Econ 140 Final Essay
Exploring the WTO's Impact on Trade

Members:
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The paper, "Do We Really Know That the WTO Increases Trade?", published in The American Economic Review in March 2004, investigates the relationship between the World Trade Organization (WTO) and the growth of international trade, utilizing panel data and a gravity model. Authored by Andrew K. Rose, the paper critically evaluates existing research and empirical evidence to determine if WTO membership indeed leads to a substantial increase in trade among its member countries.

The article acknowledges the widespread belief that the WTO, previously known as the General Agreement on Tariffs and Trade (GATT), plays a pivotal role in promoting global trade and economic growth. This assumption posits that joining the WTO results in heightened trade flows due to reduced trade barriers, improved market access, and enhanced trade rules and regulations. However, Rose questions the validity of this assumption and sets out to test whether the evidence supports the idea that the WTO genuinely drives trade expansion.

In the process of replicating the study, Andrew K. Rose plays a pivotal role. His contributions and insights guide researchers through the replication process, ensuring accuracy, credibility, and scholarly value. Rose's original study outlines the methodology, data sources, and analytical techniques he employed, particularly within the framework of a gravity model applied to panel data analysis. Replicators can closely follow his methodological framework, maintaining consistency and reducing variations in the replication process, leading to results directly comparable to the original findings.

The regression model that Rose implements is called the 'gravity model'. The term 'gravity' comes from an analogy used for the covariates used in the regression. The model recognizes that the value of trade and the distance between two countries are negatively correlated, which is similar to the relationship between the force of gravity between two objects and their distance. As distance between two countries decreases, the more likely they are to trade with one another. Similarly, in physics, as the distance between two objects decreases, their gravitational pull on one another also increases. Thus the use of distance as a regressor for trade is the reason for this naming convention.

The replication of this study could not have been possible without Rose's publication of his dataset on his website. In the panel data, each row represents two countries for a given year. By having two countries per row for a specific year, there needs to be a way to uniquely identify their interaction which is why we can find

subscripts *i*/*j* and *t* in the regression equation. Each (*i*, *j*) corresponds to country *i* being paired with country *j* and each *t* value corresponds to the given year.

The dependent variable of the regression equation is the log value of the bilateral trade between two countries at a given time ($\ln(X_{ijt})$). On the RHS, the model uses many regressors such as indicator variables determining if the two countries are in the same region, speak the same language, if the countries are landlocked etc. In the model, the regressors with beta coefficients are control variables, those with gamma coefficients are treatment variables, and those with phi coefficients are allocated for a time fixed effect. And after setting up the regression equation, Ordinary Least Squares (OLS) is then implemented to solve for these gravity model coefficients.

$$\begin{aligned}\ln(X_{ijt}) = {} & \beta_0 + \beta_1 \ln D_{ij} + \beta_2 \ln(Y_i Y_j)_t \\ & + \beta_3 \ln(Y_i Y_j / Pop_i Pop_j)_t + \beta_4 Lang_{ij} \\ & + \beta_5 Cont_{ij} + \beta_6 Landl_{ij} + \beta_7 Island_{ij} \\ & + \beta_8 \ln(Area_i Area_j) + \beta_9 ComCol_{ij} \\ & + \beta_{10} CurCol_{ijt} + \beta_{11} Colony_{ij} \\ & + \beta_{12} ComNat_{ij} + \beta_{13} CU_{ijt} \\ & + \beta_{14} FTA_{ijt}, + \Sigma_t \phi_t T_t + \gamma_1 Bothin_{ijt} \\ & + \gamma_2 Onein_{ijt} + \gamma_3 GSP_{ijt} + \varepsilon_{ijt}\end{aligned}$$

The regressors with gamma coefficients are bothin, onein, and GSP. The bothin variable takes the value of 1 when both countries in the country pair are members of the WTO/GATT and 0 otherwise. Similarly, onein takes the value of 1 when only one of the countries in the pair has joined the WTO/GATT. Lastly, GSP equals 1 if at least one country has benefited from the Generalized System of Preferences (GSP). The GSP is a trade program that many countries use to provide duty-free or reduced-duty access to their markets for products imported from other countries.

The demographic features of countries are controlled to determine the causal effect of GATT/WTO, and GSP status on trade. It is clear that demographic features affect trade value. For instance, as explained previously it is more likely for two countries to trade when they are closer to each other. It is clear that South Korea might prefer trading with Japan rather than Uruguay (the farthest country from it), assuming all else being equal. Or if two countries have high GDP, then the bilateral trade value between two countries is likely to be large. For the same reason, other demographic features should be controlled for as well.

The first table we recreated for our project presents the estimates and corresponding standard errors that our model produces. The first column has no restrictions on the data and hence is promptly named “default”. The second column contains our estimates and standard errors for our model coefficients when we exclude industrial countries from the training data. The third column is similarly constructed, except we exclude years prior to 1970. Lastly, the fourth column is similar to the default column except we include ‘with country effects’, which essentially includes every country pair factor as a regressor. As seen below we nearly perfectly match Rose’s original table, with the exception of our lack of a fourth column.

The reason our fourth column couldn’t come to fruition is because of the limited memory we had available for our regression analysis. With 178 countries in our dataset, we are left with an immense amount of covariates in our regression because we need to pair every country with every other country. This means that we have $nCr(178,\ 2)$ covariates which are well over 15,000 regressors just from our country pairs. Thus we couldn’t compute our coefficient estimates for the fourth column. What made the memory issue even worse was the use of clustering robust standard errors, which Rose implemented in his paper. The use of this clustering technique overloaded our memory space on Datahub. We couldn’t even output one column of information. To get around this problem, we installed RStudio Desktop and ran it from our personal machines. Doing so, enabled us to compute the first three columns this way. However, the fourth column, due to both the high number of covariates and the use of the clustering robust standard error technique, led to a memory overload on RStudio Desktop as well, leaving us with a blank column four.

```
> data4web$country_pair_factor <- as.factor(interaction(data4web$cty1, data4web$cty2))
> lm1.4 <- lm(ltrade ~ bothin + onein + gsp + ldist + lrgdp + lrgdppc + rta +
+               custrict + comlang + border + landl + island + lareap + comcol
+             + curcol + colony + comctry + country_pair_factor + factor(year),
+             data=data4web)
Error: vector memory exhausted (limit reached?)
```

Taking a closer look at our results, we point out that the coefficients corresponding to the log distance variables are all negative, relatively large in magnitude, and statistically significant. This implies that the trade value between two countries decreases the further apart they are from one another. Furthermore, the coefficients corresponding to the wealth of the nations, specifically $\log(GDP_1 \times GDP_2)$ and $\log(GDP\ PC_1 \times GDP\ PC_2)$ - are positive, large, and significant. This applies to all estimates regarding the other demographic features.

In all four columns, both estimates regarding GATT/WTO membership - bothin, onein - are either very small (relative to the estimates for GSP), not statistically significant, or both. In fact, in the first three columns the estimates are negative.

However, estimates for GSP are quite large and statistically significant in all columns other than column 2. To summarize, we can conclude that joining GATT/WTO does not encourage trade, whereas the GSP promotes trade.

In our replication code, the first code block runs the regressions with different constraints corresponding to each column. To do so, for columns 2 and 3 we implement these constraints by filtering our data; while for column 4, we simply add the country pair factors as regressors to the default model. As we mentioned earlier, our efforts to replicate column 4 failed due to a limited memory issue; thus we omitted the code for replicating column 4 to prevent R from crashing when running the entire file.

Rose's Results

TABLE 1—BENCHMARK RESULTS

	Default	No industrial countries	Post 1970	With country effects
Both in GATT/WTO	−0.04	−0.21	−0.08	0.15
	(0.05)	(0.07)	(0.07)	(0.05)
One in GATT/WTO	−0.06	−0.20	−0.09	0.05
	(0.05)	(0.06)	(0.07)	(0.04)
GSP	0.86	0.04	0.84	0.70
	(0.03)	(0.10)	(0.03)	(0.03)
Log distance	−1.12	−1.23	−1.22	−1.31
	(0.02)	(0.03)	(0.02)	(0.02)
Log product real GDP	0.92	0.96	0.95	0.16
	(0.01)	(0.02)	(0.01)	(0.05)
Log product real GDP p/c	0.32	0.20	0.32	0.54
	(0.01)	(0.02)	(0.02)	(0.05)
Regional FTA	1.20	1.50	1.10	0.94
	(0.11)	(0.15)	(0.12)	(0.13)
Currency union	1.12	1.00	1.23	1.19
	(0.12)	(0.15)	(0.15)	(0.12)
Common language	0.31	0.10	0.35	0.27
	(0.04)	(0.06)	(0.04)	(0.04)
Land border	0.53	0.72	0.69	0.28
	(0.11)	(0.12)	(0.12)	(0.11)
Number landlocked	−0.27	−0.28	−0.31	−1.54
	(0.03)	(0.05)	(0.03)	(0.32)
Number islands	0.04	−0.14	0.03	−0.87
	(0.04)	(0.06)	(0.04)	(0.19)
Log product land area	−0.10	−0.17	−0.10	0.38
	(0.01)	(0.01)	(0.01)	(0.03)
Common colonizer	0.58	0.73	0.52	0.60
	(0.07)	(0.07)	(0.07)	(0.06)
Currently colonized	1.08	—	1.12	0.72
	(0.23)		(0.41)	(0.26)
Ever colony	1.16	−0.42	1.28	1.27
	(0.12)	(0.57)	(0.12)	(0.11)
Common country	−0.02	—	−0.32	0.31
	(1.08)		(1.04)	(0.58)
Observations	234,597	114,615	183,328	234,597
R^2	0.65	0.47	0.65	0.70
RMSE	1.98	2.36	2.10	1.82

Notes: Regressand: log real trade. OLS with year effects (intercepts not reported). Robust standard errors (clustering by country-pairs) are in parentheses.

Our Results

Regressor	Default	no industrial countries	post 1970
bothin	-0.04 (0.05)	-0.21 (0.07)	-0.08 (0.07)
onein	-0.06 (0.05)	-0.2 (0.06)	-0.09 (0.07)
gsp	0.86 (0.03)	0.04 (0.1)	0.84 (0.03)
ldist	-1.12 (0.02)	-1.23 (0.03)	-1.22 (0.02)
lrgdp	0.92 (0.01)	0.96 (0.02)	0.95 (0.01)
lrgdppc	0.32 (0.01)	0.2 (0.02)	0.32 (0.02)
regional	1.2 (0.11)	1.5 (0.15)	1.1 (0.12)
custrict	1.12 (0.12)	1 (0.15)	1.23 (0.15)
comlang	0.31 (0.04)	0.1 (0.06)	0.35 (0.04)
border	0.53 (0.11)	0.72 (0.12)	0.69 (0.12)
landl	-0.27 (0.03)	-0.28 (0.05)	-0.31 (0.03)
island	0.04 (0.04)	-0.14 (0.06)	0.03 (0.04)
lareap	-0.1 (0.01)	-0.17 (0.01)	-0.1 (0.01)
comcol	0.58 (0.07)	0.73 (0.07)	0.52 (0.07)
curcol	1.08 (0.23)	NA (NA)	1.12 (0.41)
colony	1.16 (0.12)	-0.42 (0.57)	1.28 (0.12)
comctry	-0.02 (1.08)	NA (NA)	-0.32 (1.04)

In the second part of our code, the first three lines are allocated for computing standard errors, while the last three lines produce coefficient matrices (an object of the class coeftest). Initially, the standard errors from our replication of the table differed from the original paper. To overcome this issue, we re-read the paper, and realized that we simply used a different scheme for computing the robust standard error. We then switched our methodology to match that of Rose's paper and use clustered standard errors. To compute the clustered standard errors we implemented the package "multiwayvcov". The rest of our code simply consists of a function that creates and displays our table along with calling the respective functions.

The second table we recreated for our project aims to determine the impact that membership in the GATT/WTO has on bilateral trade between different countries by depicting the regression estimates and their respective standard errors for the bothin, onein, and GSP covariates in our gravity model. The table shows these estimates in 5 year intervals ranging from 1950 to 1995 to show how the coefficients change overtime. To achieve this, the same regression is run but on data corresponding to the given year. As you can see below, our recreation of Rose's table almost perfectly matches the original, with only minute differences which we attribute to the likely difference in the number of significant digits used across the various computations along with a likely different robust standard error scheme

Our Results

```
> create_table2(lms)
[1] "year: 1950     bothin: 0.59  (0.12)  onein: 0.21(0.08)   gsp: ---- (-)"
[1] "year: 1955     bothin: 0.64  (0.11)  onein: 0.3(0.09)   gsp: ---- (-)"
[1] "year: 1960     bothin: 0.4  (0.09)  onein: 0.07(0.06)   gsp: ---- (-)"
[1] "year: 1965     bothin: 0.23  (0.07)  onein: 0.14(0.07)   gsp: ---- (-)"
[1] "year: 1970     bothin: -0.14  (0.09)  onein: -0.04(0.09)   gsp: 0.39 (0.23)"
[1] "year: 1975     bothin: -0.32  (0.09)  onein: -0.16(0.09)   gsp: 0.91 (0.06)"
[1] "year: 1980     bothin: -0.07  (0.09)  onein: 0.03(0.09)   gsp: 0.89 (0.06)"
[1] "year: 1985     bothin: 0.2  (0.12)  onein: 0.16(0.12)   gsp: 0.77 (0.07)"
[1] "year: 1990     bothin: 0.6  (0.15)  onein: 0.43(0.15)   gsp: 0.73 (0.07)"
[1] "year: 1995     bothin: -0.5  (0.14)  onein: -0.67(0.15)   gsp: 0.57 (0.06)"
>
```

Rose's Results

TABLE 2—CROSS-SECTIONAL ANALYSIS

	Both in GATT/WTO	One in GATT/WTO	GSP
1950	0.59	0.21	—
	(0.12)	(0.09)	
1955	0.64	0.30	—
	(0.11)	(0.09)	
1960	0.40	0.07	—
	(0.10)	(0.07)	
1965	0.23	0.13	—
	(0.07)	(0.07)	
1970	−0.15	−0.04	0.40
	(0.10)	(0.10)	(0.23)
1975	−0.33	−0.16	0.92
	(0.11)	(0.11)	(0.05)
1980	−0.09	0.02	0.90
	(0.11)	(0.11)	(0.05)
1985	0.18	0.15	0.80
	(0.15)	(0.16)	(0.06)
1990	0.58	0.43	0.76
	(0.20)	(0.21)	(0.05)
1995	−0.50	−0.66	0.59
	(0.21)	(0.21)	(0.05)

As we can see in both our table and Rose's table the magnitude of the coefficients for the variables bothin and onein begin to decrease as time goes on, and even reach a negative value when the GSP is introduced. In other words, the impact that being a member of the GATT/WTO has on international trade between countries began to lessen as time passed. The point in which these estimates start to become negative is in 1970. Notice that in the tables we have blank information on the GSP estimates before 1966. This is simply because the GSP hadn't been conceived at this point in time. Thus with the introduction of the GSP and other programs like the GSP which began to be implemented as time passed on, we see that it's not the membership of the GATT/WTO that is important for trade, but rather the policies that were introduced due to these programs. And as time passes on they begin to have more of an impact, because there are more policies being implemented along with the fact that oftentimes policies take some time before large scale effects come to fruition.

To replicate the second table, similar to the first table, we split our code into two main functions. One that takes in a list of years and creates the linear models for those years, and another function that takes in the linear models and displays the relevant information from them to create our table. When extracting the standard errors from the models, we used the sandwich package to compute our robust standard errors, as the paper also used some general method to compute robust standard errors. As mentioned previously this may be a cause of the slight difference between Rose's table and our table.

Some troubles that we encountered along the way when creating the code was dealing with the fact that we had NA values for the GSP column in our data prior to 1966. To deal with this, we set our variables for the GSP estimate and GSP standard error to be a string that would be nice to read for output (a series of dashes) to indicate that nothing was there. We accomplished this with just a simple if statement. But this led to another problem down the line. When we output our results we need to round our estimates and standard errors. This is because we need to match the number of significant digits present in Rose's output for the sake of consistency and presentation. So if we were in the situation where our model was training on the data for years before 1966, then our code would attempt to round a string variable, which would lead to an error. So to handle this, we implemented a try catch block of code to catch the error and take care of the necessary formatting in such a situation. This way our code remained robust to errors and also smooth and abstracted away into functions, allowing us to simply call our two functions without needing to worry about all the impurities and discrepancies that may exist.

Both our replications yielded results consistent with the original findings. The outcomes obtained in our study closely align with those reported by Rose, reinforcing the conclusions drawn from the original research. This consistency between our

replicated results and the original study underscores the reliability and validity of both the original research and our replication efforts.

In conclusion, Andrew K. Rose's article thoughtfully challenges the prevailing belief in the unequivocal impact of the WTO on international trade, particularly within the framework of a gravity model. While not outright dismissing this notion, the article emphasizes the necessity for rigorous and comprehensive research, encompassing the intricacies of a gravity model and panel data analysis to unravel the complex relationship between WTO membership and trade expansion. Our successful replication of this study further validates Rose's approach and findings, highlighting the significance of his contributions to the field of international trade research.

Work Cited

Rose, Andrew K. “Andrew K. Rose: Research at Berkeley-Haas.” Andrew K Rose Recent Research, faculty.haas.berkeley.edu/arose/RecRes.htm#Software. Accessed 4 Aug. 2023.

Rose, Andrew K. "Do We Really Know That the WTO Increases Trade?" The American Economic Review, vol. 94, no. 1, Mar. 2004, pp. 98-114. Stable URL: https://www.jstor.org/stable/3592771.