The European Debt Crisis' influence on U.S. Real Exchange Rates and Real Interest Rates

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INTRODUCTION

By March of 2010, the European Union had officially entered a debt crisis (Paris & Granitsas, 2010). The euro had been falling against the dollar in the weeks leading up to the announcement, which continued for some time. Doubts regarding public finances of Eurozone countries, Portugal, Ireland, Italy, Greece, and Spain, started to emerge. This financial downturn hit Greece the hardest. Their 10 year bond yield started to approach 7% and their government debt hit about 113% of its GDP (Bagus, 2010). For this paper I will look deeper into the European Debt Crisis and see how it has affected the factors pertaining to real exchange rates and real interest rates. The economics literature suggests that real exchange rates are primarily influenced by inflation, interest rates, current account deficits, government debt, GDP, and the value of a currency based on its trade weighted index. In addition to these factors, I will also analyze the influence of the crisis on the price of oil, since oil is a major commodity to the United States and its price influences consumer confidence and aggregate demand. Finally, I will examine the influence of the European Debt Crisis on the exchange rate between the dollar and the euro. I hypothesize that the crisis will have a negative impact on real exchange rates in the Unites States as well as a negative impact on real interest rates.

The motivation from this paper was sparked from my participation in my college's Federal Fund Challenge Team[1]. I was assigned to research international aspects and the dollar. I found it fascinating that there was so much attention on the European Debt Crisis. This surprised me because the research I obtained with the Federal Fund Challenge Team, stated that the majority of the United States' trading comes from countries outside the European Union. Only 7.8% of the U.S.'s foreign trade comes from Eurozone countries, Germany, France, and the Netherlands. I decided to look more into this topic by analyzing the data related to real exchange rates and real interest rates. I do feel as though the crisis has had some impact on the United States' real exchange rates and real interest rates, but not to the point of causing much concern.

LITERATURE REVIEW

Considering that the European Debt Crisis is a recent dilemma, finding literature regarding this topic was difficult. I also wanted to stay away from articles that delved into the causes of the European Debt Crisis. The focus of this paper is the influence of the European Debt Crisis on U.S. exchange rates and real interest rates, rather than the underlying details of the Crisis itself. My research targets real exchange rates and real interest rates and the host of independent variables that describe them.

Kildegaard (2006) studies the determinants on the peso-dollar exchange rate. For his model he uses the nominal exchange rate as his dependent variable along with the relative price of domestic (Mexican) output, the relative productivity of the domestic trade able goods sector, the relative share of government consumption to GDP at home vs. abroad, and the real world price of oil as his independent variables. He uses the nominal exchange rate over the real

[1] The Federal Fund Challenge Team is a group of students who are either Economic or Business majors that cover current economic issues from all aspects to present to members of Richmond's Federal Reserve. Schools compete against one another from all over the region.

exchange rate due to findings that reject proportionality between nominal exchange rates and prices, considering that real exchange rate accounts for inflation. His findings indicate that higher domestic productivity and higher relative government spending are associated with an appreciation of the nominal exchange rate. He also found that as the real world price of oil increases, the nominal exchange rate becomes devalued.

Two additional studies conducted by Andres Bergvall (2004) and Lothian and Taylor (2008) found that real exchange rates are transitory and that the productivity of a country and consumer preferences are major factors determining real exchange rates. In addition to productivity, Joyce and Kamas (2003), add that capital accounts and government share influence exchange rates. Jason Van Bergen (2010) explains in an article that there are six factors that influence exchange rates. He discusses how inflation, interest rates, current account deficits, public debt, terms of trade, and political stability, all contribute to the fluctuations of exchange rates. From the Bureau of Labor Statistics, Ulics and Mead (2010) insist that due to the European Debt Crisis, the price of petroleum had dropped since the euro fell 10.3% to the dollar. The reoccurring theme is that productivity has a lot to do with real exchange rates. Based on the above literature, I will incorporate the level of productivity in my real exchange rate model.

Bremmes, Gjerde and Sattem (2001) looked at the short term and long term interest rates of the United States, Germany, and Norway, where they agreed that shocks in the world's major interest rates, in general, influence much smaller interest rate markets. Engen and Hubbard (2005) wrote a journal article talking about the influences that make interest rates change in a time of national debt. They proposed that interest rates would increases about two to three base points if there is an increase in government debt equivalent to 1% of GDP. Based on my own knowledge from various business and economic classes, I have learned that savings, consumption, and worth of a country all have an impact on interest rates as well.

THEORETICAL ANALYSIS

The European Debt Crisis began when a few European Union Countries started to borrow and spend more money than they could afford. With these countries finding themselves in severe debt, the value of the euro and the confidence of its use have dramatically declined. Even though the European Union had issued a 750 billion euro bailout plan in May 2010 to restore confidence in its economy, the euro kept declining. Essentially, with a declining euro, the U.S. exchange rate with the euro should become stronger. Based on the literature and theory, however, real exchange rates in the United States are not just influenced by the worth of another countries currency.

For my paper, I have decided to use two economic models. The first deals with real exchange rates and the other deals with real interest rates. The description of the variables for Model 1 is found in Table 1, along with the mean and standard deviation of those variables. Likewise, the description of the variables for Model 2 is found in Table 2, along with the mean and standard deviation of those variables.

<u>Model 1</u>:

$$RER_i = \beta_0 + \beta_1 RBC_i - \beta_2 RGDP_i - \beta_3 TWI_i + \beta_4 OIL_i - \beta_5 lnRPCR_i - \beta_6 lnRIR_i - \beta_7 EDC_i + \square_i \qquad (1)$$

<u>Model 2</u>:

$$lnRIR_i = \beta_0 - \beta_1 RBC_i + \beta_2 RGDP_i + \beta_3 RPC_i + \beta_4 NFGS_i - \beta_5 EDC_i + \square_i \qquad (2)$$

Table 1: Summary Results of Real Exchange Rate Model

Variable Title	Description	Mean	SD
RER	Dependent Variable. Real exchange rate is the value of the Dollar compared to the value of the Euro in terms of trade. The units are in dollars.	1.38	0.102
RBC	Reserve Bank Credit, which is the amount of debt the federal reserve is in. The units are in billions of dollars.	82.17	69.4
RGDP	Real Gross Domestic Product is the woth of a nation taking inflation into consideration. The units are in billions of dollars.	13101.3	191.23
TWI	Trade Weighted Index, which is based upon the year 2007 when it is equal to 100. It measures the average price of a home good relative to the average price of goods of trading partners, using the share of trade with each country as the weight for that country.	102.57	4.76
OIL	European Brent Spot Price of oil. Measured in dollars per barell	25.8	33.6
lnRPCR	The log of Real Primary Credit Rate, which is a type of interest rate. Units are measured in percentage.	-0.08	0.7
lnRIR	The log of Real Interest Rate on a 4 year treasury bill. Units are measured in percentage.	-1.72	1.45
EDC	European Debt Crisis. A dummy variable equal to 1 if the date is during the debt crisis.	0.247	0.43
N	Number of Observations	713	

Table 2: Summary Results of Real Interest Rate Model

Variable Title	Description	Mean	SD
lnRIR	Dependent Variable. Real Interest Rate on a 4 year treasury bill. The units are in percentages.	-0.08	0.7
RBC	Reserve Bank Credit, which is the amount of debt the federal reserve is in. The units are in billions of dollars.	82.17	69.4
RGDP	Real Gross Domestic Rpoduct is the woth of a nation taking into consideration inflation. The units are in billions of dollars.	13101.3	191.23
RPC	Real Personal Consumption, the amount of goods in terms of dollars American's consumed in a given month. The units are in billions of dollars.	9233.95	79.7
NFGS	Net Federal Government Savings, the amount the federal government saves each month. The units are in billions of dollars.	-1060	346.3
EDC	European Debt Crisis. A dummy variable equal to 1 if the date is during the debt crisis.	0.25	0.43
N	Number of Observations	713	

Equation 1 expresses my prediction on how the independent variables will affect real exchange rates. I predict that RBC and OIL will decrease the value of the dollar, making the real exchange rate increase, giving both of these variables positive coefficients. As RBC increases, the Federal Reserve is spending more money and as oil increases consumers will have less disposable income, both making the value of the dollar fall. RGDP, TWI, lnRPCR and lnRIR, are predicted to make the real exchange rate shrink, increasing the value of the dollar against the euro giving these variables a negative coefficient. My predictions on how the explanatory variables will affect real interest rates are shown in Equation 2. I believe all of the explanatory variables, except RBC will have a positive influence on real interest rates. Based on theory, as a worth of a nation increases, so should the interest rates. The increase in RGDP, RPC, and NFGS, contribute to the wealth of a nation. On the other hand, an increase in RBC shows just the opposite. The Federal Reserve Bank spends money to help jump start the economy. As we have seen recently with Quantitative Easing, when the government spends a lot money, real interest rates will start to go down. In both of my models I have EDC as a dummy variable equal to 1 if the date is during the European Debt Crisis. I predict that EDC will have a negative effect on real exchange rates and real interest rates. During the European Debt Crisis, the euro fell immensely. In theory, this should increase the value of the dollar against the euro, making the real exchange rate smaller. As the dollar strengthens, U.S. goods in various nations will become more expensive, leaving people to buy less American goods. If exports start to decline then there will be less economic growth. With less growth, real interest rates could fall.

DATA

When I ran my first regressions, I found errors regarding my predicted functional forms and evidence of multicollinearity, serial correlation, and heteroskedasticity. Table 7 shows the various equations of Model 1 as I alter it to fix for any errors. Table 3 shows the same thing regarding Model 2. To start with my data analysis, I will begin by explaining Model 2 involving real interest rates. I decided to do this because I need to first define the variables that affect real interest rate. I will then use these variables to help define the effects on real exchange rates.

Table 3: Real Interest Rate Model Equations

	RIR Regression Equations			
β	(2.0)	(2.1)	(2.2)	(2.3)
RBC	-0.0025	-----	-----	-----
	(-8.16)***	-----	-----	-----
lnRBC	-----	-0.257	-----	-0.305
	-----	(-7.14)***	-----	(-28.21)***
RGDP	0.0016	-----	-----	-----
	(13.83)***	-----	-----	-----
lnRGDP	-----	16.44	-----	17.74
	-----	(8.44)***	-----	(15.79)***
RPC	0.00075	-----	-----	-----
	(-2.68)***	-----	-----	-----
lnRPC	-----	-0.167	49.52	-----
	-----	(-0.06)	(22.77)***	-----
NFGS	0.00086	-----	-----	-----
	(-12.96)***	-----	-----	-----
lnNFGS	-----	0.184	1.74	-----
	-----	(-1.38)	(39.93)***	-----
EDC	-0.008	0.021	-0.406	0.0025
	(-0.26)	(-0.55)	(-8.74)***	(0.08)
N	721	537	721	537
$\bar{R}$-squared	0.91	0.65	0.899	0.65
F-Test	1638.74	202.34	2156.41	336.51

Notes: Each regression from Model 1 is listed above. The first regression is listed under column 1.0, the second under column 1.1, etc. Under each variable's coefficient is listed the corresponding t-score in parenthesis. The t-scores are shown with statistical significance where the term "***" defines a t-score that is significant up to the 99th percent level. The term "**" defines a t-score that is significant up to the 95th percent level, and the term "*" defines a t-score that is significant at the 90th percent level.

Table 3 shows the various equations that were formulated after correcting for specific errors. The first column of Table 3 shows all the variables used in the equations. Not all the variables were used at the same time. The next four columns are the multiple equations I formulated with each variable's estimated coefficient. A dashed line for a certain variable indicates that that variable was not used in a specific equation. The t score, located in parenthesis under the coefficient lists the variable's t-score from that given equation. For example, the t-score for RBC in equation 2.0 is -8.16. At the bottom of the table are rows for the number of observations, the adjusted R squared, and the F score for each equation. The adjusted R squared tells us the goodness-of-fit of the regression. The F-test is commonly used as a test of the overall significance of the included independent variables in a regression model. The significance level is labeled the F score. The first equation, 2.0, is the original predicted model seen in the beginning of this paper. After running the regression, the estimated coefficients looked too small. I went back over the equation and noticed that I had the wrong functional form. I had misinterpreted the definition of the log form. After going back and redefining my variables, I came up with the same equation except that lnRIR was changed to RIR, and the rest of the variables were put into log form except EDC. After running a regression for the new equation, 2.1, I noticed the coefficients looked a lot better. I then tested for multicollinearity by running a correlation command. Perfect multicollinearity is when the variation in one explanatory variable can be completely explained by movements in another explanatory variable (Studenmund, 2006). Table 4 shows us that there is evidence of multicollinearity. An indication of possible multicollinearity is when the correlation between two variables is higher than 0.7. Table 4 shows us that there are multiple correlations that are higher

Table 4: Correlation for Equation 2.1

	RIR	lnRBC	lnRGDP	lnRPC	lnNFGS	EDC
RIR	1					
lnRBC	-0.52	1				
lnRGDP	0.31	0.46	1			
lnRPC	0.2	0.49	0.91	1		
lnNFGS	0.64	-0.92	-0.21	-0.32	1	
EDC	0.13	0.51	0.81	0.88	-0.38	1

Variance Inflation Factor

Variable	VIF	1/VIF
lnRBC	15.27	0.065
lnNFGS	13.7	0.072
lnRGDP	8.97	0.111
lnRPC	8.83	0.113
EDC	4.96	0.201
Mean VIF	10.35	

than 0.7. When this happens we look at the variance inflation factor (VIF), which is also part of Table 4. When the VIF of a variable is higher than 5, we know there is some kind of

multicollinearity. The VIF's in Table 4 indicate strong probability of multicollinearity. Now, I will go back to equation 2.1 and figure out which variables would have multicollinearity.

After reviewing equation 2.1, I realized that lnRGDP and lnRPC complement each other. As the worth and productivity of a nation increases so do people's income. As people earn more money, they are likely to consume more goods. As RGDP rises, so will RPC. Also, I realized that RBC and NFGS are basically saying the same thing. As the credit of reserve bank grows, the savings of the reserve banks will shrink. These two variables are negatively correlated, as seen in Table 4. From this, we can eliminate either lnRGDP and lnRBC or lnNFGS and lnRPC from the equation. The question is which pair is the correct one to eliminate. Instead of taking the chance of randomly picking one pair, I decided to make two more equations. One equation, 2.2, contains lnNFGS, lnRPC, and EDC as the independent variables. The other equation, 2.3, contains lnRGDP, lnRBC, and EDC as the independent variables. Once I ran the regression for both of these equations, the coefficients and the t scores were pretty solid. At this point I was still unsure of which equation to use.

I decided that I would test both equations for serial correlation and heterskedasticity. To test for serial correlation I decided to use the Durbin-Watson *d* Test, which determines if there is first-order serial correlation in the error term. First order serial correlation measures the functional relationship between the value of an observation of the error term and the value of the previous observation of the error term (Studenmund, 2006). In order to run this test, I needed to find the Durbin-Watson d-statistic, using equation 3.

$$d = \sum_2^T (e_i - e_{i-1})^2 / \sum_1^T (e_i^2) \qquad (3) \qquad \text{Where } e_i = \text{OLS residuals}$$

Table 5: Durbin-Watson d-Statistic for RIR Model

Equation	d (original)	d (transformed)	Hypothesis
2.2	0.02	1.84	H0: ρ ≤ 0
2.3	0.05	1.48	HA: ρ > 0
Critical Values dL & dU:		(1.55,1.67)	
Appropriate Decision Rule for a two-tailed test:			
if d < dL	Reject H0		
if d > 4 - dL	Reject H0		
if 4 - dU > d > dU	Do not reject H0		
otherwise	Inconclusive		

Table 5 shows the Durbin-Watson d statistic for the RIR Model equations 2.2 and 2.3. The first column lists the equation being tested. The second column list the original d-statistic, while the third column list the d-statistic once the equation has been transformed using the Prais Winsten regression. The Prais Winsten is a method of ridding an equation of pure first order serial correlation and in the process, restoring the minimum variance property to its estimation (Studenmund, 2006). The last column identifies the null hypothesis and the alternative hypothesis. Below that is the range for the lower bound and upper bound critical values. The critical range values were obtained using a two-sided, 5% critical value chart. The bottom part of Table 5 lists the appropriate decision rule for a two- tailed Durbin-Watson test.

The original d statistic for equation 2.2 is 0.02. Since this d statistic is below the critical value range, we can reject H_0. Rejecting the null hypothesis tells us that there is serial correlation. I then corrected for this error by running the Prais Winsten regression. The transformed d-statistic for equation 2.2, 1.84, is in the "do not reject" H_0 region. Since we cannot reject the null hypothesis, we can assume that serial correlation does not exist anymore. Next, I tested for serial correlation in equation 2.3. The original d statistic came out to be 0.05, the region that rejects the null hypothesis stating there is serial correlation. I then used the Prais Winsten test to correct for this error. The transformed d statistic came out to be 1.48. This new d statistic is in the inconclusive range, telling us that we cannot sufficiently reject nor accept serial correlation.

From the above findings, I decided to use equation 2.2, with independent variables lnRPC, lnNFGS, and EDC, as my final predicted model for RIR. I am using this equation because I know there is no longer serial correlation, while the opposite is true for equation 2.3.

Table 6
Serial Correlation and Heteroskedasticity

Estimated Coefficients		
β	(2.2.1)	(2.2.2)
lnRPC	36.73	-7.75
	(5.64)***	(7.81)***
lnNFGS	1.96	0.32
	(14.29)***	(-5.65)***
EDC	-0.028	0.13
	(-0.55)	(6.58)***
N	721	721
$\bar{R}$-squared	0.502	0.204
F-Test	243.67	32.66

Table 6 shows the estimated coefficients for equation 2.2, once the equation had been corrected for serial correlation. The estimated coefficients from the Prais Winston regression are shown in the column labeled 2.2.1 and the variables' t score is located beneath the corresponding coefficient.

Next, I check for pure heteroskedasticity occurs when the variance of the error term is not constant. To test for heteroskedasticity, I used the Breusch-Pagan test. The Breusch-Pagan test, also known as the White Test, detects heteroskedasticity by running a regression with the squared residuals as the dependent variable (Studenmund, 2006). To obtain the squared residuals I used equation 4.0.

$$(e_i)^2 = \alpha_0 + \alpha_1 \text{lnRPC}_i + \alpha_2 \text{lnNFGS}_i + \alpha_3 \text{EDC}_i + \alpha_4 \text{lnRPC}^2{}_i + \alpha_5 \text{lnNFGS}^2{}_i + \alpha_6 \text{EDC}^2{}_i + \alpha_7 \text{lnRPC}_i \text{lnNFGS}_i + \alpha_8 \text{lnRPC}_i \text{EDC}_i + \alpha_9 \text{lnNFGS}_i \text{EDC}_i + u_i \qquad (4.0)$$

Once I obtained the residual squared value, I ran a regression using that value as my dependent variable. After running the regression I used the estat hettest command (chi squared test) to obtain the fitted values of $(e_i)^2$: chi^2 and Prob. > chi^2. The regression produced the following results: $\text{chi}^2 = 1142.40$ and Prob. > $\text{chi}^2 = 0.000$. We also are given H_0: $\rho \geq 0.1$ = Constant Variance or homoskedasticity and H_A: $\rho < 0.1$ = No Constant Variance or heteroskedasticity. Since the ρ value obtained is 0.00 we reject the null hypothesis and assume heteroskedasticity. To correct for heteroskedasticity, I ran a regression with $(e_i)^2$ as my dependent variable and added a robust command. The coefficients for the model corrected for heteroskedasticity are found above in Table 6 under column 2.2.2. Now that I have corrected my estimated Model 2 for multicollinearity, serial correlation, and heteroskedasticity, I can move on to my first model.

Table 7 shows the various equations for Model 1 that were formulated after correcting for specific errors. The first column lists all of the variables used in figuring out my final predicted model. The second column is my original predicted equation, 1.0. Upon running a regression using equation 1.0, I saw that my estimated coefficients were very small. I went back and looked at my equation and realized I had the wrong functional form again. I redefined my variables, having only RGDP and RBC in log form, lnRGDP and lnRBC. I then ran another regression with the predicted equation, 1.1, corrected for functional form errors. After I received the variables coefficients, I tested those variables for multicollinearity.

Table 8 shows the correlation coefficients of the variables in equation 1.1. There are signs of multicollinearity between multiple variables. I then ran the command to find the VIF's for each variable. The results are on the right side of Table 8. From the variance inflation factor results, it can be concluded that there is multicollinearity in equation 1.1. To try and fix the multicollinearity error, I decided to take out OIL, since OIL and TWI were highly correlated.
The next equation in Table 7, 1.2, disregards OIL, and lists the coefficients and corresponding t scores for each. After I ran the regression for equation 1.2, I noticed that the t score was insignificant for RIR.

Knowing that lnRPC and lnNFGS explains the variable RIR, I decided to substitute RIR with these two variables. After running a regression with the two new variables, I obtained the estimated coefficients listed under column 1.3 in Table 7. From the results of equation 1.3 I notice that the t score for lnRBC and the estimated coefficient are both very small. I decided to

Table 7: Real Exchange Rate Model Equations

	RER Regression Equations						
β	(1.0)	(1.1)	(1.2)	(1.3)	(1.4)	(1.5)	(1.6)
RBC	0.001	-----	-----	-----	-----	-----	-----
	(-11.72)***	-----	-----	-----	-----	-----	-----
lnRBC	-----	-0.011	-0.013	0.002	-----	-----	-0.037
	-----	(-3.22)***	(-5.21)***	(-0.38)	-----	-----	(-6.18)***
RGDP	0.010	-----	-----	-----	-----	-----	-----
	(-3.70)***	-----	-----	-----	-----	-----	-----
lnRGDP	-----	-1.71	-1.69	-1.62	-----	-----	0.71
	-----	(-10.05)***	(-10.06)***	(-7.20)***	-----	-----	(-2.51)**
TWI	-0.023	-0.022	-0.022	-0.022	-0.021	-----	-----
	(-50.80)***	(-35.62)***	(-54.10)***	(-57.94)***	(-63.83)***	-----	-----
OIL	-0.002	0.000	-----	-----	-----	0.003	0.006
	(-0.24)	(-0.77)	-----	-----	-----	(-24.7)***	(-21.61)***
RPCR	-----	-0.045	-0.050	-0.053	-0.012	-----	-0.17
	-----	(-5.72)***	(-9.31)***	(-11.12)***	(-4.12)***	-----	(-13.09)***
lnRPCR	-0.050	-----	-----	-----	-----	-----	-----
	(-13.68)***	-----	-----	-----	-----	-----	-----
RIR	-----	0.014	0.012	-----	-----	-----	-----
	-----	(-1.09)	(-0.94)	-----	-----	-----	-----
lnRIR	0.002	-----	-----	-----	-----	-----	-----
	(-2.34)	-----	-----	-----	-----	-----	-----
lnRPC	-----	-----	-----	-1.87	-1.19	2.63	-----
	-----	-----	-----	(-6.09)***	(-4.46)***	(-5.55)***	-----
lnNFGS	-----	-----	-----	0.064	0.005	-0.059	-----
	-----	-----	-----	(-4.58)***	(-0.69)	(-8.92)***	-----
EDC	-0.070	-0.069	-0.069	-0.045	-0.101	-0.15	-0.12
	(-20.50)***	(-17.25)***	(-17.28)***	(-9.92)***	(-23.67)***	(-18.79)***	(-17.25)***
N	713	535	535	535	719	719	535
$\bar{R}$ Squared	0.95	0.92	0.92	0.93	0.94	0.77	0.74
F-Test	2325.50	939.13	1096.42	1075.66	2316.21	617.16	303.78

Table 8: Correlation for Equation 1.1 RER

	RER	lnRBC	lnRGDP	TWI	OIL	EDC	RPCR	RIR
RER	1.00							
lnRBC	0.36	1.00						
lnRGDP	-0.09	0.45	1.00					
TWI	-0.68	-0.66	-0.59	1.00				
OIL	0.40	0.62	0.69	-0.87	1.00			
EDC	0.30	0.51	0.81	-0.40	0.55	1.00		
RPCR	-0.03	-0.52	0.31	0.03	0.22	0.13	1.00	
RIR	-0.26	-0.19	0.09	0.09	0.13	0.19	0.42	1.00

Variance Inflation Factor

Variable	VIF	1/VIF
OIL	14.2	0.07
lnRBC	11.15	0.089
RPCR	8.23	0.121
TWI	7.17	0.139
lnRGDP	5.59	0.178
EDC	4.24	0.235
RIR	1.47	0.68
Mean VIF	7.44	

run a correlation command of the variables in equation 1.3, to see if the two new variables affected the original ones. Table 9 shows the correlation coefficients of the variables in equation 1.3. Just like in Model 2, the correlation between lnRBC and lnNFGS, lnRGDP and lnRPC is very strong, indicating multicollinearity. I decided to find the variance inflation factors for these variables, listed on the right side of Table 9. The VIF's clearly indicate multicollinearity.

Table 9: Correlation for Equation 1.3 RER

	RER	lnRBC	lnRGDP	TWI	RPCR	lnRPC	lnNFGS	EDC
RER	1.00							
lnRBC	0.36	1.00						
lnRGDP	-0.09	0.46	1.00					
TWI	-0.68	-0.67	-0.59	1.00				
RPCR	-0.31	-0.52	0.31	0.03	1.00			
lnRPC	-0.17	0.50	0.90	-0.54	0.21	1.00		
lnNFGS	-0.36	-0.92	-0.21	0.54	0.64	-0.33	1.00	
EDC	-0.30	0.52	0.81	-0.40	0.13	0.88	-0.38	1.00

Variance Inflation Factor

Variable	VIF	1/VIF
lnRBC	17.51	0.057
lnNFGS	13.28	0.075
lnRGDP	10.26	0.097
lnRPC	6.76	0.148
RPCR	3.2	0.312
EDC	2.62	0.326
TWI	2.52	0.397
Mean VIF	8.92	

Since lnRPC and lnNFGS were highly correlated with lnRGDP and lnRBC in Model 2, I decided to drop lnRGDP and lnRBC for the next equation. After running the regression for equation 1.4, I found that lnNFGS had a t score that was very low. Again, I decided to run a correlation command for the variables in this equation. After running this command I saw that the correlation between RPCR and lnNFGS was .89, and the VIF indicated that there was multicollinearity. Due to RPCR being a type of interest rate and lnNFGS being a variable that explained RIR, it is not surprising that RPCR and lnNFGS are highly correlated.

I knew some changes needed to be made to my equation. I thought about which variables were correlated with one another, whether there were any omitted variables, and if there were any variables that may be irrelevant. Considering there was multicollinearity with RPCR and lnNFGS, I decided to drop RPCR. Since lnNFGS and lnRPC are accounting for one interest rate, there is a good chance that one explains the other. I also noticed that the correlation between TWI and the dependent variable had been consistently high throughout. I then realized that I wanted to see how the price of oil was affecting RER, and I had neglected that variable for most of my regressions.

My new predicted equation, 1.5, consists of the independent variables: OIL, lnNFGS, lnRPC, and EDC. I ran a regression for this equation and came up with the results listed in Table 7. All of the estimated coefficients looked reasonable and the t scores were high across the board. The $\bar{R}^2$ was smaller, but I was confident that I had the right variables. To make sure one variable was not a perfect linear function of any other explanatory variable, I ran the correlation command. Table 10 shows the correlation coefficients for equation 1.5. In this table, there is no evidence of multicollinearity. This tells me that equation 1.5 is so far a good fit for Model 1.

Table 10: Correlation for Equation 1.5 RER

	RER	OIL	lnNFGS	lnRPC	EDC
RER	1.00				
OIL	0.75	1.00			
lnNFGS	0.40	0.42	1.00		
lnRPC	0.28	0.66	0.27	1.00	
EDC	-0.42	0.01	-0.44	0.53	1.00

I also wanted to run a regression with the lnRGDP and lnRBC variables, to see if these variables would be a better fit. For the final predicted equation, 1.6, I decided to test out the variables lnRGDP, lnRBC, OIL, RPCR, and EDC; I used RPCR because there was no evidence that neither lnRGDP nor lnRBC explained RPCR. We know from Model 2 that lnRGDP and lnRBC do explain RIR to some degree, but not for RPCR. I ran a regression using these variables and obtained the estimated coefficients and t scores listed in Table 7. All of the estimated coefficients look reasonable and all of the t- statistics are high. Just like equation 1.5, the $\bar{R}^2$ was lowered from previous equations, but it was not low enough to disregard. I ran

Table 11: Correlation for Equation 1.6 RER

	RER	lnRGDP	lnRBC	OIL	RPCR	EDC
RER	1.00					
lnRGDP	-0.09	1.00				
lnRBC	0.36	0.46	1.00			
OIL	0.40	0.69	0.63	1.00		
RPCR	-0.31	0.31	-0.52	0.22	1.00	
EDC	-0.30	0.81	0.52	0.55	0.13	1.00

another correlation to see if there were any signs of multicollinearity. Table 11 shows the correlation coefficients results. There are no signs of multicollinearity. The correlation coefficient between lnRGDP and OIL is a bit high, but not high enough to be concerned about. Now that I have two equations for my first model, I will test for serial correlation and heteroskedasticity in both of them.

To test for serial correlation and heteroskedasticity, I will use the Durbin-Watson d Test to see if first-order serial correlation exists. I will use equation 3 to calculate the d statistic. In order to use the Durbin-Watson, I first need to change the functional forms of my equation. All the variables that can be put into log form are done so. For equation 1.5, RER is put into log form, lnRER, as well as OIL, lnOIL. I left lnNFGS and lnRPC alone because they are already in log form. In Model 2, we did not put the dependent variable into log form because RIR was already a percentage. One would use the log form to see the percentage change of the dependent variable related to a one-unit increase in an independent variable. I left EDC alone because it is my dummy variable and does not vary throughout the observations. Equation 1.5.1 is my predicted equation to use for the Durbin Watson test.

$$lnRER_i = \beta_0 + \beta_1 lnRPC_i + \beta_2 lnNFGS_i + \beta_3 lnOIL_i - \beta_4 EDC_i \quad (1.5.1)$$

For equation 1.6, I had to change the functional form as well. I put RER in log form, lnRER, as well as OIL, lnOIL. I left RPCR alone because the units are in percentage terms. The variables lnRGDP and lnRBC are already in log form so I did not have to do anything with them and EDC is left alone because it is my dummy variable. Equation 1.6.1 is my second predicted equation that I will use for the Durbin Watson test.

$$lnRER_i = \beta_0 + \beta_1 lnRBC_i + \beta_2 lnRGDP_i + \beta_3 lnOIL_i - \beta_4 RPCR_i - \beta_5 EDC_i \quad (1.6.1)$$

Table 12: Durbin-Watson d-Statistic for RER Model

Equation	d (original)	d (transformed)	Hypothesis
1.5.1	0.06	1.52	H0: ρ ≤ 0
1.6.1	0.11	1.55	HA: ρ > 0
Critical Values dL & dU:		(1.51,1.72)	
Appropriate Decision Rule for a two-tailed test:			
if d < dL	Reject H0		
if d > 4 - dL	Reject H0		
if 4 - dU > d > dU	Do not reject H0		
otherwise	Inconclusive		

Table 12 shows the results after running the Durbin-Watson test for equation 1.5.1 and 1.6.1. The original d statistics show the d statistic before correcting for serial correlation and the transformed d statistic is the d statistic after correcting for serial correlation. The hypothesis column lists the null and the alternative hypothesis. The critical values for the lower bound and upper bound d statistics were obtained using a 5% two sided level of significance chart. The original d statistic for both equations is well below the critical value range. Both d statistics allows us to reject the null hypothesis. We accept the alternative hypothesis that says there is serial correlation. To correct for both of the serial correlations, I used the Prais Winston test. After running the Prais Winston test, I received the transformed d statistics listed above. Both transformed d statistics fall in the inconclusive region. Due to evidence of serial correlation being inconclusive, I looked at the estimated coefficients, t scores and $\bar{R}^2$ of equations 1.5.1 and 1.6.1 to see which equation is a better fit. Table 13 lists these values in the same format as Table 3 and Table 7. The estimated coefficients from equation 1.5.1 and 1.6.1 are not very different. Both sets of coefficients look reasonable, but do not vary much. Both sets of t scores look great, but again,

Table 13
Real Exchange Rate Model: Equations 1.5.1 & 1.6.1

	Equations	
β	(1.5.1)	(1.6.1)
lnRBC	-----	0.008
	-----	(-1.66)*
lnRGDP	-----	-1.07
	-----	(-2.87)**
RPCR	-----	-0.033
	-----	(-4.01)***
lnOIL	0.166	0.145
	(-17.22)***	(-11.1)***
EDC	-0.039	-0.033
	(-5.48)***	(-4.51)***
lnNFGS	0.013	-----
	(1.56)	-----
lnRPC	-0.93	-----
	(-1.85)*	-----
N	719	535
$\bar{R}$ Squared	0.92	0.905
F-Test	2013.94	1026.66

not much variation. The t scores regarding lnOIL and EDC which are variables used in both equations have slightly higher scores in equation 1.5.1. Moving down to the $\bar{R}^2$ and the F score, equation 1.5.1 has slightly better results. $\bar{R}^2$ is a bit larger in equation 1.5.1 and the F score is significantly higher than equation 1.6.1. Even from these results, I am not confident on which equation fits best.

I have decided to test for heteroskedasticity in both predicted equations. For equation 1.5 I will use equation 5 to obtain the squared residuals in order to use the Breusch-Pagan test.

$(e_i)^2 = \alpha_0 + \alpha_1 \text{lnRPC}_i + \alpha_2 \text{lnNFGS}_i + \alpha_3 \text{OIL}_i + \alpha_4 \text{EDC}_i + \alpha_5 \text{lnRPC}^2_i + \alpha_6 \text{lnNFGS}^2_i + \alpha_7 \text{OIL}^2_i + \alpha_8 \text{EDC}^2_i + \alpha_9 \text{lnRPC}_i \text{lnNFGS}_i + \alpha_{10} \text{lnRPC}_i \text{EDC}_i + \alpha_{11} \text{lnRPC}_i \text{OIL}_i + \alpha_{12} \text{lnNFGS}_i \text{EDC}_i$
$\alpha_{13} \text{lnNFGS}_i \text{OIL}_i + \alpha_{14} \text{EDC}_i \text{OIL}_i + u_i$ (5)

Once I have obtained the squared residual, I will use equation 1.5.2 to run the Breusch-Pagan test.

$(e_i)^2 = \alpha_0 + \alpha_1 \text{lnRPC}_i + \alpha_2 \text{lnNFGS}_i + \alpha_3 \text{OIL}_i + \alpha_4 \text{EDC}_i + u_i$ (1.5.2)

After running the Breusch-Pagan test, I came up with the following results: $\text{chi}^2 = 266.10$ and Prob. > $\text{chi}^2 = 0.0$. Just like Model 2, the null hypothesis and the alternative hypothesis are given, H_0: $\rho \geq 0.1$ = Constant Variance or homoskedasticity and H_A: $\rho < 0.1$ = No Constant Variance or heteroskedasticity. Since the ρ value obtained is 0.00 we reject the null hypothesis and assume there is heteroskedasticity.

For equation 1.6 I will use equation 6 to obtain the squared residuals for the Breusch-Pagan test.

$(e_i)^2 = \alpha_0 + \alpha_1 \text{lnRBC}_i + \alpha_2 \text{lnRGDP}_i + \alpha_3 \text{RPCR}_i + \alpha_4 \text{OIL}_i + \alpha_5 \text{EDC}_i + \alpha_6 \text{lnRBC}^2_i + \alpha_7 \text{lnRGDP}^2_i + \alpha_8 \text{RPCR}^2_i + \alpha_9 \text{OIL}^2_i + \alpha_{10} \text{EDC}^2_i + \alpha_{11} \text{lnRBC}_i \text{lnRGDP}_i + \alpha_{12} \text{lnRBC}_i \text{RPCR}_i + \alpha_{13} \text{lnRBC}_i \text{OIL}_i +$

α_{14}lnRBC$_i$EDC$_i$ + α_{15}lnRGDP$_i$RPCR$_i$ α_{16}lnRGDP$_i$OIL$_i$ + α_{17}lnRGDP$_i$EDC$_i$ + α_{18}lnRPCR$_i$OIL$_i$ + α_{19}lnRPCR$_i$EDC$_i$ α_{20}OIL$_i$EDC$_i$ + u$_i$ (6)

Once I have gotten the squared residual, I will then use equation 1.6.2 for the Breusch-Pagan test.

$(e_i)^2 = \alpha_0 + \alpha_1\text{lnRBC}_i + \alpha_2\text{lnRGDP}_i + \alpha_3\text{RPCR}_i + \alpha_4\text{OIL}_i + \alpha_5\text{EDC}_i + u_i$ (1.6.2)

Once I ran the Breusch-Pagan test for equation 1.6.2, I received the following results: chi^2 = 0.02 and Prob. > chi^2 = 0.89. The ρ value came out to be higher than 0.1, which means the null hypothesis cannot be rejected, indicating that there is constant variance, homoskedasticity.

Table 14
Real Exchange Rate Model: Equations 1.5.2 & 1.6.2

	Equations	
β	(1.5.2)	(1.6.2)
lnRBC	-----	0.0000
	-----	(-0.92)
lnRGDP	-----	0.0870
	-----	(4.63)***
RPCR	-----	0.0000
	-----	(-0.92)
OIL	0.0000	0.0000
	(-4.32)***	(-2.33)**
EDC	0.0010	0.0000
	(2.57)***	(-2.99)***
lnNFGS	0.0020	-----
	(4.32)***	-----
lnRPC	-0.0100	-----
	(-0.48)	-----
N	719.00	535.00
$\bar{R}$ Squared	0.07	0.09
F-Test	7.40	7.02

Table 14 lists the estimated coefficients, t scores, number of observations, $\bar{R}^2$s, and the F scores for equations 1.5.2 and 1.6.2, which are corrected for heteroskedasticity. For equation 1.5.2, I added the robust command to the regression to fix for heteroskedasticity. The adjusted R-squared for both equations is insignificantly small. Looking at these results, it is clear that equation 1.5.2 and 1.6.2 were both affected by heteroskedasticity leaving the variables in both equations with little explanatory value.

Looking back at all of my results, I picked one equation from each model to explain the dependent variable. For Model 1, I decided to use the equation 1.6. In this equation real exchange rates are the dependent variable and the independent variables consisted of lnRGDP, lnRBC, RPCR, OIL, and EDC. I decided that this equation fits best with my model based on theory and I know that it is now fixed for multicollinearity, serial correlation and heteroskedasticity.

In my second model, where real interest rates were the dependent variable, I decided to use equation 2.2. Equation 2.2 consisted of lnRPC, lnNFGS, OIL, and EDC as the independent variables. I chose this equation because the OLS was consistently high throughout my regression and theories suggest that real interest rate is influenced by consumption and government debt. Overall I feel as though I used the correct variables and picked the right equations to explain my dependent variables.

RESULTS

In this section I will explain the procedures that I used to decide upon my final results. I will then talk about the meaning of each estimated coefficient that my regressions produced. Both models have multiple independent variables that show their influence on the corresponding dependent variable. After I gathered my researched and decided on specific independent variables to use, I ran my first set of regressions. My first corrections came when looking for multicollinearity. If there was evidence of multicollinearity, I made sure to use theory and my own knowledge to fix the problem. When multicollinearity was fixed for, I then tested for serial correlation. If I needed to fix for serial correlation I ran a specific regression which would produce a new set of coefficients. Next, I tested for heteroskedasticity. If there was any sign of heteroskedasticity, I ran a robust command to rid the equation of the error, which would give me a new set of OLS. I will analyze the final OLS outcomes and talk about the significance of the variables given each estimated coefficient.

Model 1 explains the factors that influence real exchange rates. In equation 1.6, I used various explanatory variables to help explain the movements of U.S./Euro real exchange rates.

Table 7 shows the original estimated coefficients when running a regression for equation 1.6. In this equation there are five explanatory variables. The first, lnRBC has an estimated coefficient of -.037 and a t score of -6.18. This says that a one unit increase in lnRBC will result in a decrease of RER by .037%. The next variable, lnRGDP, has an estimated coefficient of .71 and a t score of 2.51. This can be translated the same way as lnRBC. A one unit increase of lnRGDP will result in a .71% increase of real exchange rates. OIL is the third variable with an estimated coefficient of .006 and a t score of 21.61. This says that as the price of a barrel of European Brent Spot Oil increases by one dollar, the real exchange rate will increase by .006 units. RPCR has an estimated coefficient of -.17 and a t score of -13.09. This indicates that as RCPR increase by one percent, RER will decrease by 17%. The last variable in this equation is the dummy variable, EDC. The estimated coefficient for this variable is -.12 with a t score of -17.25. This implies that during the European Debt Crisis, the real exchange rate will decreased by .12 units.

I then tested equation 1.6 for serial correlation using the Durbin Watson test. Once I found out that there was serial correlation, I used the Prais Winsten method to fix it. Table 13 shows the fixed coefficients listed under equation 1.6.1. The following estimated coefficients are the values that I received once I had rid the equation of serial correlation. The estimated coefficient for: lnRBC = .01 with-statistic = 1.66, lnRGDP= -1.07 with t score = -2.87, RPCR = -.03 with t score = -4.01, lnOIL= .15 with t score = 1.11, and EDC = -.03 with t score = -4.51. Looking at the estimated coefficients for this equation, it is apparent that the original equation had a high amount of serial correlation. After correcting for serial correlation, the estimated coefficients changed including the signs of the coefficients. The t scores are also lower in equation 1.6.1 meaning the variables are no longer as good of a fit as the original. Next, I tested my model for heteroskedasticity using the Breusch-Pagan test. If there was any sign of heteroskedasticity, I used a robust command to fix for the error. Table 14 under equation 1.6.2, shows the corrected estimated coefficients after equation 1.6.1 had been fixed for heteroskedasticity.

The second model looks at the factors influencing real interest rates. Equation 2.2 is the original equation I used as my base for testing for serial correlation and heteroskedasticity. This equation can be seen in Table 3 with the rest of the variables. The first variable, lnRPC had an estimated coefficient of 49.52 and a t score of 22.77. The next variable, lnNFGS = 1.74 with t score = 39.93. The last variable EDC = -4.06 with t score = -8.74. These coefficients and t scores seemed very high which could indicate omitted variable bias.

I then tested for serial correlation using the Durbin Watson test. After recognizing that the equation did have serial correlation, I used to Prais Winsten method to fix for it. Table 6 shows the corrected coefficients under equation 2.2.1. Next, I tested the equation for heteroskedasticity using the Breusch-Pagan test.. I did indeed find indicators that my equation had heteroskedasticity. When I ran the Breusch-Pagan test I received a ρ score of 0.0 for which I then corrected for by using the robust command. Table 6 under equation 2.2.2, shows the new estimated coefficients after I corrected for heteroskedasticity. After using the robust command, it is easy to see that my results had some heteroskedasticity. The new estimated coefficients are more reasonable and all of the new t scores are in the 95th percentile level. With the new estimated coefficients, I am very confident that they correctly explain the dependent variable.

SUMMARY

In my original hypothesis, I had predicted that the European Debt Crisis would have a negative impact on real exchange rates and real interest rates. Nearly all of the regressions came up with EDC having a negative estimated coefficient. On one hand I can say that my results do support my hypothesis. On the other hand I would not say that the European Debt Crisis has had a severe impact on both real exchange rates and real interest rates. From the estimated coefficient results, we can say that during the European Debt Crisis, the real exchange rate does go down and so does real interest rate. When real exchange rates decrease, this means the dollar is getting stronger. Also, lower interest rates are supposed to encourage people to borrow money. It could be possible that real exchange rates and real interest rates are highly correlated. As real exchange rates decrease and the dollar becomes stronger, U.S. goods and services overseas become more expensive. When exported goods start to decline, the productivity in that country will start to decline which can lower interest rates. At this time the government may spend money to encourage borrowing which, in turn could decrease the value of the dollar, making the real exchange rate rise.

I also predicted that the price of oil would have a positive impact on exchange rates, decreasing the value of the dollar. Oil is a very important commodity around the world. I figured that as the price of oil increased, one's purchasing power would decrease, lowering the value of the dollar. From my results, the change in price of oil has primarily resulted in an increase in the real exchange rate. The data does support my hypothesis regarding the price of oil.

Overall, I believe my analysis is sufficient. I was able to identify wrong functional forms, omitted variables, and irrelevant variables. I also ran regressions to test for multicollinearity, serial correlation, and heteroskedasticity and was able to correct for all of them. In the end, my coefficients and t scores were not as strong as I had hoped, but then again I originally did not predict the final equations for my two models. In conclusion, I have found evidence to support my hypothesis that the European Debt Crisis has had a negative impact on real exchange rates between the dollar and the euro and a negative impact on real interest rates. In the future I will look into exchange rates as a whole and see how major crisis have made an impact on these rates.

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APPENDIX A: (RER)

Do file:

```
log using "E:\ECON 448\final.smcl"
edit
tsset date
generate lnrpcr=ln(rpcr)
generate lnrir=ln(rir)
regress rer rbc rgdp twi oil lnrpcr lnrir edc
generate lnrbc=ln(rbc)
generate lnrgdp=ln(rgdp)
regress rer lnrbc lnrgdp twi oil rpcr rir edc
correlate rer lnrbc lnrgdp twi oil rpcr rir edc
estat vif /*test for multicollinearity*/
regress rer lnrbc lnrgdp twi rpcr rir edc
generate lnnfgs=-ln(-nfgs)
generate lnrpc=ln(rpc)
regress rer lnrbc lnrgdp twi rpcr lnrpc lnnfgs edc
correlate rer lnrbc lnrgdp twi rpcr lnrpc lnnfgs edc
estat vif
regress rer twi rpcr lnrpc lnnfgs edc
regress oil lnrpc lnnfgs edc
correlate oil lnrpc lnnfgs edc
regress lnrbc lnrgdp oil rpcr edc
correlate lnrbc lnrgdp oil rpcr edc
generate lnrer=ln(rer)
generate lnoil=ln(oil)
regress lnrer lnoil lnrpc lnnfgs edc
predict xb1
generate uhat1=lnrer-xb1
generate uhat1sq=uhat1^2
generate uhat1sqlag=uhat1sq[_n-1]
plot uhat1sq uhat1sqlag
estat dwatson /*obtain the dwatson d score*/
prais lnrer lnoil lnnfgs lnrpc edc /*fix for serial correlation*/
predict lnrerGLShat
summarize lnrerGLShat
regress lnrer lnrgdp lnrbc lnoil rpcr edc
estat dwatson
prais lnrer lnrgdp lnrbc lnoil rpcr edc
regress rer lnnfgs lnrpc oil edc
predict volhat
predict rerhat
generate ehat=rer-rerhat
generate ehat2=ehat^2
regress ehat2 lnnfgs lnrpc oil edc
estat hettest/*test for heteroskedasticity*/
regress ehat2 lnnfgs lnrpc oil edc, robust
regress rer lnrgdp lnrbc rpcr oil edc
regress ehat2 lnrgdp lnrbc rpcr oil edc
estat hettest
regress ehat2 lnrgdp lnrbc rpcr oil edc
```

APPENDIX B: (RIR)

Do File:

```
edit
tsset date
generate lnrir=ln(rir)
generate lnrbc=ln(rbc)
generate lnrgdp=ln(rgdp)
generate lnrpc=ln(rpc)
generate lnnfgs=-ln(-nfgs)
regress lnrir rbc rgdp rpc nfgs edc
regress rir lnrbc lnrgdp lnrpc lnnfgs edc
correlate rir lnrbc lnrgdp lnrpc lnnfgs edc
estat vif /*testing for multicollinearity*/
regress rir lnrpc lnnfgs edc
correlate lnrpc lnnfgs edc
predict xb1
generate uhat1=lnrir-xb1
generate uhat1sq=uhat1^2
generate uhat1sqlag=uhat1sq[_n-1]
plot uhat1sq uhat1sqlag
estat dwatson
prais rir lnnfgs lnrpc edc
regress rir lnrgdp lnrbc edc
estat dwatson /*getting the dwatson d score*/
prais rir lnrgdp lnrbc edc
regress rir lnnfgs lnrpc edc
predict rirhat
generate ehat=rir-rirhat
generate ehat2=ehat^2 /*obtaining the squared residuals*/
regress ehat2 lnnfgs lnrpc edc
estat hettest
```