Trans-Pacific Partnership) is a Free Trade Agreement between countries on the Pacific Rim: Canada, Mexico, Peru, Chile, New Zealand, Australia, Brunei, Singapore, Malaysia, Vietnam and Japan signed in December 2018. It aims to liberalise trade and remove almost all tariff barriers on goods and services traders. It covers nearly all goods ranging from financial services to telecommunications to food.

15% of global trade and 13.4% (US$13.5 trillion) of the world's GDP are represented by CPTPP signatory nations. With a population of 500 million people in the increasingly wealthy Asia-Pacific region, CPTPP is one of the largest free trade agreements in the world by GDP.

India decided against signing the CPTPP because of the tougher labour and environmental criteria. The FTA's draught includes minutely specific requirements for strict transparency as well as norms for the protection of investments and the host country's right to control trade.

Trade between India and the CPTPP group is active. India's balance of accounts with the group was negative in 2017. The top three consumers of India's $41 billion in exports to other members were Malaysia, Singapore, and Vietnam. In contrast, India purchased goods and services worth about US $58 billion, with Australia, Japan, and Malaysia being the top exporters to this country. Precious Stones, Oil & Mineral Fuels, and Industrial Equipment were India's top exports to the group in 2017, while Oil & Mineral Fuels, Precious Stones & Metals, and Metal Ores were India's top imports. These prices as well as the trade have significantly increased over time.

Objective

We hope to analyse counterfactual scenarios and provide solutions to the following issues through this research.

- If India were to join the CPTPP group, how would the value and volume of its bilateral trade with other CPTPP members change?
- What impact would this agreement have on trade between current CPTPP members and non-members?

Additionally, we want to quantify any trade diversion or creation effects that the structural gravity model reveals after analysis.

Approach

We examine a scenario in which India joins the CPTPP under the current FTA. Give the new group the name CPTPP+. We would use a structural gravity model to obtain estimates for trade under the new CPTPP+ regime. There are several approaches available in the extensive literature on gravity model estimating (such as PPML, SILS and Non-linear least squares), we want to compare various methods in order to obtain the most accurate estimates possible to address the problems raised above. The following are some of the techniques we want to use to find the partial effects of the FTA on trade:

- Two-way fixed effects methodology
- Structural Iterated Least Squares Estimator
- Poisson Pseudo Maximum Likelihood estimation
- Gamma Pseudo Maximum Likelihood estimation

- Non -Linear Least Squares Estimator

Literature Review

Gravity Model:

Gravity model's early iterations were mostly based on intuitive elements that might have influenced trading. In order to more effectively describe the actual data, Anderson 1979 changed the model to include more parameters and variables. According to Tinbergen's 1962 primitive gravity model, economic size has a positive impact on trade flow value whereas distance has a negative impact. The model has been used by economists over the years to explain trade together with qualitative factors like population, population density, and cultural diversity. Anderson and Wincoop then put forth a contemporary structural gravity model in 2003. They contended that bilateral trade between nations was reliant on barriers to bilateral trade between the two and was proportional to the outcome of the two countries' resistance to multilateral trade.

Non-linear least squares estimation is one of the more recent techniques for gravity model estimation. Non-linear least squares analysis is used to fit a set of m observations to a model that is non-linear in n unknown parameters. The fundamental principle of the method is to estimate the model using a linear one, followed by iterative parameter adjustment.
The existing literature offers some intriguing methods for estimating the theoretically consistent gravity equation, including the use of price indices for all the countries in a dataset (Baier & Bergstrand, 2007), non-linear least squares (Anderson & van Wincoop, 2003), and country-specific dummies like exporter and importer fixed effects (Baier & Bergstrand, 2007; Hayakawa & Yamashita, 2011). The last approach mentioned above is the one that is most usually used to handle the problem of MRTs in gravity equations. This prompted the incorporation of MRTs in later GMoT-related studies. Baier and Bergstrand (2007) refer to remoteness as what Anderson and van Wincoop (2003) refer to as MRTs. The problem with employing remoteness in the gravity equation is that it is logically illogical because it only considers distance as a trade barrier and ignores other trade obstacles as well as the difficulty of assessing a country's internal distance. The solution to this issue is to use the first order Taylor series expansion, which is a linear approximation of MRTs, as opposed to the conventional non-linear procedure suggested by Anderson and van Wincoop (2003). This illustrates that commerce between the reporting nation and the partner nations is based on bilateral trade costs as opposed to multilateral trade costs, and multilateral trade costs as opposed to global trade costs.

The gravity model has always been empirically insightful, however despite the model's outcomes being consistent with the data, it lacks a strong theoretical foundation that takes into account origin-destination pairs, which has led to criticism from experts for the Foreign Trade Review (Deardorff, 1984, 1998). The multilateral resistance terms MRTs4 and shifts in relative pricing were two difficult and real-world factors that the model ignored. To ensure that the intuitive GMoT has a solid microeconomic foundation and that its conclusions do not contradict the fundamental theories of trade, it was necessary to make several fundamental alterations. Additional advancements include the constant elasticity of substitution (CES) function and the assumption of product differentiation (Anderson, 1979), the micro-founded gravity equation under the increasing returns framework (Bergstrand, 1985, 1989; Ekanayake et al., 2010; Trung Kien, 2009), the Hecksher-Ohlin framework for GMoT, rising returns and monopolistic competition (Helpman & Krugman, 1985), and GMoT based on standard trade theory (Anderson & Yotov, 2010). There have been numerous advancements made to bring the empirical estimation of the gravity model closer to a standard theory, such as the use of GMoT in the panel setting where MRTs are time-varying (Baldwin & Taglioni, 2006), the use of PPML estimation to address the issues of heteroscedasticity and measurement error in the model (Silva & Tenreyro, 2006), and the addition of country, time, and dyad fixed effects in the (Baier & Bergstrand, 2007).

Estimators:

- Two-way fixed effects methodology: A fixed effects model is a statistical model in statistics when the model parameters are constants or non-random variables. In contrast, mixed models and models with random effects have all or some of the model parameters as random variables. Because unobserved heterogeneity is stable throughout time, these models help to mitigate the bias caused by omitted variables. Using differencing, this heterogeneity can be eliminated from the data, for instance by subtracting the group-level average across time or by calculating a first difference, which will eliminate any time invariant model components.

- Structural Iterated Least Squares Estimator: Head and Mayer (2014) created the estimating approach for gravity models known as SILS. The relationship between the terms of Multilateral Resistance and the costs of transactions is used by SILS. An iterative process is used to estimate the parameters. Loops are executed by the function until the arguments no longer significantly change.

- Poisson Pseudo Maximum Likelihood estimation: Silva and Tenreyro (2006) assert that estimating gravity equations by OLS in their additive form results in inconsistency in the presence of heteroscedasticity and advise estimating gravity models by OLS in their multiplicative form using PPML. That holds true even when there are fixed effects, which can be inserted as dummy variables just like in a straightforward OLS model. This is a peculiar quality of nonlinear maximum likelihood estimators, many of which have ill-defined characteristics when fixed effects are included. Because the majority of theory-consistent models demand the inclusion of fixed effects by exporter and by importer, the point is particularly crucial for gravity modelling.

- Gamma Pseudo Maximum Likelihood estimation: Similar to PPML, this estimate approach uses the gamma distribution rather than the poisson distribution, which involves different data structure assumptions and prevents the use of zero trade values. Silva and Tenreyro (2006) suggest that PPML is preferable than GPML, particularly in the situation of heteroscedasticity, however Head and Mayer (2014) stress that there are instances where GPML is preferable to PPML depending on the data structure.

- Maximum Likelihood with Heckman Correction: The bilateral trade matrix commonly has zero trade flows. Zeros appear more frequently when the degree of product disaggregation increases. Helpman et al. (2008) report that about half of the bilateral trade matrix is filled with zeros, even when utilising aggregate trade data. Because the logarithm of 0 is undefined, OLS automatically discards these observations, which raises questions regarding sample selection bias. Using Heckman's sample selection correction is one approach to solving this issue (1979).

- Non - Linear Least Squares Estimator : In order to fit a set of m observations to a model that is non-linear in n unknown parameters (m n), non-linear least squares analysis is utilised. In various types of nonlinear regression, it is used. The method's basic idea is to estimate the model using a linear one and then iteratively adjust the parameters.

India and CPPTP:

According to research, the creation and implementation of FTAs could be detrimental to non-member nations. However, only a few papers have examined the quantitative impacts of FTA; further study is required in this area to better understand the subject. This study of the literature examines the qualitative and quantitative effects on non-participants of an FTA like the CPTPP.

Tianguo Li and Laihui Xie's (2015) research asserts that India's involvement in CTPP will strengthen India's position as one of the leaders in the financial, capital, and software sectors, resulting in increased welfare in India. The Indian textile sector will suffer as a result of non-participation.

Another significant FTA is RCEP, which, in contrast to CPTPP, has higher trade barriers against third parties. Hence, the RCEP has a greater influence on trade diversion. Estimates indicate that excluded RCEP nations will suffer greater welfare losses than excluded countries under the CPTPP. (2014) Dan Ciuriak

Using the GTAP model, Rahman and Anjum Ara attempted to assess the welfare impact of the CPTPP on the countries of South Asia. Their research revealed that if CPTPP countries choose deeper FTA, as they already are, then. The exports and welfare losses for the South Asian countries will decline. India, as the largest economy in the region, will lose the most real GDP. The same conclusion is drawn from a related study by Akman et al. (2015), which noted that regional trading agreements (RTAs) will have a negative effect on third parties. They will join RTAs out of a fear of being left out.

Petri and Plummer (2016) assert that the CPTPP nations will see an increase in FDI as a result of GDP growth and liberalisation, indicating that the rest of the globe will encounter difficulties in luring Investment.

Approach

Data Requirements:

Data required for this analysis consists of all trade data for member nations of CPTPP and India, including but not limited to variables such as value of merchandise exports, GDP of exports and importers, geographical distance, contiguity of land border and language spoken. We would be extracting data from the following three databases for our analysis:

- **International Monetary Fund** (IMF)
- **World Integrated Trade Sources** (WITS)
- **United Nations Conference on Trade and Development** (UNCTAD)
- **CEPII**

Method and Model:

The general gravity model formulation is as follows:

$$\mathbf{Trade_{ij,t} = (gdp_{j,t}) * (gdp_{j,t})/dist_{ij} * \epsilon_{ij,t}}$$

However, upon estimation using ordinary least squares, one finds that it is ridden with problems(omitted variable bias) leading to incorrect estimates. Hence, we use structural gravity model as follows:
Log-linear specification of structural model used in two-way fixed effects for its estimation in India-CPTPP trade can be written as

$$\mathbf{logX_{ij,t} = \beta_1 log(gdp_{exp}) + \beta_2 log(gdp_{imp}) + \beta_3 log(distance_{ij}) + \beta_4 border_{ij} + \beta_5 TB_i + \beta_5 t_{ij}}$$
$$\mathbf{\beta_6 TB_j + \beta language_{ij} + \sum_{k=1}^{k=12} a_k Imp_k + \sum_{k=1}^{k=12} b_k Exp_k + \epsilon_{ij,t}}$$

For analysis of India's trade with CPTPP, data from member countries (11 in total) and of India will be required. In order to estimate the gravity equation for India-CPTPP Trade the value of merchandise exports, GDP of exports and importers, geographical distance, contiguity of land border, spoken language are to be taken. Further year dummies to capture the effects of specific geopolitical events that could affect trade.

For doing estimation using SILS, PPML and NLS we will be using generalised linear model to estimate the gravity model in its multiplicative form

$$\mathbf{log\lambda_{ij} = \beta_1 gdp_{exp} + \beta_2 gdp_{imp} + \beta_3 distance_{ij} + \beta_4 border_{ij} + \beta_5 TB_i + \beta_6 TB_j + \beta_5 t_{ij}}$$
$$\mathbf{\beta_7 language_{ij} + \beta_8 otherRTA_{ij} + \beta_9 TC_{ij} + \beta_{10} TD\_1_j + \beta_{11} TD\_2_i + \sum_{k=1}^{k=12} a_k Imp_k + \sum_{k=1}^{k=12} b_k Exp_k + \epsilon_{ij,t}}$$

For the analysis of trade-creation and trade-diversion effects in CPTPP+ all original member countries and India are included. This model, along with variables included previously, also includes the existence of other RTAs between partners and three trade creation and diversion dummies. The three trade creation and trade diversion dummies capture trade creation, exporter trade diversion and importer trade diversion. Further, to capture multilateral trade resistance terms for countries, we will use 12 importer and 12 exporter dummies.

- **$X_{ij,t}$** - Imports to country i from country j
- **gdp_{exp}** - Exporter GDP
  gdp_{imp} - Importer GDP
- **$Distance_{ij}$** - Distance between importer and exporter nation
- **$Border_{ij}$** - whether the nation i,j share common land border takes value 1 if they share common land border
- **T_i** - year dummies i^{th} takes value 1 for i^{th} year b/w [1,n]
- **TC_{ij}** - measure of exporter trade creation, takes value 1 if both i,j nations are part of CPTPP+, otherwise 0
- **TD_1_j** - measure of exporter trade diversion, takes value 1 when the exporter is part of CPTPP+, otherwise 0
- **TD_2_i** - measure of importer trade diversion, takes value 1 when the importer is part of CPTPP+, otherwise 0
- **Imp_k** - Importer dummies variable which takes value 1 if k^{th} nation is importer $K \in [1,12]$
- **Exp_k** - Exporter dummies variable which takes value 1 if k^{th} nation is exporter $K \in [1,12]$
- $\epsilon_{ij,t}$ - error term

This model seeks to capture trade-creating and trade-diverting effects of the proposed CPTPP+. It requires the inclusion of external trade partners to capture its diverting effects. We restrict our gravity model only to merchandise trade as data related to services for all member countries is largely unavailable.

Results

We obtain the following results after running the codes submitted along with the paper.

CPTPP (without India)

Fixed effects estimation:

```
. regress ln_trade ln_distance simpleaverage lngdpexp lngdpimp tbexp tbimp commonlanguage commonbo
> rder i.exp i.imp, robust cluster(dist)
note: 10.exp omitted because of collinearity
note: 11.exp omitted because of collinearity
note: 10.imp omitted because of collinearity
note: 11.imp omitted because of collinearity
```

```
Linear regression                               Number of obs     =        315
                                                F(24, 54)         =      29.67
                                                Prob > F          =     0.0000
                                                R-squared         =     0.6131
                                                Root MSE          =     2.1839

                                    (Std. Err. adjusted for 55 clusters in distance)
```

ln_trade	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ln_distance	-1.29457	.21919	-5.91	0.000	-1.734019	-.8551205
simpleaverage	-.0566007	.0232702	-2.43	0.018	-.1032546	-.0099469
lngdpexp	.6908432	.1556074	4.44	0.000	.3788691	1.002817
lngdpimp	-.2180613	.2042063	-1.07	0.290	-.6274704	.1913477
tbexp	.3032906	.2460715	1.23	0.223	-.190053	.7966342
tbimp	.552826	.1965076	2.81	0.007	.1588519	.9468001
commonlanguage	1.106153	.3361255	3.29	0.002	.4322615	1.780044
commonborder	-.0900485	1.053135	-0.09	0.932	-2.201457	2.02136

Baier and Bergstrand Methodology:

Estimation of model with MRTs without fixed effects

```
Linear regression                               Number of obs     =        315
                                                F(8, 54)          =      13.87
                                                Prob > F          =     0.0000
                                                R-squared         =     0.4035
                                                Root MSE          =     2.6399

                                         (Std. Err. adjusted for 55 clusters in dist)
```

log_trade	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ln_dist_star	-1.303596	.3356144	-3.88	0.000	-1.976462	-.6307298
log_gdp_i	.798344	.1418588	5.63	0.000	.5139342	1.082754
log_gdp_e	.8581764	.1362704	6.30	0.000	.5849706	1.131382
commonborder	.8330036	.6266377	1.33	0.189	-.4233293	2.089337
commonlanguage	.6748397	.4290889	1.57	0.122	-.1854316	1.535111
simpleaverage	-.0597788	.0213979	-2.79	0.007	-.102679	-.0168787
tbexp	.2511092	.1495911	1.68	0.099	-.048803	.5510213
tbimp	.2548799	.1907453	1.34	0.187	-.1275415	.6373012
_cons	-25.66841	4.259502	-6.03	0.000	-34.2082	-17.12863

NLS:

```
Imports.Value.in.1000.USD ~ dist_log + loggdpexp + loggdpimp +
    Simple.Average + CommonLanguage + CommonBorder + tbexp +
    tbimp + ausimp + brnimp + canimp + chlimp + jpnimp + mysimp +
    meximp + nzlimp + perimp + sgpimp + vnmimp + ausexp + brnexp +
    canexp + chlexp + jpnexp + mysexp + mexexp + nzlexp + perexp +
    sgpexp + vnmexp

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-902177        7     2088    23611  1294063

Coefficients: (6 not defined because of singularities)
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)    -152.48678 1469.62195  -0.104  0.91743
dist_log         -4.02416    1.00908  -3.988 8.44e-05 ***
loggdpexp         3.79028    4.73244   0.801  0.42384
loggdpimp        11.25188  113.61162   0.099  0.92118
Simple.Average   -0.11494    0.01626  -7.069 1.17e-11 ***
CommonLanguage    3.04482    2.32704   1.308  0.19176
CommonBorder     -9.51711    3.38489  -2.812  0.00526 **
tbexp             0.82616    0.96807   0.853  0.39414
tbimp             2.38944   23.10198   0.103  0.91769
```

SILS:

```
Call: y_log_sils ~ dist_log + Simple.Average + CommonLanguage + CommonBorder +
    tbexp + tbimp
Residuals:
      Min        1Q    Median        3Q       Max
-351.6302   -2.7320    0.6359    3.1643    7.2507

Coefficients:
                  Value    Std. Error t value
(Intercept)     341.9504   4.4747    76.4186
dist_log         -1.5220   0.4455    -3.4164
Simple.Average   -0.0655   0.0421    -1.5564
CommonLanguage    2.1950   0.8110     2.7066
CommonBorder      0.2926   1.7412     0.1680
tbexp             3.1992   0.2696    11.8655
tbimp             1.8259   0.2560     7.1316

Residual standard error: 4.668 on 308 degrees of freedom
```

GPML:

```
y_gpml ~ dist_log + Simple.Average + CommonLanguage + CommonBorder +
    tbexp + tbimp + loggdpexp + loggdpimp + ausimp + brnimp +
    canimp + chlimp + jpnimp + mysimp + meximp + nzlimp + perimp +
    sgpimp + vnmimp + ausexp + brnexp + canexp + chlexp + jpnexp +
    mysexp + mexexp + nzlexp + perexp + sgpexp + vnmexp

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-4.1587  -1.9017  -0.9119   0.3391   3.9457

Coefficients: (6 not defined because of singularities)
               Estimate Std. Error t value Pr(>|t|)
(Intercept)     4.49920   15.64898   0.288 0.773929
dist_log       -1.20117    0.15839  -7.584 4.58e-13 ***
Simple.Average -0.06519    0.01741  -3.744 0.000218 ***
CommonLanguage  0.83035    0.29957   2.772 0.005935 **
CommonBorder    0.04492    0.57413   0.078 0.937692
tbexp           0.60929    0.13091   4.654 4.96e-06 ***
tbimp           0.44576    0.12444   3.582 0.000399 ***
loggdpexp       0.86338    0.88159   0.979 0.328223
loggdpimp       0.21327    0.78938   0.270 0.787214
```

PPML:

```
Call:
y_ppml ~ dist_log + loggdpexp + loggdpimp + Simple.Average +
    CommonLanguage + CommonBorder + tbexp + tbimp + ausimp +
    brnimp + canimp + chlimp + jpnimp + mysimp + meximp + nzlimp +
    perimp + sgpimp + vnmimp + ausexp + brnexp + canexp + chlexp +
    jpnexp + mysexp + mexexp + nzlexp + perexp + sgpexp + vnmexp

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-952.04  -198.02   -70.38     9.34  1920.41

Coefficients: (1 not defined because of singularities)
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)    -4.788e+01  2.410e+05   0.000 0.999842
dist_log       -1.262e+00  1.825e-01  -6.915 2.88e-11 ***
loggdpexp      -1.965e-01  9.338e+03   0.000 0.999983
loggdpimp       2.249e+00  7.064e+03   0.000 0.999746
Simple.Average -5.594e-02  1.621e-02  -3.450 0.000642 ***
CommonLanguage  2.097e-01  3.513e-01   0.597 0.550965
CommonBorder   -1.110e+00  6.098e-01  -1.820 0.069841 .
tbexp          -1.322e-01  1.671e+04   0.000 0.999994
tbimp           5.300e+00  2.665e+04   0.000 0.999841
```

COUNTERFACTUALS i.e. CPTPP+

This is the case when India joins CPTPP and forms CPTPP+

Fixed effects:

Linear regression			
	Number of obs	=	379
	F(26, 65)	=	37.20
	Prob > F	=	0.0000
	R-squared	=	0.6068
	Root MSE	=	2.1262

(Std. Err. adjusted for 66 clusters in distance)

ln_trade	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
ln_distance	-1.224605	.19889	-6.16	0.000	-1.621815	-.8273939
simpleaverage	-.0303106	.0168746	-1.80	0.077	-.0640116	.0033904
lngdpexp	.742443	.1406198	5.28	0.000	.4616059	1.02328
lngdpimp	-.2182625	.2005341	-1.09	0.280	-.6187569	.1822318
tbexp	.0446043	.2130136	0.21	0.835	-.3808134	.4700219
tbimp	.4328014	.1942176	2.23	0.029	.0449221	.8206807
tradecreation	-.2648277	.8009311	-0.33	0.742	-1.864397	1.334742
impdiversion	-2.544346	.7745392	-3.28	0.002	-4.091208	-.9974844
expdiversion	0	(omitted)				
commonlanguage	1.024008	.333101	3.07	0.003	.3587592	1.689257
commonborder	.1179628	1.001137	0.12	0.907	-1.881446	2.117372

BAIER BERGSTRAND

Linear regression			
	Number of obs	=	379
	F(10, 65)	=	15.36
	Prob > F	=	0.0000
	R-squared	=	0.4020
	Root MSE	=	2.5646

(Std. Err. adjusted for 66 clusters in distance)

ln_trade	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lndiststar	-1.2344	.3133442	-3.94	0.000	-1.860192	-.6086089
simpleaverage	-.0384566	.0170363	-2.26	0.027	-.0724804	-.0044329
lngdpexp	.8568529	.1242114	6.90	0.000	.6087856	1.10492
lngdpimp	.7801873	.1343275	5.81	0.000	.5119167	1.048458
tbexp	.2125557	.1364033	1.56	0.124	-.0598606	.484972
tbimp	.2740103	.1757375	1.56	0.124	-.0769616	.6249823
tradecreation	.2568425	.7094306	0.36	0.718	-1.159988	1.673673
impdiversion	-2.336697	.6855044	-3.41	0.001	-3.705744	-.9676502
commonlanguage	.6978753	.4400304	1.59	0.118	-.1809262	1.576677
commonborder	.9640576	.625006	1.54	0.128	-.2841656	2.212281
_cons	-25.01126	4.136544	-6.05	0.000	-33.27251	-16.75002

NLS:

```
Call:
Imports.Value.in.1000.USD ~ dist_log + loggdpexp + loggdpimp +
    Simple.Average + CommonLanguage + CommonBorder + tbexp +
    tbimp + tradecreation + impdiversion + expdiversion + ausimp +
    brnimp + canimp + chlimp + jpnimp + mysimp + meximp + nzlimp +
    perimp + sgpimp + vnmimp + ausexp + brnexp + canexp + chlexp +
    jpnexp + mysexp + mexexp + nzlexp + perexp + sgpexp + vnmexp

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-905922       10     2539    30425  1294051

Coefficients: (7 not defined because of singularities)
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)    -178.41091 1589.34875  -0.112  0.91069
dist_log         -3.83995    0.84675  -4.535 7.91e-06 ***
loggdpexp         3.61728    4.40391   0.821  0.41199
loggdpimp        10.91436  100.88715   0.108  0.91391
Simple.Average   -0.11250    0.01482  -7.593 2.84e-13 ***
CommonLanguage    2.79362    2.11899   1.318  0.18824
CommonBorder     -8.98831    2.96577  -3.031  0.00262 **
tbexp             0.80787    0.90181   0.896  0.37095
tbimp             2.34074   20.51466   0.114  0.90922
tradecreation    31.10261  284.34598   0.109  0.91296
impdiversion     21.61171  284.41140   0.076  0.93947
expdiversion           NA         NA      NA       NA
```

SILS:

```
Call: y_log_sils ~ dist_log + Simple.Average + CommonLanguage + CommonBorder +
    tbexp + tbimp + tradecreation + impdiversion
Residuals:
     Min       1Q   Median       3Q      Max
-10.9603  -2.2640   0.1835   2.3136   6.7753

Coefficients:
                 Value   Std. Error t value
(Intercept)      1.6271  3.0654      0.5308
dist_log        -2.2185  0.2728     -8.1316
Simple.Average  -0.0619  0.0239     -2.5913
CommonLanguage   0.7074  0.5344      1.3237
CommonBorder    -0.4713  1.1267     -0.4183
tbexp            4.7032  0.1681     27.9841
tbimp            3.7598  0.1609     23.3685
tradecreation    2.0374  0.9091      2.2411
impdiversion    -1.1675  1.2187     -0.9580

Residual standard error: 3.41 on 370 degrees of freedom
```

GPML

```
Call:
y_gpml ~ dist_log + Simple.Average + CommonLanguage + CommonBorder +
    tbexp + tbimp + loggdpexp + loggdpimp + tradecreation + impdiversion +
    expdiversion + ausimp + brnimp + canimp + chlimp + jpnimp +
    mysimp + meximp + nzlimp + perimp + sgpimp + vnmimp + ausexp +
    brnexp + canexp + chlexp + jpnexp + mysexp + mexexp + nzlexp +
    perexp + sgpexp + vnmexp

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-4.1112  -1.9447  -0.7911   0.1686   4.2498

Coefficients: (7 not defined because of singularities)
                Estimate Std. Error t value Pr(>|t|)
(Intercept)    -1.104e+01  1.615e+01  -0.684 0.494453
dist_log       -1.109e+00  1.528e-01  -7.260 2.51e-12 ***
Simple.Average -5.092e-02  1.403e-02  -3.629 0.000326 ***
CommonLanguage  8.182e-01  2.969e-01   2.756 0.006151 **
CommonBorder    2.894e-01  5.591e-01   0.518 0.605092
tbexp           5.180e-01  1.246e-01   4.157 4.06e-05 ***
tbimp           4.092e-01  1.201e-01   3.407 0.000734 ***
loggdpexp       1.075e+00  8.189e-01   1.312 0.190299
loggdpimp       1.015e+00  7.549e-01   1.345 0.179480
tradecreation   2.804e+00  1.904e+00   1.472 0.141835
impdiversion   -1.419e+00  2.583e+00  -0.550 0.583007
expdiversion          NA         NA      NA       NA
```

PPML

```
Call:
y_ppml ~ dist_log + loggdpexp + loggdpimp + Simple.Average +
    CommonLanguage + CommonBorder + tbexp + tbimp + tradecreation +
    impdiversion + ausimp + brnimp + canimp + chlimp + jpnimp +
    mysimp + meximp + nzlimp + perimp + sgpimp + vnmimp + ausexp +
    brnexp + canexp + chlexp + jpnexp + mysexp + mexexp + nzlexp +
    perexp + sgpexp + vnmexp

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-949.48  -190.07   -62.80    13.28  1946.38

Coefficients: (2 not defined because of singularities)
                Estimate Std. Error t value Pr(>|t|)
(Intercept)    -6.740e+01  3.137e+05   0.000 0.999829
dist_log       -1.211e+00  1.644e-01  -7.365  1.2e-12 ***
loggdpexp      -8.840e-01  1.339e+04   0.000 0.999947
loggdpimp       4.796e+00  8.829e+03   0.001 0.999567
Simple.Average -4.926e-02  1.393e-02  -3.538 0.000456 ***
CommonLanguage  1.672e-01  3.240e-01   0.516 0.606053
CommonBorder   -1.027e+00  5.577e-01  -1.842 0.066327 .
tbexp           2.814e+00  4.306e+03   0.001 0.999479
tbimp           2.411e+00  1.464e+04   0.000 0.999869
tradecreation   1.646e+01  3.873e+04   0.000 0.999661
impdiversion    1.320e+01  1.974e+04   0.001 0.999467
```

Comparison of Results from various methods:

CPTPP						
Coefficients	**Fixed Effects Estimation**	**Baier and Bergstrand Method**	**NLS**	**SILS**	**GPML**	**PPML**
Distance	-1.29457 ***	-1.303596 ***	-4.02416 ***	-1.522	-1.20117 ***	-1.262 ***
Duty	-0.056607 **	-0.0597788 ***	-0.11494 ***	-0.655	-0.06519 ***	-0.05594 ***
Exporter GDP	0.6908432	0.8581764	3.79028		0.86338	-0.1965
Importer GDP	-0.2180613	0.798344	11.25188		0.21327	2.249
Technical Barrier Exporter	0.3032906 ***	0.2511092	0.82616	3.1992	0.60929 ***	-0.1322
Technical Barrier Importer	0.552826	0.2548799	2.38944	1.8259	0.44576 ***	5.3
Common Language	1.106153 ***	0.6748398	3.04482	2.195	0.83035 **	0.2097
Common Border	-0.0900485	0.8330026	-9.51711 **	0.2926	0.04492	-1.11

CPTPP+						
Coefficients	**Fixed Effects Estimation**	**Baier and Bergstrand Method**	**NLS**	**SILS**	**GPML**	**PPML**
Distance	-1.224605 ***	-1.2344 ***	-3.83995 ***	-2.2185	-1.109 ***	-1.211 ***
Duty	-0.303106	-0.0384566 **	-0.1125 ***	-0.0619	-0.05092 ***	-0.04926 ***
Exporter GDP	0.742443	0.8568529	3.61728		1.075	-0.884
Importer GDP	-0.2182625	0.7801873	10.91436		1.015	4.796
Technical Barrier Export	0.0446043	0.2125557	0.80787	4.7032	0.518 ***	2.814
Technical Barrier Import	0.4328014 **	0.2740103	2.34074	3.7598	0.4092 ***	2.411
Trade Creation	-0.2648277	0.2568425	31.10261	2.0374	2.804	16.46
Import Diversion	-2.544346 ***	-2.336697 ***	21.61171	-1.1675	-1.419	13.2
Export Diversion	0		NA		NA	
Common Language	1.024008 ***	0.6978753	2.79362	0.7074	0.8182 **	0.1672
Common Border	0.1179628	0.9640576	-8.98831 **	-0.4713	0.2894	-1.027

Conclusion

Each of the six estimation methods reveals a negative correlation between distance and imports, consistent with the theory underlying the gravity model. The relationship between importer and exporter GDP is also positive, as predicted by the gravity model, excluding the ppml model. One of the coefficients in PPML is negative but insignificantly so. All estimation methodologies estimate a significant negative correlation between tariff rates and imports. Other trade barriers, such as common language, also have a positive impact on all forms of commerce.Common border, on the other hand, reveals a perplexing result in which NLS and PPML have a negative impact on trade. The distance elasticity is very close to -1 for all methods except NLS and SILS, which correspond to the typical value observed in goods markets.
As the Poisson and Gamma PML coefficients are distinct from one another and both are distinct from the OLS, it is plausible to conclude that heteroskedasticity is not an issue and the OLS estimates can be utilised. However, the distance and duty estimates are comparable and distinct from OLS. Some estimations were omitted due to correlation or the formation of a singular matrix during estimation.

Counterfactuals analysis:
Estimates of Exporter and Importer GDP, distance between countries, tariff rates, and geographical and social barriers influence import values similarly to that of our model estimation with CPTPP countries, which is consistent with the theory of the gravity model. Except for fixed effects, the trade creation dummy coefficient is positive across all estimation methods, indicating an increase in the value of trade between CPTPP+ nations. This was anticipated, as nations that produced certain commodities at a high price in their country will begin importing inexpensive products from India. The positive relationship between NLS and PPML for importer diversion dummies supports the

theory that trade with non-member countries will transfer to member countries. Due to the correlation between independent variables, estimates for some variables are unavailable.

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Report for Plaigraism:
https://drive.google.com/file/d/1OoueWt4zFFVw1DnBCPb2yVRu5TVsg0eP/view?usp=share_link