General Equilibrium impact of India leaving IPEF
A Structural Gravity Analysis

Research Paper Presentation

Presented by
- **Deeksha Rawat (210303)**
- **Krutuparna Paranjape (210536)**
- **Shivansh Gupta (210986)**
- **Pratik Ranjan (210758)**
- **Pulak Gautam (210791)**

Department of Economic Sciences

Indian Institute of Technology Kanpur

Things to Ponder

Let's see through the following news article

- The number of RTA's have increased from 32 to 599 in the past 3 decades
- After a long delay, India-UK free trade deal expected to be signed in July
- India, 13 others of IPEF ink supply chain resilience pact to reduce dependence on China
- India does not rush into trade agreements if it is not fair, balanced, equitable: Piyush Goyal

Things to Ponder

But,

- Are the Trade Agreements really effective?
- Should developing countries join the mad rush of entering into trade agreements?
- How should policymakers evaluate the effectiveness of some schemes?
- Do signing of trade agreements by one country affect the trades of others too?

Introduction

We try to answer the formerly stated questions by analysing the impact of India leaving IPEF

[Brief intro to IPEF](#)

IPEF was launched in May 2022, includes India and 13 partners that together account for 40% of world GDP. The framework seeks to create high-level agreements across four pillars: Trade (Pillar I); Supply Chains (Pillar II); Clean Economy (Pillar III); and Fair Economy (Pillar IV)

Research Gap

- Existing research focuses on the use of the Gravity model and the General Equilibrium Impact Analysis in the western region; however, such detailed analysis is absent in emerging nations such as India.

- There is a critical need for policymakers in developing nations like India to assess the effect of engaging in such trade agreements so that they can accordingly build the agreements and act to their benefit.

Literature Review

- Gravity model was first proposed by Jan Tinbergen (1962) who conceptualised it on Newton's law of Gravity.

- Helpman(1987) analysed the relation between income inequality in trading partners and trade volume.

- Chaney (2008) introduced the role of firm level characteristics and market structure in shaping trade flows.

- Baier and Bergstrand (2007) studied the implications of NAFTA and analysed whether NAFTA has led to trade diversion or trade creation

Literature Review

- Anderson and Wincoop (2003) revolutionised the gravity model by introducing multilateral trade resistances. Equation (1) is a typical gravity equation, which relates bilateral trade (Xij) between exporter i and importer j to exporter output (Yi), importer expenditures (Ej), global output (Y), bilateral trade costs (τij), the elasticity of substitution (σ), and outward and inward multilateral resistances (Πi and Pj).

$$X_{ij} = \frac{Y_i E_j}{Y} \left(\frac{\tau_{ij}}{\Pi_i P_j} \right)^{1-\sigma}, \tag{1}$$

$$\Pi_i^{1-\sigma} = \sum_j \left(\frac{\tau_{ij}}{P_j} \right)^{1-\sigma} \frac{E_j}{Y}, \tag{2}$$

$$P_j^{1-\sigma} = \sum_i \left(\frac{\tau_{ij}}{\Pi_i} \right)^{1-\sigma} \frac{Y_i}{Y}, \tag{3}$$

$$p_i = \left(\frac{Y_i}{Y} \right)^{\frac{1}{1-\sigma}} \frac{1}{\gamma_i \Pi_i}, \tag{4}$$

Literature Review

- Head and Mayer (2014) provides great insights into theoretical foundations, empirical applications, methodological advancements, and policy implications of Gravity model and also employed this model and did PTI, MTI and GETI analysis to evaluate the impact of EU.

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

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

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

Broad Objectives

1. Estimating Structural Gravity Model and Counterfactual analysis of India Leaving the IPEF
   - Estimate Base line coefficients
   - Perform Counterfactual Experiment
   - Produce Country-Wise General Equilibrium impacts and bilateral trade results
2. Estimating General Equilibrium Impacts (PTI, MTI, GETI) of the IPEF framework through a yes/no table.

Hypothesis Testing

- **Hypothesis 1:** Opting Out of IPEF has a significant positive impact on India's GDP, decline in IMR and OMR terms, and a significant increase in exports

- **Hypothesis 2:** If India opts out of IPEF, we hypothsize that smaller countries in the IPEF framework such as Fiji, Brunei, Indonesia etc witness a decline in their exports as well as GDP whereas larger nations such USA and China witness an increase in their exports, GDP etc owing to differential chnages in multilateral resistances.

- **Hypothesis 3:** We hypothesize that the smaller nations would witness a substantial increase in intra-national trade corresponding to a decline in their international trade as listed above.

# Hypothesis Testing : Estimating General Equilibrium Impacts

It is hypothesiszed that PTI (Partial Trade Impact), MTI (Modular Trade Impact), GETI (General Equilibrium Trade Impact) are higher in presence of the following factors comapred to when they are absent(yes-values higher than no-values)

- IPEF trade agreement
- Border Links
- Common Colony (Colonial Link)
- RTA(Regional Trade Agreements) / FTA(Free Trade agreements)

Plotting Normalized Exports(from India) vs GDP

Normalized GDP vs. Normalized Exports from India
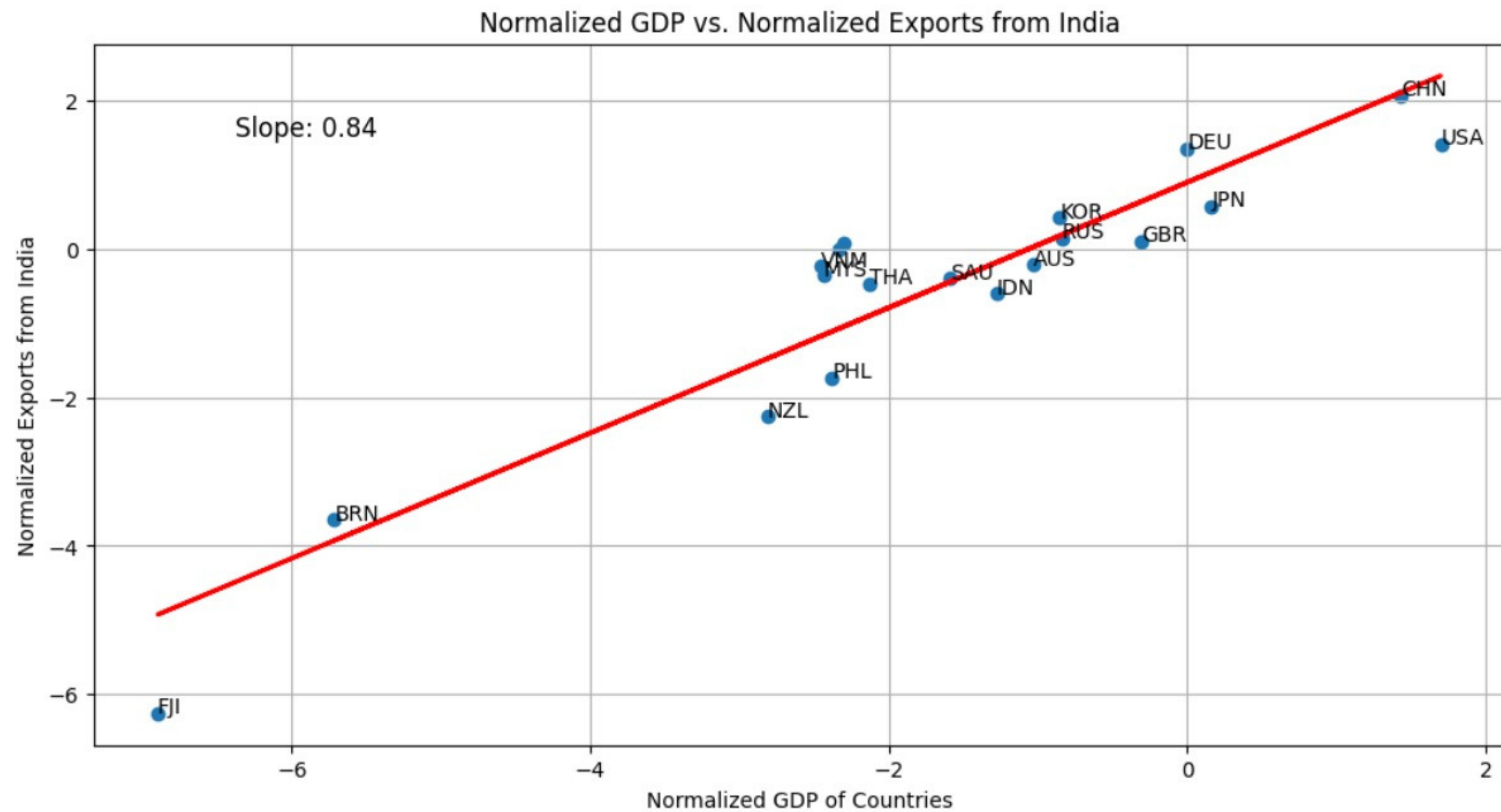
Plotting Normalized Exports(from India) vs Log(distance)

ln_dist vs. Normalized Exports from India
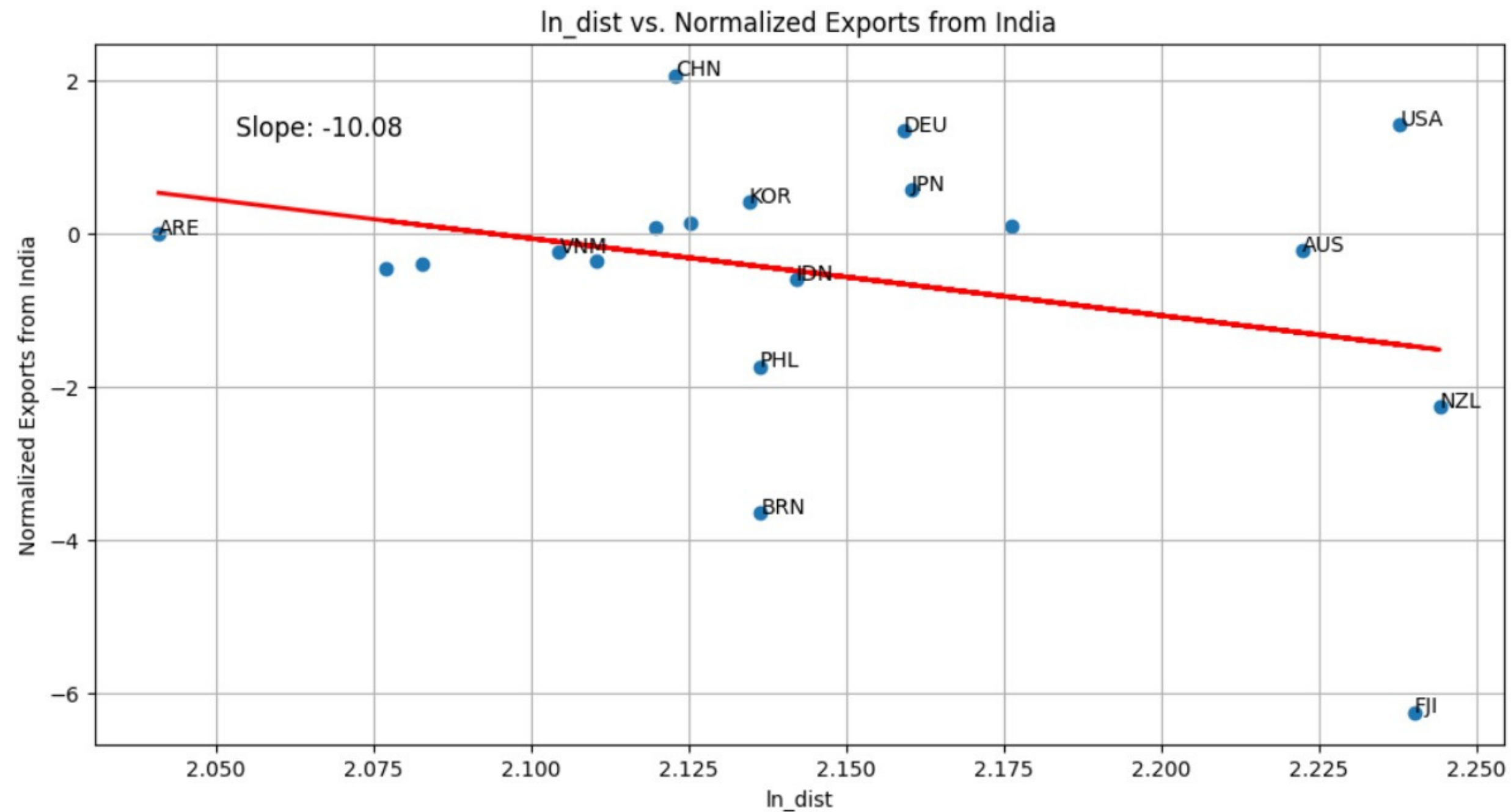
Data

- **Selected 20 countries**
  14 IPEF countries and other top 6 non-IPEF trading partners of India were chosen as they would constitute the bulk on Indian trade.
  Selected countries:
  IPEF: Australia, Brunei, Fiji, India, Indonesia, Japan, Republic of Korea, Malaysia, New Zealand, Philippines, Singapore, Thailand, Vietnam & USA
  Other Trading Partners: China, UAE, Saudi Arabia, Russia, South Korea

- **Selected the variables to be used in the gravity model, based on economic and cultural factors**

Variables

Label	Variable Description	Measure
country_id_o	Origin Country ID	Country code for which the effect is studied
country_id_d	Destination Country ID	Country code for the partner country
dist	Distance	Distance (in km) b/w the origin and the destination country
Export (US$ Thousand)	Export	Total Exports from the country of origin measured in USD Thousand
Import (US$ Thousand)	Import	Total Imports in the country of origin measured in USD Thousand
MFN Weighted Average (%)	Average of most favoured nation rates weighted by the product import shares corresponding to each partner country.	In Percentage measure
contig	Contiguity	1 if contiguity present, 0 otherwise
comlang_off	Common Language	1 for common official or primary language, 0 otherwise
comlang_ethno	Common Ethnic Language	1 if a language is spoken by at least 9% of the population in both countries, 0 otherwise
comcol	Common Coloniser Before 1945	1 for common coloniser post 1945, 0 otherwise
col45	Common Coloniser Post 1945	1 for pairs in colonial relationship post 1945, 0 otherwise
comleg_pretrans	Pre Transition Common Legal Origin	1 if common legal origins before transition, 0 otherwise
comleg_posttrans	Post Transition Common Legal Origin	1 if common legal origins after transition, 0 otherwise

Variables

transition_legalchange	Legal Origin Change Post Transition	1 if common legal origin changed since transition 0 otherwise
comrelig	Common Religion	1 if common religion, 0 otherwise
heg_o	Dummy if origin is current or former hegemon of destination	1 if true, 0 otherwise
heg_d	Dummy if the destination is current or former hegemon of origin.	1 if true, 0 otherwise
gdp_o	Origin GDP	GDP of the country of observation
gdp_d	Destination GDP	GDP of the partner country
gatt_o	Dummy if origin is GATT/WTO member	1 if true, 0 otherwise
gatt_d	Dummy if destination is GATT/WTO member	1 if true, 0 otherwise
wto_o	Dummy if origin is a member of the WTO	1 if true, 0 otherwise
wto_d	Dummy if destination is a member of the WTO	1 if true, 0 otherwise
eu_o	Dummy if origin is a member of the EU	1 if true, 0 otherwise
eu_d	Dummy if destination is a member of the EU	1 if true, 0 otherwise
rta	Dummy if a RTA has been signed between the origin and the destination country	1 if true, 0 otherwise

Data Sources

The data was collected manually for each selected variable from the following two websites:

- **wits.worldbank.org**
  The data regarding bilateral trade, import and export, and tariffs was collected from the WITS website.

- **CEPII's gravity dataset**
  The data related to distance, common colony, language and ethnic and legal background and other corresponding dummies were taken from this dataset

The data was then integrated to create a square dataset which was later used for conducting the analysis

Methodology

Steps Involved....

The Python Methodology :

- Python Package used - ***gegravity*** - estimates GE structural gravity models
  - conducting counterfactual simulations

```
!pip install gegravity
```

- Additional Packages to be used - ***pandas*** and ***gme***

- Load the dataset

- ***gme* package -** estimates the model using Poisson Pseudo Maximum Likelihood (PPML)

Steps Involved....

- Create and estimate an **econometric gravity model**

```python
# Create Gravity Model
gme_model = gme.EstimationModel(gme_data, # Specify data to use
                                lhs_var="exports",                              # dependent, "left hand side" variable
                                rhs_var=["ipef","contig", # independent variables
                                        "lndist","international", "comcol", "ln_exporter_gdp", "ln_importer_gdp"],
                                fixed_effects=[["exporter"],["importer"]])    # Fixed effects to use
```

- Define the **GE model**

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

# ----
```

Steps Involved....

- **Build a Baseline Model** - constructs the actual baseline structural terms using the baseline trade cost estimates supplied to the model, cost and expenditure data, and the elasticity of substitution

```python
# Solve the baseline model
##
ge_model.build_baseline(omr_rescale=100)
```

- We get the estimates of the baseline model

						coef	std err	z	P>|z|	[0.025	0.975]
contig						1.4356	0.848	1.693	0.091	-0.227	3.098
lndist						-0.4522	0.361	-1.252	0.210	-1.160	0.256
international						-7.9417	1.036	-7.669	0.000	-9.971	-5.912
comcol						2.9734	0.841	3.534	0.000	1.324	4.622
ln_exporter_gdp						0.5489	1.562	-0.351	0.725	-3.610	2.513
ln_importer_gdp						2.7327	1.579	1.731	0.084	-0.362	5.827
ipef						-2.7916	0.853	-3.274	0.001	-4.463	-1.120

Steps Involved....

- **Define counterfactual experiment** - For India Leaving IPEF, set **ipef** variable to 0 for the rows having importer or exporter as India with the IPEF members

```
exp_data.loc[(exp_data["importer"] == "IND") & (exp_data["exporter"] == "USA"), "ipef"] = 0
exp_data.loc[(exp_data["importer"] == "USA") & (exp_data["exporter"] == "IND"), "ipef"] = 0
```

Sample code for setting IPEF = 0 for USA (Following up for other IPEF members)

- Use **OneSectorGE.define_experiment** method for counterfactual

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

Steps Involved....

- **Conditional counterfactual MRs** - Reconstruct conditional MRs for the counterfactual version of the mode

```python
# Simulate the counterfactual model
#
ge_model.simulate()
```

- **Full counterfactual GE mode** - Solve for the full GE model and derive counterfactual IMRs, OMRs, factory gate prices

- Produce a collection of other results such as total counterfactual **imports**, **exports** and **real GDP**

Steps Involved....

The STATA Methodology :

- **Data Cleaning and Structuring -**

  - Remove countries which have zero import or zero export from any other countries
  - Check whether the data is square, i.e., no. of rows = $_nP_2 + n = n^2$

- Calculate **Partial Trade Impact (PTI) -**

```stata
global RHS "ldis lang colony rtapoor ipef home"
foreach x of varlist $RHS {
scalar PTI_`x'=round(exp(b_`x'),0.001)
}
```

- Calculate **Real MR terms** using **contractual mapping** (contracmapdn) and using earlier calculated estimates normalized w.r.t. estimates of the base country, DEU (Germany)

```stata
use squaretradeprod, clear
* Normalizing country
* The Phis and Omegas
* are normalized by Phi of the below country
global normal = "DEU"
* MR terms computation
contracmapdn Y_i X_n iso_o iso_d phi_in, gen1(Omega_i) gen2(Phi_n) dfactor(1) norm($normal)
```

Steps Involved....

- **Counterfactual Scenario -** Calculate MR terms (say, by revoking IPEF), and their ratios to the earlier calculated MR terms - gives MTI (modular trade impact) due to these variables

```
***************
*counterfactuals*
***************
* Variables that are to be turned "off"
foreach x of varlist  rtapoor ipef lang colony home{
gen `x'_prime = 0
gen  phi_in_`x'_prime = phi_in*exp(b_`x'*(`x'_prime-`x'))
* counterfactual MR terms
contracmapdn Y_i X_n iso_o iso_d phi_in_`x'_prime, gen1(Omega_i_`x'_prime) gen2(Phi_n_`x'_prime) dfactor(1) norm($normal)
* ratio of real to counterfactual trade
gen Xratio_`x' = 1/(exp(b_`x'*(`x'_prime-`x'))*(Omega_i/Omega_i_`x'_prime)*(Phi_n/Phi_n_`x'_prime))
*
qui sum Xratio_`x' if `x'==1,d
scalar MTI_`x'=round(r(p50),0.001)
qui sum Xratio_`x' if `x'==0,d
scalar MTInm_`x'=round(r(p50),0.001)
}
scalar list
```

Steps Involved....

- **GETI Calculation and Welfare -** adjust the income terms following the change in trade costs

```
*Then calculate final changes in trade flows (trade shares)
qui gen num_in = (wh_i0)^epsilon*phih_in
qui egen denom_n = sum(pi_in*num_in), by(iso_d)
qui gen pihat_in = num_in/denom_n
qui gen xprime_n = (wh_n0*X_n)
qui gen Xin_prime = pihat_in*pi_in*(xprime_n)
qui gen GETI_`x'=1/(Xin_prime/Xin)
qui sum GETI_`x' if `x' == 1,d
scalar GETI_`x'=round(r(p50),0.001)
qui sum GETI_`x' if `x' == 0,d
scalar GETInm_`x'=round(r(p50),0.001)
qui save GETI_`x', replace
*
qui egen nb_`x' = sum(`x'), by(iso_o)
qui keep if iso_o == iso_d
qui gen Xratio_`x' = 1/(Xin/Xin_prime)
qui gen Welfare_`x'=pihat_in^(1/(-epsilon))
qui sum Welfare_`x' if nb_`x'>0,d
scalar Welf_`x'=round(r(p50),0.001)
qui sum Welfare_`x' if nb_`x'==0,d
scalar Welfnm_`x'=round(r(p50),0.001)
*
}
```

Results, Observations and Inferences

Python - Counterfactual Analysis Results

- *Country Wise General Equilibrium Results (%changes) as obtained from the example files :*

	Factory Gate price-change (%change)	IMR (% change)	OMR (%change)	GDP (% change)
ARE	−1.97446	−0.29488	0.009025	0.405464
AUS	−0.0111412	0.29931	0.040626	−0.26073
BRN	−0.0276208	1.075025	0.143828	−0.57895
CHN	−0.0148599	−0.16269	0.036012	0.152686
DEU	−0.0000097	0	0.06713	−0.06332
FJI	−0.0272696	1.687636	0.130122	−0.67097
GBR	−0.0154765	0.174388	0.064748	−0.20062
IDN	−0.0110283	0.220428	0.028236	−0.2034
IND	0.0344888	−0.37032	−0.19674	0.977194
JPN	−0.01632	0.043418	0.034129	−0.07358
KOR	−0.0114603	0.152377	0.043437	−0.16865
MYS	−2.15425	0.198492	−0.08395	−1.91354
NZL	−0.0112001	0.648673	0.033851	−0.41357
PHL	−0.0110621	0.426526	0.039131	−0.32565
RUS	−0.0153855	0.256432	0.116126	−0.28734
SAU	−0.0155249	0.362522	0	−0.98248
SGP	0.1540114	0.213965	0.04181	−1.79084
THA	−0.0109658	0.355499	0.03058	−0.28443
USA	−0.0165472	−0.05304	0.051256	0.003982
VNM	−0.0895739	0.3952353	0.09770792	−0.347475

Counterfactual Analysis Results

- *Country Wise General Equilibrium Results (%changes) as obtained from the example files :*

	Exports (%change)	Imports (%change)	welfare statistic	intranational trade change (percent)
ARE	0.06460117	−0.71757	0.711509	−0.64843
AUS	0.4598693	3.05781	1.352684	3.307849
BRN	−0.508628	8.977803	2.374988	32.84211
CHN	0.3816473	−0.34356	0.867539	−0.2631
DEU	0.3732333	0.344587	1.067599	0.589462
FJI	−0.540959	51.94224	3.039195	91.98318
GBR	0.3639121	1.559303	1.250973	2.009951
IDN	0.4424906	1.150928	1.255334	2.274342
IND	6.614131	0.12056	0.505767	−0.85828
JPN	0.4151185	0.748074	1.079421	0.769554
KOR	0.4433501	1.576889	1.202868	1.680362
MYS	−2.18941	−3.58713	−1.09464	1.433019
NZL	0.4167396	9.951036	1.705235	10.02217
PHL	−0.487453	4.746615	1.482905	5.242071
RUS	0.476208	−2.10955	1.403184	3.331666
SAU	−1.148	−0.88762	57.08734	−1.01682
SGP	−2.70462	−3.44662	−1.26448	2.294292
THA	0.4927145	2.813917	1.397478	4.005284
USA	1.046436	0.209693	0.996034	0.240144
VNM	0.4178989	2.910718	1.532508	5.371238

Impact on India

- Opting out of the IPEF would lead to a positive change in India's GDP, given the significant positive change in India's GDP(0.97%), significant reduction in IMR and OMR terms.We also observe that our Country Exports are projected to infact increase if it opts the trade framework.

- One specific reason for this might be that leaving IPEF might allow India more flexibility in setting its trade policies and negotiating bilateral agreements tailored to its specific economic interests. This could potentially result in increased trade opportunities .

- Overall we can say that while exiting the IPEF could offer India some opportunities for economic expansion, careful strategic planning and negotiation would be necessary to maximise the benefits and mitigate any potential downsides of such a decision.

Impact on Smaller Developing Countries

- We would also like to discuss the potential impact of India leaving the IPEF on global trade dynamics. As evident from the results obtained, the smaller countries such as Brunei, Fiji etc witness a negative change in their GDP and a positive change in their IMR/OMR terms indicating that,if India were to exit the agreement, it could indeed have major repercussions, on these nations which tend to have higher trade with our country particularly owing to such trade agreements.

- India is likely to have significant trade relationships with these smaller nations within the framework of the IPEF. If it withdraws, the loss of access to the Indian market could indeed result in trade barriers for these countries.

- This underscores the interconnectedness of global trade agreements and the potential ripple effects of a member country's decision to exit such agreements.

Impact on Larger Countries : USA, China, Japan

- According to the results obtained, if India leaves the IPEF, larger countries like the USA and China could potentially benefit from increased bilateral trade with India. Both the USA and China are major global economic players with significant trade influence.They witness a large increase in exports,GDP and welfare.

- India's departure from the IPEF might lead to a reconfiguration of global trade relationships, with larger economies seeking to capitalise on the opportunity to strengthen their economic ties with India. The results obtained confirm to this as USA and China have a significant positive change in GDP and exports.

Intranational Trade V/S Inter-national Trade

- Our findings point that Intra-National Trade increases for smaller countries if India decides to leave IPEF.With India's departure from the IPEF, smaller countries could experience higher trade costs.

- Faced with higher barriers to international trade, smaller countries may increasingly focus on their domestic markets. This shift towards intra-national trade involves conducting business within their own borders rather than engaging in cross-border trade.

PTI, MTI, GETI Results

Yes/No table

Table 2: 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	1.052	.89	1.401	.802	1	1
IPEF	1.2361	3.442	.654	.468	3.186	.973	1	1.006
Common language	.33	1.391	1.028	.896	1.503	1.061	1	1.013
Colonial link	.84	2.316	1.001	1	1.001	1	1	1
Border Effect	1.55	4.711	10.092	2.049	1.287	.484	.954	.

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

Observations and Inferences

We observe that the 'yes' values are significantly higher than 'no' values for all factors that contribute to reduction in trade costs including RTA, IPEF, Common Language etc for each of three indices of PTI, MTI, GETI.

We consult to the country-specific results that we obtained earlier which point out that India benefits from leaving the trade framework in terms of percentage changes in IMR, OMR, exports, GDP etc.

Appendix

- <u>**References**</u>

[1] Gravity Cookbook: <u>Link</u>

[2] McCallum, J., 1995, National Borders Matter: Canada-U.S. Regional Trade Patterns, American Economic Review 85, 615-623.

[3] Anderson, Wincoop, Gravity with Gravitas: A Solution to the Border Puzzle, American Economic Review vol. 93, no. 1, March 2003 170-192

[4] Head, K. and T. Mayer, 2021, The United States of Europe: A gravity model evaluation of the four freedoms, Journal of Economic Perspectives 35(2): 23-48

Appendix

- **Codes**

Link to Drive folder containing codes, data results

Thank You :-)

Questions ?