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International Trade and the Eurozone: A Gravity Model Study

Trent J. Davis, Washington State University

I. Background

After implementation in 1999 the Euro has quickly become the second most traded currency in the world (Cohen, 2015). The idea behind the Eurozone is to increase economic unification, increase political cooperation, and overall to create a more stable platform for Europe to continue its development. One of the most immediate effects the formation of the Eurozone had on the continuation of economic unification was the transaction costs between member countries quickly fell. By eliminating currency arbitrage between member countries the barriers to enter international trade agreements decreased. A decrease in costs, and an increase in competition, quickly followed suit.

In theory joining the Eurozone, and any currency union in general, should increase international trade flows [sum of imports and exports] due to decreasing costs between member trading partners, and an increase of competition which further decreases costs. With currency arbitrage being eliminated between two Eurozone countries and the increase of competition, the total costs of trading should decrease resulting in a statistically significant, net positive, impact on international trade flows.

An empirical model will be developed to identify whether adopting the Euro has a net positive impact on the sum of imports and exports, in other words international trade flow. The model will measure whether or not one, both, or neither trading partner is a member of the Eurozone. It will also take into account how many years said trading partners have been a member of the Eurozone. 26 European countries will be tested against 83 trading partners, some being members of the Eurozone and some not. Regarding the 83 trading partners their integration into the Eurozone, or a different currency union, will be tested as well. The two main hypothesizes being tested are as follows:

1. Joining the Eurozone results in a statistically significant positive impact on the sum of imports and exports for the joining country.
2. The longer a country is a member of the Eurozone has a statistically significant positive impact of the sum of imports and exports of the member country.

II. Literature Review

After European countries introduced the Euro as their currency they saw a jump in international trade by roughly 5 percent (Bladwin, et al., 2008). Relative prices within the EU began to decrease after the introduction of the Euro resulting in increased trade flows. The price reduction is attributed to the Law of One Price (Allington, Paul, & Florian, 2005). Since the Eurozone essentially became one market instead of individual 17 markets the price of goods more or less levelled out, in part to currency arbitrage being eliminated within the Eurozone. However, these findings only affected intra-EU trading. The findings showed the idea of one-price-one-market made international trade between the member economies much more common place, which could account for the rise in overall international trade.

A second proposition regarding the increase in international trade was the increase of the amount of goods original exporters began to sell to member states (Baldwin, 2006). This theory actually discounts the idea that prices began to equalize. Even though the transaction costs decreased between member states the law of supply and demand pricing continued. In other words, prices still would differentiate within different economies even though many treated the Eurozone as one market. Instead the argument states that the amount of products being exported by member economies increased, and this is the reason for the overall growth of international trade post-Euro integration. Evidence also shows how individual countries benefitted from this situation while others saw relatively zero change in net exports and imports. Out of the Eurozone members Spain saw the greatest growth of international trade while gains in Greece were negligible at best [some evidence even points to a contraction of international trade in Greece] (Baldwin, 2006).

Glick and Rose (2002) used the Gravity Model of International Trade in order to explain the relationship between currency unions and international trade flows. Taking into account bilateral trade agreements, population statistics, colonization statistics, and demographic information such as geological factors and cultural attributes of the tested countries they attempted to show a positive relationship between international trade flows and currency unions. While much of my research is based off of their findings, and model, there is one large difference between the two. Their model did not take into account the length of time a country has been a member of a currency union. Instead, their focus on currency unions consisted of a binary variable stating whether the tested countries were a member of a currency union, and a second binary variable stating whether the currency union that either tested country could be in were the same. Upon completing their model, they found international trade flows increased by roughly three times their original amounts if both tested countries were members of the same currency union (Glick & Rose, 2002). While this conclusion is consistent with the hypothesis stating being a member of a currency union increases international trade flows it does not take into account the amount of time either tested country has been a member of a currency union, which is a pillar of my model.

This research will be highlighting the effects of joining the Eurozone not only in the short-run, but the long run as well. Currency union integration decreases costs of trade between member states. The decrease of costs will result in an increase of competition, further lowering costs to trading partners. Over time as competition increases, and costs decrease, the amount of trade member countries partake in should increase. The variable accounting for time is a simple variable accounting for the rise in competition and reduced costs. My research will focus around both the initial currency union integration, and post-currency union integration. With the abolishment of currency arbitrage between member states, and decreased costs leading to increased competition, international trade should increase significantly.

III. Economic Theory

International trade is one of the four key components one needs to take into account when measuring aggregate demand. When a country sees increased exports compared to imports the aggregate demand curve shifts up, and vice-versa when imports increase. Investment, energy, resources, transportation costs and technology are all major aspects of international trade, as are differing exchange rates and currencies. It is important to take into account all of these aspects when measuring international trade data as they all affect aggregate demand. Many models have

been developed to explain international trade levels and what affects them. The Gravity Model of International Trade can be used to draw a relationship between joining a currency union and international trade flows. This relationship is based in classical economic theory of aggregate demand.

The gravity model of international trade, based off of Newton's equation explaining gravitational force between two physical objects, attempts to explain relationships between two countries participating in international trade (Verlinde, 2011). The base version of the Gravity Model of International Trade is:

$$Equation\ 1: F_t = \beta \cdot \frac{GDP_1 \cdot GDP_2}{d^n}$$

The model is testing the sum of imports and exports, F_t, between two countries, GDP_1 and GDP_2. According to the model the only way to increase the trade flow between the two countries is to either increase the GDP of one, or both, of the active countries or to decrease the distance between them, assuming all else is held constant (Anderson, 1979). Unlike Newton's original equation, where the distance variable consists of solely a physical distance between two objects, the distance variable in the gravity model takes into account other variables that would bring two countries closer together such as; using a shared currency, shared land borders, an international sea port, and the physical distance between the trading partners. The variable measuring theoretical distance is the most important factor when the equation is used for predicting international trade. The model being developed accounts for currency union integration, shared languages, shared land borders, and whether or not either of the trading partners are landlocked. All of these variables have a large influence on the distance variable within this model.

Instead of showing whether trade flows will increase with a higher GDP the model will demonstrate how trade flows increase when one, or both, trade partners are members of a currency union, specifically focusing on the Eurozone. In regards to this model being a member of a currency union will decrease the distance variable. By joining a currency union a country is attempting to develop stronger economic relations with other members of said union. When adopting a common currency, currency arbitrage will become non-existent. In theory this should increase the amount of trade the member countries partake in.

By conducting research measuring the amount of trade countries who have adopted the Euro realised, both before and after adaptation, a positive statistical change in trade flows should be observable. In regard to intra-Eurozone trading those numbers will increase significantly upon adaptation of the Euro (Glick & Rose, 2002). International trade regarding countries outside of the Eurozone should also increase as currency union adaptation increases competition and decreases overall costs of trade (Glick & Rose, 2002).

The main hypothesis being tested is: a country that joins the Eurozone sees a significant increase in the international trade flows as the distance variable of the Gravity Model, which takes into account whether a country is a member of the Eurozone, will decrease. By measuring trade flows [sum of imports and exports] of a country, both before and after Eurozone integration, an increase of international trade post-integration should be observable. Also tested is the amount of time a country has been a member of the Eurozone. Post-Euro integration should result in a

decrease in costs between trading partners, especially intra-Eurozone trading partners. A result of the reduced costs between trading partners will be an increase in competition. Increased competition will reduce prices further than the original reduction of simply joining the currency union. A reduction of costs, resulting in increased competition, will increase international trade a member of a currency union will realise over time (Rose, 1999).

IV. Results

A. Full Model

The full model takes into account 26 home trading partners on the European continent and tests them against 83 trading partners located around the world, including Europe. This model is developed to show a general increase in total international trade when one of the home trading European countries adopts the Euro.

The Gravity Model was estimated using simple robust [to account for the issue of heteroscedasticity] OLS regressions. The model fits the data very well as the R-squared value equals 0.829, meaning 82.9 percent of the variation in trade flows was accounted for by the model. The observed coefficients were mainly consistent with what was originally expected. The independent variables measuring real GDP, whether or not the trading partner is a member of a currency union, the amount of years a country is a member of the Eurozone, if the trading partners share a land border, and if the two countries shared a common language all had positive coefficients. This makes intuitive sense since countries with higher real GDP values would be expected to trade more. The hypothesis that countries with higher GDPs will trade more is supported by both the coefficients being positive, and the variable being statistically significant. There are four coefficients with values negatively pertaining to expected trade flows: distance between the two countries, whether a country is in the Eurozone or not, the number of years the trading partner has been a member of a currency union, and if the EU country being test is landlocked. The coefficients pertaining to the variables distance[km] and whether or not the country is landlocked are consistent with the hypotheses. The further a country is away from its trading partner the less they will trade. If a country is landlocked then it is harder for it to distribute its own goods and receive goods, so the country is expected to realize lower values of trade due to increased costs, as seen with the negative coefficient.

The model was developed to determine whether or not there is a positive connection between being a member of a currency union and trade flows between countries. Out of the four variables accounting for currency unions in the model all but one, whether or not a country is a member of the Eurozone, are statistically significant at a 0.05 level. Out of the three statistically significant variables two have positive coefficients, how long a country has been in the Eurozone and whether or not the trading partner is a member of a currency union, with coefficients of 0.014 and 0.470 respectively, these results are consistent with their respective hypothesises. However, the variable accounting for how long the partner country has been in a currency union had an unexpected negative coefficient of -0.0381. The combination of the coefficients regarding the trade partner's currency union implementation is interesting. If the trading partner is a member of a currency union then the log value of the trade flows automatically increases by 0.470, but for each year the country is a member of said currency union its trade flow value will decrease by 0.038, assuming all else is held constant. The negative coefficients regarding the variables pertaining to the Eurozone membership, and how long the partner country has been in a currency

union, are surprising. The negative values go against the original hypothesis that both of these variables would have a positive impact on trade.

Curiously the variable showing whether the European trade partner is a member of the Eurozone is not statistically significant. While the original hypothesis predicted it would have a positive coefficient the variable actually has a negative coefficient. However, the p-value equals 0.535, meaning it has no statistical impact on the results of the model.

Table 1: Regression Results – Full model

Dependent Variable = ln(Trade Flow)

Independent Variable	**Coef.**	**Std. Err.**	**t-test**	**p-test**
Intercept	-5.422	1.035	-5.23	0
Real GDP	1.074	0.055	19.26	0
Distance (km)	-0.039	0.010	-3.86	0
Eurozone membership, yes or no	-0.022	0.035	-0.62	0.535
Eurozone membership years	0.014	0.004	3.31	0.001
Trading partner currency union membership, yes or no	0.470	0.043	10.71	0
Trading partner currency union membership years	-0.038	0.004	-9.19	0
Shared boarder, yes or no	1.321	0.041	31.55	0
EU country landlocked, yes or no	-1.155	0.070	-16.49	0
Trading partner landlocked, yes or no	7.836	0.113	68.83	0
Shared language	0.856	0.035	24.23	0
R-squared		0.829		
Number of Obs.		37175		
Prob > F		0		

B. European Model

Unlike the original model, where worldwide trade was taken into account, only international trade flows between European countries will be measured in this model.

Table 2: Regression Results - European Model

Dependent Variable = ln(Trade Flow)

Independent Variable	**Coef.**	**Std. Err.**	**t-test**	**p-test**
Intercept	4.405	1.732	2.54	0.011
Real GDP	0.827	0.074	11.13	0
Distance (km)	0.023	0.012	1.82	0.069
Eurozone membership country one, yes or no	0.122	0.042	2.86	0.004
Eurozone membership years, country one	-0.018	0.005	-3.42	0.001
Eurozone membership country two, yes or no	-0.0124	0.042	-0.29	0.77
Eurozone membership years, country two	-0.044	0.005	-8.24	0
Shared border, yes or no	1.411	0.033	41.73	0
EU country landlocked, yes or no	-0.558	0.055	-10.01	0
Trading partner landlocked, yes or no	-0.912	0.086	-10.52	0
Shared language	0.451	0.047	9.5	0
R-squared		0.859		
Number of Obs.		13,871		
Prob > F		0		

The R-squared value of the model equalled 0.859, meaning the model accurately predicts 85.9 percent of the dependent variable. Also, the overall Prob > F value is equal to 0, showing the model is statistically significant at a 0.05 level. While these values were relatively expected after running the original model, the coefficients for the variables Eurozone membership country one, yes or no, Eurozone membership years, country one, Eurozone membership country two, yes or no, and Eurozone membership years, country two are surprising:

Only one of these four variables; Eurozone membership country one, yes or no; has a positive coefficient of 0.122 [this variable is also statistically significant at a 0.05 level]. The positive coefficient is consistent with the original hypothesis. In theory if a country adapts the Euro as its currency, and is located and trading within Europe, then the amount of international trade the country sees should go up as the currency being used will be more standardized in regards to the trading partners, thus, decreasing the overall cost of trade.

However, two variables that were hypothesized to have positive coefficients were shown to be negative. The variables Eurozone membership years, country one; and Eurozone membership years, country two; have coefficients equal to -0.018 and -0.044 respectively [these variables are statistically significant at a 0.05 level as their p-values equal 0.001 and 0 respectively]. Both of these variables are measuring the amount of time the home country and/or trading partner have been members of the Eurozone. The original hypothesis of these two variables stated they would have a positive relationship with international trade flows. It was thought the longer a country has been using the Euro the sum of exports and imports would increase as the Euro would become more and more stable over time. However, this model shows the opposite. It shows that for each year the home country uses the Euro its international trade flow will decrease by 1.838 percent, and for each year the partner country uses the Euro the amount of trade between the two countries decreases by 4.410 percent. These results do not support the original hypothesises that both of these variables would have a positive relationship in regards to international trade.

Following the similarities, the secondary model has with the original model one of the four variables; Eurozone membership country two, yes or no; was not statistically significant at any level. This variable is measuring whether or not the partner country that is being traded with is a member of the Eurozone or not. The p-value of said variable is equal to 0.77, thus, it has no statistical significance within the model. However, this is not necessarily unexpected. The binary variables pertaining to whether trade partner one and two are in the Eurozone are essentially the same. For example, if Spain is either the home country or the trading partner its values for Eurozone membership country one, yes or no; and Eurozone membership country two, yes or no; will be the same respectively. The fact that the variable accounting for “country two” i.e. the trade partner is not significant does not necessarily show that currency unions do not have any relationship in regards to international trade flows. Instead, the statistical insignificance of this variable shows a possible necessary change to the model needs to be made.

Instead of including two variables describing whether or not countries within Europe are individual members of the Eurozone, like the previous model has, a new variable describing whether or not both countries are in the Eurozone should be implemented. This would be a binary variable with a value of zero if one or both countries are not in the Eurozone, and a value of one if both countries are in the Eurozone. This idea is the basis for the third model developed.

C. Intra-Eurozone Trading Model

As with the first two models the overall model is highly accurate. A value of 0.858 for the R-squared statistic shows the variables and data account for 85.8 percent of the dependent variable. The model is also statistically significant at a 0.05 level as the Prob > F is equal to 0. This is consistent with the prior two models.

Table 3: Regression Results - Intra-Eurozone trading model

Dependent Variable = ln(Trade Flow)

Independent Variable	**Coef.**	**Std. Err.**	**t-test**	**p-test**
Real GDP	2.033	1.679	1.21	0.226
Distance (km)	0.949	0.081	11.62	0
Shared border, yes or no	0.023	0.015	1.54	0.123
Both trading partners are Eurozone members, yes or no	0.170	0.029	5.7	0
EU country one landlocked, yes or no	1.412	0.033	42.76	0
EU country two landlocked, yes or no	-0.576	0.061	-9.44	0
Shared language	-1.140	0.075	-15.18	0
Real GDP	0.448	0.056	7.87	0
R-squared		0.858		
Number of Obs.		13,871		
Prob > F		0		

The main concern for the third model was to identify a relationship between trade partners who are both members of the Eurozone and their international trade flows. The variable pertaining to both trading countries being Eurozone members was hypothesized to have a positive relationship with the expected trade flows. As shown above the coefficient for this variable is a positive at 0.170, and has a p-value equal to 0. This results in a supported hypothesis that countries that are both members of the Eurozone will partake in higher levels of trade than countries who are not both members. The findings of this model are consistent with prior research showing trade flows between two countries who are members of the same currency union partake in significantly more trade than countries who are not both members of the same currency union (Glick & Rose, 2002). While the findings of this model do not show an increase as large prior research it is still

consistent with the idea that intra-currency union trading is statistically higher than non-intra-currency union trading.

One of the largest differences this model had in regards to the variables revolves around the physical distance variable. Unlike in the prior models this variable was not statistically significant at any level. However, since this model only takes into account trading partners within the European continent, which is relatively small, the distance between trading partners is not expected to have as high an impact on trade as it would in the first model.

All other variables within the model were statistically significant at a 0.05 level as their p-values were all equal to 0. Also, the coefficients of the variables all made sense and supported the hypothesises regarding them. The variables pertaining to real GDPs, shared land borders, and shared language all had positive coefficients. The variables pertaining to whether or not the tested countries were landlocked both have negative coefficients as landlocked countries have a higher cost of trade (theorized to be due to the absence of an international sea port), thus, decreasing total trade.

V. Conclusion

After analysing the empirical model results a conclusion can be drawn that being in the Eurozone may or may not increase international trade flows. A surprising result showed that in regards to worldwide trade being a member of the Eurozone does not have a statistically significant impact on total trade flows. On top of this the variable stating whether the trade partner was in a currency union had a very significant increase on international trade levels. The variable took into account the Eurozone as well as all other currency unions currently being used today. The results show being a member of a currency union should have a positive impact on total trade flows, but it does not specify the currency union being tested. This result regarding whether or not joining the Eurozone specifically increases international trade flows or not is inconclusive. Even though the coefficient for how many years the trade partner was in a trade union was negative it would take roughly fifteen years, all other variables held constant, for the negative coefficient to outweigh the positive coefficient of the trading partner's currency union implementation.

A key aspect of this research was to show a direct relationship with trade flows and how long a country has been a member of a currency union. After analysing the results of all three models it can be concluded that the length a country is a member of a currency union does have a statistically significant impact on the amount of international trade the country partakes in. However, while the original hypothesis stated "the longer a country is a member of a currency union the more trade said country will conduct" the evidence shows this may not be the case. The tested results of the first model, testing worldwide trade, show the longer a country has used the Euro the more international trade the country will conduct. This contradicts the model testing European trading partners which provided evidence that the longer a country is a member of the Eurozone the less international trade the country will partake in. While both variables are statistically significant the results are inconclusive regarding the effect time has on the Euro due to the coefficients being positive for one and negative for the other.

One of the most important observations regarding the Eurozone and trade was intra-Eurozone trading. The results show roughly a 17 percent increase in international trade will be realized within the Eurozone once both trading partners are members. This isn't surprising. When countries trade using the same currency the cost of goods is minimized and currency arbitrage is non-existent. This phenomenon results in increased international trade between Eurozone member countries due to decreasing trade costs.

One of the shortcomings of the research was the lack of using other currency unions than just the Eurozone. While other currencies unions were accounted for they were not specifically defined, nor organized into different variables. Instead, for the variable defining whether or not the trading partner is in a currency union, all currency unions were treated the same. If these currency unions had been individually defined the results may have been different.

Further research regarding different currency unions should take place. This research essentially focused on the implications of the Eurozone and it did not weigh other, specific currency unions, the same. While a variable was included to determine if the partner trade country was in a currency union this variable did not define which currency union was being analysed. Was it a country that is a member of the Communauté Financière Africaine, the East Caribbean Dollar, or a different currency union? These types of questions were not addressed in this research. By defining what currency unions are being tested a more distinct correlation between trade and currency unions could be observed. Future research should include all currency unions and specify what currency union is being accounted for, for each tested country.

VI. Appendices

A. Data Description:

In order to create an accurate gravity model of trade macro level data will be the focus. The main variables needed are real GDP, import and export data, and trade flows. Along with these main variables there will be many secondary variables defining the distance variable within the gravity model.

The trade data necessary is from Eurostat, a database created by the European Commission tracking multiple macro-economic indicators, such as international trade data, for all EU countries. The import and export statistics used, along with the trade flow data, is from the Eurostat database, BEC.

Along with the data discussed above, information regarding multiple other variables have been taken into account to accurately determine the distance variable. This variable does not just take into account the physical distance between two trading countries, although that is one aspect of it, but instead takes into account many other factors. These variables consist of: whether or not the European trading partner is a member of the Eurozone and how long they have been a member, whether the subsequent trading partner is in a currency union (does not have to be the Eurozone) and how long they have been a member, whether or not one or both trading partners are landlocked, whether or not the trading partners share a land border, and finally whether or not the trading partners have a shared language.

To define the physical distance between the tested countries the geographical centroid of each country was found using longitude and latitude. Once these were found the *Haversine Equation* was used to find the exact distance, in kilometres, between the centroids:

Equation 2:

$$Distance\ in\ km = \sin(\frac{lat2 - lat1}{2})^2 + \cos(lat1) * \cos(lat2) * \sin(\frac{long2 - long1}{2})^2$$

The variables *lat1* and *lat2* refer to the latitude of the centroids of the tested countries. Similarly, the variables *long1* and *long2* represent the longitude of the centroids of the tested countries.

The data description table and summary statistics table are located below:

Table 4: Data

LABEL	VARIABLE DESCRIPTION	SOURCE	DATA PERIOD	DATA INTERVAL	OBSERVATION UNIT
Trade Flow	Sum of imports & exports	Eurostat	1988-2013	Annual	Euros
ln(rGDP*rGDP)	Natural Log of real GDP of home country * read GDP of partner country	Penn World Tables	1988-2010	Annual	USD
ln(Centroid Distance)	Natural log of the distance between tested countires centroids	Portland State University	N/A	N/A	Kilometers
Lang	Do the countries share a language? Yes or no.	CIA Worldfact Book	N/A	N/A	Binary Variable
Border	Do the countries share a border? Yes or no.	CIA Worldfact Book	N/A	N/A	Binary Variable
Lock	Is the country landlocked? Yes or no.	CIA Worldfact Book	N/A	N/A	Binary Variable
Euro Currency Union	Is the home coutry a member of the Eurozone? Yes or no.	European Central Bank	1988-2010	Annual	Binary Variable
Euro Currency Union Time	How long has the home country been a member of the Eurozone?	European Central Bank	1988-2011	Annual	Years
Parnter Currency Union	Is the partner country a member of a currency union? Yes or no.	Various Sources	1988-2012	Annual	Binary Variable
Partner Currency Union time	How long has the partner country been a member of a currency union?	Various Sources	1988-2013	Annual	Years

Table 5: Summary Statistics Table

Label	Unit	Observations	Mean Value	Std. Deviation	Min. Value	Max Value
Trade Flow	Euros	37175	17.98	3.177	1.099	25.391
ln(rGDP*rGDP)	USD	50465	19.035	1.262	15.066	22.382
ln(Centroid Distance)	Kilometers	50465	9.011	0.717	5.214	9.901
Lang	Binary Variable	50465	0.038	0.192	0	1
Border	Binary Variable	50465	0.035	0.185	0	1
Lock	Binary Variable	50465	0.249	0.432	0	1
EuroCurrencyUnion	Binary Variable	50465	0.256	0.437	0	1
EuroCurrencyUnionTime	Years	50465	1.548	3.177	0	12
PartnerCurrencyUnion	Binary Variable	50465	0.134	0.341	0	1
PartnerCurrencyUnionTime	Years	50465	1.463	4.813	0	37

Table 6: Home Variable Countries

Home Variable Countries Tested:

26 European Countries

Belgium	Italy
Bulgaria	Lithuania
Croatia	Luxemburg
Cyprus	Malta
Czech Republic	Netherlands
Denmark	Poland
Estonia	Portugal
Finland	Romania
France	Slovakia
Germany	Slovenia
Greece	Spain
Hungary	Sweden
Ireland	United Kingdom

Table 7: Trade Partner Countries

Partner Trade Countries Tested: 83

Argentina	Greece	Paraguay
Australia	Guatemala	Peru
Austria	Guinea	Philippines
Bahrain	Hong Kong	Poland
Bangladesh	Hungary	Portugal
Belarus	Iceland	Romania
Belgium	India	Russia
Bolivia	Indonesia	Saudi Arabia
Brazil	Iran	Singapore
Bulgaria	Ireland	Slovakia
Cameroon	Israel	Slovenia
Canada	Italy	South Africa
Chile	Ivory Coast	South Korea
China	Japan	Spain
Colombia	Jordan	Sri Lanka
Costa Rica	Kenya	Sweden
Croatia	Lithuania	Switzerland
Cyprus	Luxemburg	Syria
Czech Republic	Madagascar	Taiwan
Denmark	Malaysia	Thailand
Dominican Republic	Malta	Tunisia
Ecuador	Mauritius	Turkey

Egypt	Merico	Ukraine
Estonia	Morocco	United Arab Emirates
Finland	Netherlands	United Kingdom
France	Norway	United States of America
Germany	Pakistan	Uruguay
Ghana	Panama	

B. Emperical model explanation:

The empirical model will be based off the Gravity Model of International Trade with trade flows being the dependent variable, while real GDP and Distance will be the independent variables. The foundation of the functional form is modelled after Glick and Rose's (2002) model. However, their model did not take into account how long a country had been a member of a currency union, which is an important test statistic in this model. As the data being used is panel data all three common estimation errors may be present in the model; heteroscedasticity, multicollinearity and autocorrelation. An OLS estimator will be used to run a three-way fixed effects model. The model will determine the natural log value of international trade flows in regards to the natural log value of real GDP, the natural log value of the physical distance between the tested countries, and characteristics of the tested countries [such as currency union information]. The natural log values will be regressed in order to observe the expected percentage changes in trade flows between countries. Measuring the dependent variable as a change in percentage, neither real nor nominal values, is essential as the GDP values, and trade flow values, will differ drastically between certain countries. Using the natural log format will diminish the biases these inconsistencies may have on the results. To account for possible omitted variable bias the model will be a three way fixed effects model regarding the European countries, their trade partners and time.

$$Equation\ 3\text{: } \ln(Trade\ Flow_{A,B}) = \beta_0 + \beta_1 ln(rGDP_A * rGDP_B) - ln(\beta_3(Centroid\ Distance) + \beta_4 Lang + \beta_5 Border + \beta_6 Lock + \beta_7 EuroCurrencyUnion + \beta_8 EuroCurrencyUnionTime + \beta_9 PartnerCurrencyUnion + \beta_{10} PartnerCurrencyUnionTime + \beta_{11} e)$$

When analysing the Gravity Model the only two ways the dependent variable, Trade Flow, can increase is when $rGDP_{1,2}$ increases or Distance decreases. This model will be testing the distance variable of the Gravity Model.

Recall the base equation of the Gravity Model of International Trade is defined as:

Equation 4: $F_t = \beta \cdot \frac{GDP_1 \cdot GDP_2}{d^n}$

When analysing the independent variables all but the GDP values of countries 1 and 2 relate to the distance variable of the model. There are four main variables, which will help answer the overall hypothesis stating being in a currency union will increase international trade flows. These four variables are: *EuroCurrencyUnion, EuroCurrencyUnionTime, PartnerCurrencyUnion* and *PartnerCurrencyUnionTime.* By analysing the affect these four variables have on the natural log of trade flows a positive relationship between currency unions and trade flows should be determined.

The two variables *EuroCurrencyUnion* and *PartnerCurrencyUnion* are extremely similar. Both variables are binary variables and describe whether or not the tested countries are in a currency union. If the European country being tested is a member of the Eurozone the variable *EuroCurrencyUnion* will have a value of one. If the trading partner is a member of a currency union, whether it be the Eurozone or a different currency union, then the variable *PartnerCurrencyUnion* will have a value of one as well. A supporting hypothesis, for the master hypothesis, is both of these variables will have a statistically positive affect on the trade flows the tested countries realise.

If either *EuroCurrencyUnion* or *PartnerCurrencyUnion* have a value of one then the variables *EuroCurrencyUnionTime* and *PartnerCurrencyUnionTime* will have a value of one or greater, respectively. So, if *EuroCurrencyUnion* has a value of one then *EuroCurrencyUnionTime* will have to have a value of one or greater as it is measuring the amount of years the European country has been a member of the Eurozone. The relationship between *PartnerCurrencyUnion and PartnerCurrencyUnionTime* is the same, both are measuring if the trading partner is a member of a currency union, whether it be the Eurozone or not. Both variables, *EuroCurrencyUnion* and *PartnerCurrencyUnion,* are predicted to have a statistically positive relationship with the dependent variable, trade flows.

A second empirical model will be tested measuring the specific affects the Eurozone has on intra-Europe trading. In theory the adaptation of the Euro within Europe should increase the amount of trade European partners conduct with each other. The same type of data will be used however; it will only correspond with countries located in Europe. Instead of measuring whether the trading partner is in any currency union the model will measure whether the trading partner is in the Eurozone or not. The variables *EuroCurrencyUnion* and *EuroCurrencyUnionTime* will still be treated the same, and the original hypothesis that both of these variables will have a positive relationship regarding international trade will stay consistent. However, two variables

will be changing. Instead of using *PartnerCurrencyUnion* and *PartnerCurrencyUnionTime* the model will now use *EuroCurrencyUnion2* and *EuroCurrencyUnionTime2.* These variables will be treated the same as *EuroCurrencyUnion* and *EuroCurrencyUnionTime* except they will be measuring the partner countries data concerning these variables. Both of these new variables are expected to have a positive correlation to international trade flow values.

A third empirical model was developed to determine if there is a relationship regarding intra-currency union trading. This model only has one variable accounting for currency union information. It is a binary variable that has a value of one only if both the tested countries are members of the Eurozone. The model only tests countries within Europe, and is meant to determine if countries that both have adopted the Euro as their currency see higher levels of trade than if only one, or neither, country was a member of the Eurozone. The results of this model will be directly compared to results found by Glick and Rose. A positive relationship between intra-Eurozone trading and the Euro is expected. The primary hypothesises being tested are directly related to demonstrating that joining a currency union has a positive correlation upon international trade flows. Once these have been tested the overall hypothesis of;

$$H_0: Currency\ Unions \leq 0$$

$$H_1: Currency\ Unions > 0$$

should be shown to be false, as Currency Unions should have a statistically significant positive impact on trade flows.

For the models developed a standardized autocorrelation test cannot be run. The models are three way fixed effects models with a time variable being fixed, as there are multiple observations per time period. There is no standardized test that can be run in order to detect autocorrelation within three way fixed effects models

Model Test 1) Full Model Explanation & Regression Error Testing:

Ideally the model would be a three-way fixed effects model using a type command such as xtreg in STATA. However, a command wasn't available to carry this out. In order to account for the European "home" trading partner, the other trading partner and the time frames observed in the data I created three i. variables; i.Home, i.Partner and i.Periods, which when implemented into the OLS model create the same effect as a three-way fixed effects model. These three variables are separate dummy variables representing each alternative home country, each alternative trading partner and each alternative trading period. The data involved for the full model uses European countries as the home country, and then both European and non-European countries as the partner countries. Trade flows are only analysed between the "home" European countries and their partners. For example, trade between Portugal and the U.S. will be measured, but trade between the U.S. and Panama will not be measured.

The possibility of multicollinearity is very prevalent in this model. Some of the independent variables will not have a value greater than zero unless a correlated variable has a value equal to one. To test for this the VIF command was performed in STATA. The four independent variables we want to analyse in regards to currency unions are; Eurozone Membership, yes or no;

Eurozone Membership Years; Trading partner currency union integration, yes or no; and Trading partner currency union membership years. These four variables measure whether or not either trading partner is in a currency union, and if they are how many years they have been a member of said union, respectively. As you can see below the VIF values are either 10.06 or lower. As a rule of thumb any value of 10 or higher would hint at the presence of multicollinearity. However, since the highest value is equal to 10.06, essentially 10, and all of these variables are statistically significant we can conclude that multicollinearity is not an issue. On a side note, the variable accounting for real GDP values has a value of 96.84. This high value shows the variable is susceptible to multicollinearity. While this does show inflated standard errors the variable will be kept in the regression. Prior research has shown real GDP is a statistically necessary variable when using the Gravity Model of International Trade (Anderson, 1979), and given that the variable is statistically significant at a 0.05 level it will be kept.

Table 8: VIF test results - full model

VIF Diagnostic Results

Variable	**VIF**	**1/VIF**
Real GDP	96.84	0.010
Distance (km)	1.08	0.925
Eurozone Membership, yes or no	6.12	0.163
Eurozone Membership Years	5.31	0.188
Trading partner currency union, yes or no	5.61	0.178
Trading partner currency union membership years	10.06	0.099
Shared border, yes or no	1.26	0.791
EU country landlocked, yes or no	17.27	0.057
Trading partner landlocked, yes or no	24.68	0.040
Shared language	1.27	0.790
Mean	6.98	

Heteroscedasticity is also prevalent in the model. By running the hettest a p-value of 0 was determined. Even though heteroscedasticity is prevalent this isn't unexpected. One of the pillars of this model is using European countries as a "home" country to compare trade flows with. Since there is more to trade flows than simply physical distance, and what currencies are being used in the exchange, it is not surprising to find subsets of groups in the data. To counter this issue i. variables were developed and used in the robust regression. Even though there is

heteroscedasticity all but one of the independent variables are statistically significant, and with the R-squared value equalling .8293 the model is still statistically sound.

Table 9: Heteroscedasticity test results - full model

	Hettest
Fitted values of lnTradeFlow	
Chi^2	11,444.34
$P > Chi^2$	0

C. Model Test 2) European Model Explanation & Regression Error Testing:

Just like the original empirical model this model is also a three way fixed effects model, and the same command was used to carry it out. Again, I created three i. variables; i.Home, i.Partner and i.Periods, which when implemented into the OLS model create the same effect as a fixed effects model. These three variables are separate dummy variables representing each alternative home country, each alternative trading partner and each alternative period. However, unlike the original model this model only takes into account trading partners located on the European continent. It is meant to show a relationship between the Eurozone and international trade flows within Europe.

As with the original model the issue of multicollinearity could be found within the secondary model for the same reasons as the original model. In order to test for this possibility the VIF test was run:

Table 10: VIF test results – European model

VIF Diagnostic Results

Variable	VIF	1/VIF
Real GDP	92.29	0.010
Distance (km)	1.1	0.908
Eurozone membership country one, yes or no	6.12	0.163
Eurozone membership years, country one	5.35	0.186
Eurozone membership country two, yes or no	5.42	0.184
Eurozone membership years, country two	4.65	0.214
Shared border, yes or no	1.38	0.725
EU country landlocked, yes or no	9.79	0.102
Trading partner landlocked, yes or no	17.68	0.056
Shared language	1.39	0.719
Mean	6.79	

The four variables that are being specifically tested within this model are; Eurozone membership country one, yes or no; Eurozone membership years, country one; Eurozone membership country two, yes or no; and Eurozone membership years, country two. These variables are determining whether one, both, or neither of the trading partners are in the Eurozone, and for how long they have been members. As shown above none of the variables have a VIF value greater than 6.12, thus, when it comes to these four variables multicollinearity is a non-factor. Just like in the original model the variable describing the natural log function of the sum of the real GDPs of the tested countries has an extremely high VIF value, 92.92. However, this is not necessarily an issue, as it does not reduce the predictive nature of the model, nor its reliability.

Since the variables we are focusing on in this model are specific to the Eurozone, and countries who are both members and non-members of the Eurozone who are located in Europe are being tested, heteroscedasticity is to be expected. The four variables relating to currency unions; Eurozone membership country one, yes or no; Eurozone membership years, country one; Eurozone membership country two, yes or no; and Eurozone membership years, country two; are essentially mirrors of each other. For instance, the same values for these variables will be observed for the country Spain both when it is the home trading country and when it is the partner trading country [the same can be said for every country being tested in this model]. Due

to this heteroscedasticity is to be expected, and it is prevalent. After conducting a hettest a p-value of 0, and a Chi^2 value of 3004.95, was observed:

Table119: Heteroscedasticity Test – European Model

Hettest	
Fitted values of lnTradeFlow	
Chi^2	3004.95
$P > Chi^2$	0

These values show a definitive conclusion that heteroscedasticity is prevalent within the secondary model, just as it is in the original. However, just like in the original i.variables were developed to counter this issue. The "robust" command was used for the OLS regression in order to counter the issue as well. All but one of the four variables testing currency union information are statistically significant at a 0.05 level. Also, the r-squared value is equal to 0.859 showing the majority of the data fluctuations are attributed to the variables within the model.

D. Model Test 3) Intra-Eurozone Trading Model Explanation & Regression Error Testing:

A third model was developed in order to observe intra-Eurozone trading. Like the second model only countries located within Europe are included. However, unlike the previous two models only one variable, both trading partners are Eurozone members, yes or no; is used to describe the tested countries relationships with a currency union. This variable is a binary variable accounting for both countries being in the Eurozone. If both tested countries are members of the Eurozone then the variable will have a value of one. However, if only one country is a member of the Eurozone, or neither country is a member, then the variable will have a value of zero. This variable was developed in order to observe a statistical relationship between countries that are members of the Eurozone. One of the reasons the Eurozone was developed was to increase economic development between member states so this variable is expected to have a positive, statistically significant, impact on trade flows. Just like the previous two models this model is a three way fixed effects model with the same three i. variables being used.

Not surprisingly the bias of multicollinearity was present within the third model as well:

Table 12: VIF Results – Intra-Eurozone trading model

VIF Diagnostic Results

Variable	**VIF**	**1/VIF**
Real GDP	85.15	0.011
Distance (km)	1.1	0.907
Both trading partners are Eurozone members, yes or no	1.85	0.541
Shared boarder, yes or no	1.38	0.723
EU country one landlocked, yes or no	9.8	0.101
EU country two landlocked, yes or no	16.41	0.060
Shared language	1.39	0.718
Mean	6.16	

As in the previous two models the two variables showing the highest VIF values are the variables pertaining to real GDP values and whether or not the partner country is landlocked, with VIF values of 85.15 and 16.41 respectively. Even though these variables have high VIF values it does not make the model any less predictive or reliable. However, the new variable introduced regarding whether or not both trading partners are members of the Eurozone does not have multicollinearity bias, as its VIF value is equal to 1.85. The mean VIF for the entire regression is equal 6.16. As this value is not greater than 10 the overall issue of multicollinearity is not necessarily prevalent for the entire model.

Again just like the first two models the third model has a high Chi^2value of 2911.9:

Table 13: Heteroscedasticity Test – Intra-Eurozone trading model

	Hettest
Fitted values of lnTradeFlow	
Chi^2	2911.90
$P > Chi^2$	0

This value shows the bias of heteroscedasticity is prevalent within the model. While the high values found in the first models were to be expected, as they each had multiple variables describing currency unions, it is a little more surprising to find it within this model. One of the possible causes is the relationship between the two variables describing whether or not the countries are landlocked or not. Since this model is only accounting for countries located within Europe these two variables will be mirrors of each other. For instance, when Czech Republic is the home country it will have a value of one for the variable EU country one landlocked, yes or no, but when it is the partner country it will also have a value of one for the variable EU country two landlocked, yes or no, as both of the variables account for Czech Republic being a landlocked country. With the incorporation of these two variables the issue of heteroscedasticity can easily arise since they are essentially mirror variables. However, to account for this bias the "robust" command was run in STATA for the final regression.

VII. References

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