Exploring Inference Techniques in Difference-in-Differences Analysis

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1 Empirical Analysis

Since its establishment in 1995, the WTO has seen 36 states or customs territories join as Article XII members, a process governed by negotiations outlined in the Marrakesh Agreement. These negotiations, conducted under the "single undertaking", require prospective members to adhere to all WTO agreements. Accession typically involves significant domestic reforms, with governments citing reasons such as economic restructuring and market transition. Economic arguments supporting WTO membership highlight its role in reducing trade barriers, promoting international trade, and fostering economic growth. The WTO's Agreement on Agriculture, negotiated during the Uruguay Round, aimed to liberalize agricultural trade by reducing tariffs and subsidies. Additionally, the WTO provides a platform for resolving trade disputes related to agriculture and facilitates trade through measures such as customs streamlining.

This section examines the hypothesis that WTO accession positively impacted agricultural imports for Article XII members. We employ a difference-in-difference analysis, considering the staggered accession periods of these countries — for instance, China in 2001 and Ukraine in 2008.

2   Data :

To study the effects of recent WTO accession on total agricultural imports[1], we put together a large country-level panel dataset, which covers the period 1992-2015. As mentioned before, the 36 Article XII countries that ascended to the WTO post-1995 become our treatment group. We used the WTO developing country members that were already part of the GATT[2] to select the control group. [3] [4]

Subramanian and Wei (2007) discovered that while the GATT/WTO has generally benefited global trade, its impact on developing nations appears to be less pronounced. This suggests that membership in these organizations might not significantly alter the import behaviors of developing countries. Their findings echo Rose's (2004) assessment, indicating that developing nations have undertaken only modest trade liberalization efforts. Furthermore, Subramanian and Wei pointed out a trend where countries joining the GATT after the Uruguay Round tend to demonstrate greater openness in trade policies compared to long-standing developing country members. Consequently, to ensure a suitable comparison, we opted to use pre-Uruguay Round developing country members of GATT (which later came to be known as the WTO after the Uruguay Round in 1995) as our control group for analysis.

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[1] Sourced from Food and Agriculture Organisation database (FAOSTAT)

[2] The organisation was called GATT (General Agreement of Tariffs and Trade) before the inception of WTO in 1995

[3] In theory, the control group should include non-WTO members whose characteristics are similar to the acceding governments. For statistical reasons, this is not practical, because the group of countries outside the WTO is relatively small (35) and too heterogeneous to provide for a control group.

[4] We do not take into account the developed countries as part of our analysis because we want the control group to closely match the treatment group (the Article XII members are all developing nations)

3   The Model :

In the spirit of Leamer (1983), we have used a naive model for our analysis.

$$y_{igt} = \gamma_0 + \gamma_1 \cdot \alpha_g + \gamma_2 \cdot \delta_t + \beta T_{gt} + u_{igt} \tag{1}$$

The specification of the model remains same as before, where α_g represents the state effect and δ_t represents the time effect. The estimated impact of WTO ascension on the normalised value of Agri Imports is given by $\hat{\beta}$. We have performed this regression for each separate clusters of countries to understand the heterogenous treatment effect across the different clusters.

The clustering procedure looks at disaggregating the sample of WTO developing country members (both GATT and Article XII members) into a series of more homogeneous subsamples which may, for structural reasons, have different reactions to (i) economic shocks and trends; and, (ii) WTO accession treatment. The procedure, based on a series of structural socioeconomic and macroeconomic variables is implemented through two steps: (1) exclusion of outliers; and, (2) identification of clusters.[5]

The model is likely to suffer from the presence of autocorrelation in the residuals, and thus we cannot rely on the standard OLS inference. Thus we use the Bias-corrected FGLS method, since we see from our simulations, that it gives us a correctly sized test with a high degree of power, even with small number of states. This approach is particularly well-suited for our study, as we are conducting individual regressions for each cluster, thereby necessitating a robust method capable of handling autocorrelation for a small number of countries effectively.

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[5]The Appendix subsection 4 provides detailed information on the procedure and its results.

4 Matching and Clustering of the countries :

The matching procedure through clustering is aimed at disaggregating all the countries into relevant clusters, this is because we expect the countries belonging to a particular cluster will behave differently to ascension index and economic shocks.It also helps us to understand the heterogenous effect to WTO ascension of the different clusters by running separate regressions for each cluster. The process of clustering of countries was done in two steps Firstly, the exclusion of outliers through the process of hierarchical clustering. Secondly, the identification of clusters through KNN Means. The variables used for specifying socio-economic similarities and differences which has been used as the basis for both exclusion of outliers and matching of countries for clusters are: Arable land, crop production index, export of goods and services (% of GDP), External balance on goods and services(% of GDP), Foreign Direct Investment (Net Inflows, % of GDP), GDP per capita(constant 2015 US dollars) , GDP per capita growth(annual %), GNI per capita, PPP (current international $), Gross domestic savings (% of GDP), Imports of goods and services (annual % growth), Industry (including construction):value added (% of GDP), International tourism, receipts (% of total exports), Labor force participation rate, total (% of total population ages 15+) (modeled ILO estimate),Net ODA received (% of GNI), Population ages 15-64, total, Population growth (annual %), Rural population (% of total population) , Unemployment, youth total (% of total labor force ages 15-24) (national estimate),HDI.

The information has been sourced from the World Bank (World Development Indicators) and averaged over 1995 to 2000. Ideally, these variables should have been observed for the years preceeding WTO Ascension. However, due to data availibility, the values corrospond to 1995 - 2000 averages based on existing data. The missing values have been imputed by KNN Means Imputation with 5 neighbours.

Among the Article XII (our treatment group) countries Oman, Liberia, Seychelles, Afghanistan, Saudi Arabia and Chinese Taipei, Montenegro have been excluded due to unavailability of data. Among the pre-existing GATT members (our control group) Palau and Eswatini have been excluded for the same reason.

Step1: Exlusion of Outliers: The first step of matching applies heirarchial clustering on all variables using the Mahalanobis distance following Stuart(2010)with outlier threshold to be 5. The idea is to identify 5 homogenous clusters based on the above-mentioned variables. We look for strict partitioning clustering with outliers: objects can also belong to no cluster, and are considered outliers. Those are candidates for exclusion. Very small clusters (with 2 or 3 countries) also qualified as outliers. This process of exclusion was repeated 4 times. Excluded observations are treated into a single case of "outliers", with a dedicated cluster. In the first run Angola(AGO), Barbados(BRB), China(CHN), Democratic Republic of Congo (COD), Georgie (GEO), Guinea-Bissau(GNB) and India(IND) have been excluded. In the second run Armeia(ARM), Cape Verde(CPV), Congo(COG), Guyana(GUY), Jordan(JOR), Solomon Islands(SLB) and Zambia(ZMB) were excluded. The third run excluded Brazil(BRA), Fiji(FJI), Haiti(HTI), and Papua New Guinea(PNG). In the fourth and final run Tajikistan(TJK), Myanmar(MMR) and Panama(PAN) were exluded. These countries formed cluster 6.

Step 2: KNN Means Clustering The remaining countries underwent a KNN Means Clustering to be classified into 5 homogenous groups based on the same socio-economic and macroeconomic variables. The final list of countries in the clusters is summerised in the following table where the asterisk along the countries indicate that they are the treatment group:

Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Benin	Belize	Albania*	Bangladesh	Croatia*	Angola
Bolivia	Botswana	Bulgaria*	Gambia	Dominica	Armenia*
Cambodia*	Chile	Cuba	Mauritania	Estonia*	Barbados
Cameroon	Costa Rica	El Salvador	Morocco	Grenada	Brazil
Central African Republic	Dominican Republic	Kazakhstan	Nepal*	Jamaica	Cape Verde*
Chad	Ecuador*	Latvia*	Nigeria	Maldives	China*
Côte d'Ivoire	Indonesia	Lithuania*	Pakistan	Mauritius	Congo
Ghana	Namibia	North Macedonia*	Senegal	St Vincent	Congo, Dem. Rep
Guatemala	Paraguay	Moldova*	Togo	Samoa*	Fiji
Honduras	Peru	Sri Lanka	Yemen	Guinea-Bissau	Georgia*
Kenya	Philippines	Tonga*		Guyana	
Lao	Russian Federation*	Ukraine*		Haiti	
Lesotho	South Africa			India	
Mongolia*	Suriname			Jordan*	
Nicaragua	Thailand			Myanmar	
Vanuatu*	Tunisia			Panama*	
Viet Nam*	Türkiye			Papua New Guinea	
Zimbabwe	Uruguay			Solomon Islands	
	Venezuela			Tajikistan	
				Zambia	

Table 1: Resultant Clusters

5   Results of the Regression Analysis :

Table 2: Normalized Agri Imports regression table

Cluster	Normalized Agri Imports	Coefficient	Standard Error	t-stat	p-value	95% CI	
						Lower	Upper
1	Treatment	0.011	0.003	3.79	0.00***	0.005	0.017
	const_	0.009	0.001	7.44	0.00***	0.007	0.012
2	Treatment	-0.008	0.006	-1.39	0.165	-0.02	0.003
	const_	0.028	0.001	14.59	0.00***	0.024	0.032
3	Treatment	0.001	0.005	0.21	0.836	-0.0009	0.001
	const_	0.013	0.002	6.84	0.00***	0.009	0.017
4	Treatment	-0.005	0.004	-1.03	0.302	-0.014	0.004

Cluster	Normalized Agri Imports	Coefficient	Standard Error	t-stat	p-value	95% CI	
						Lower	Upper
	const_	0.019	0.001	13.74	0.00***	0.016	0.217
5	Treatment	-0.0001	0.003	-0.4	0.69	-0.0009	0.0006
	const_	0.005	0.001	3.69	0.00***	0.002	0.008
6	Treatment	-0.045	0.012	3.54	0.00***	0.020	0.070
	const_	0.035	0.008	3.95	0.00***	0.017	0.052

Notes*

1. This table summarizes the bias corrected FGLS regression results to analyse the effect of WTO ascension on normalized agricultural imports of a country.

2. The regressions are carried out clusterwise to understand the heterogenous responses of the clusters to the treatment.

3. The coefficients significant at the 1 percent level are given by ***

4. All regressions also include state and year fixed effects in addition to the intervention variable.

6   Result of Data Analysis :

Our regression analysis looks at the impact of the ascension of WTO on Article XII members' total agricultural trade imports. As we see from 5 of the Appendix, for clusters 1 and 6 we find a positive and significant (at the 1% level) impact of WTO ascencion on normalized Agri Imports. For the remaining clusters we observe there is no significant result of the same. these results confirm the heterogenity of responses, and that the fact that a thorough investigation would require looking more at the economic characteristics of the acceding governments. Figure 1 of Appendix shows the heterogenity of responses to ascension across clusters.

Here we acknowledge, some limitations to our analysis I.e a relatively short time period to observe the impact of ascension since most of the countries acceded in the 2000s and 2010s. Also, we have considered only 3 years prior to the Uruguay Round in 1995, giving us a rather short time period to observe the pre-ascension outcomes
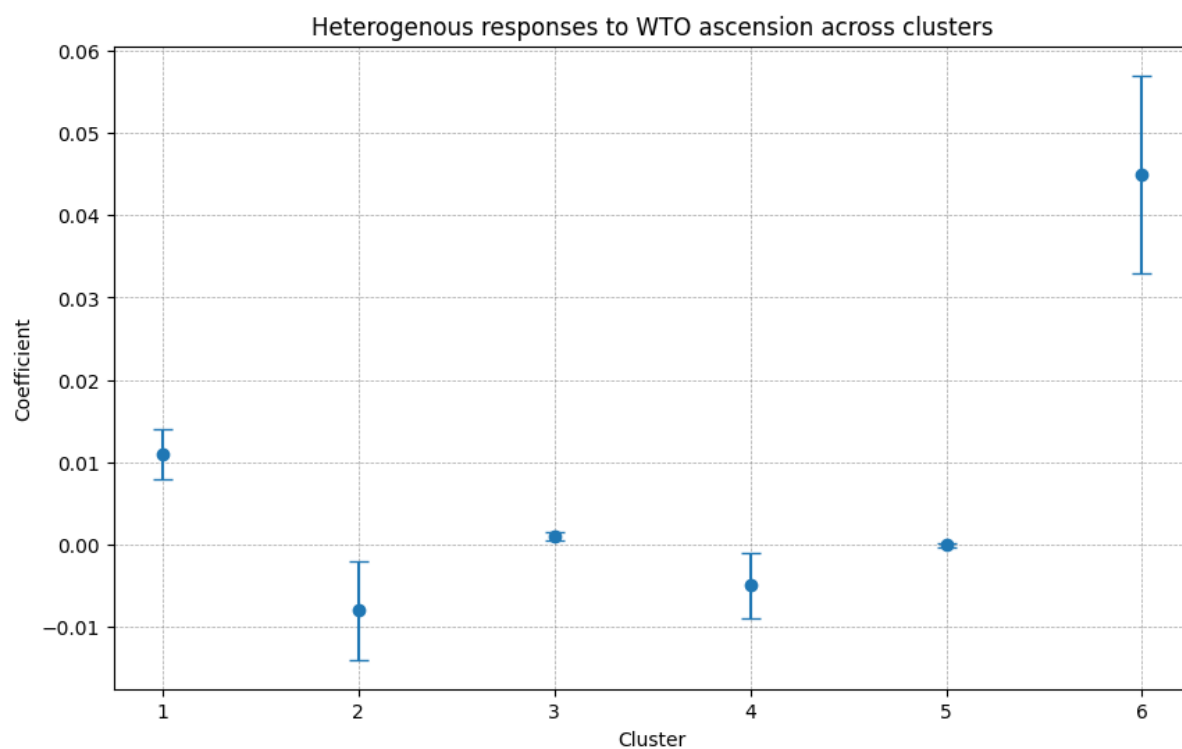
Figure 1: Heterogenous effect to WTO ascension across clusters

and to ensure parallel trends. Moreover, this short time period was also included the 2008-2009 crisis, which might have affected the agricultural imports in ways which cannot be captured by the time effects only. Moreover Clusters 2, 4 and 5 and may suffer from treatment group imbalance[6] leading to a drop in power of FGLS to detect real effect.

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[6] the ratio of the size of treatment group to control group is very low