Econometrics Project Part 2: A study of the EUR/USD Exchange rate with the Mundell-Fleming model

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Contents

1 Introduction

In our first report, our research question was to explain the evolution of the EUR/USD Exchange rate using macroeconomic variables from both monetary zones (The Euro Area and the United States). We started working with 4 variables, namely the differentials between the FED and BCE key interest rate, unemployment rates and inflation rates in the US and Euro Area, and the yield differential between the US and German 10-year treasury securities.

The key findings of the 1st part were that, over time, structural changes appear in the data, as evidenced by our Chow F-Tests. This makes it difficult to come up with a model that could explain many years of exchange rates history. The solution we found was to partition the data in pre/post 2007 financial crisis, and focus only in the latter.

Furthermore, we observed that our model performed better when incorporating lagged variables, specifically data from the preceding quarter. This adjustment reflects the understanding that the impact of major economic policy actions, such as changes in central bank interest rates, may take time to manifest in the broader economy.

Introduced the above-mentioned changes resulted in a model with a much higher coefficient of determination, higher global significance, and higher individual t-ratios for the coefficients.

The retained model of the 1st section is the following:

$$\boxed{(\hat{y}) = 1.4376 + 0.04987 \times X_{1,t-1} + 0.0522 \times X_{3,t-1} - 0.1947 \times X_{4,t-1}} \tag{1}$$

In this part of the project, we will challenge our model through more tests to obtain the most optimal model.

2 Heterogeneity in the model

2.1 Introducing dummy variables

The Mundell-Fleming model is widely used and taught in macroeconomics, however, it has its limitations, as Paul Krugman argues. Indeed, when analysing the Asian crisis, he realised that the model could not adequately explain economic fluctuations during periods of crisis, because the adjustments in exchange rates and interest rates predicted by the model were not always in line with actual events.

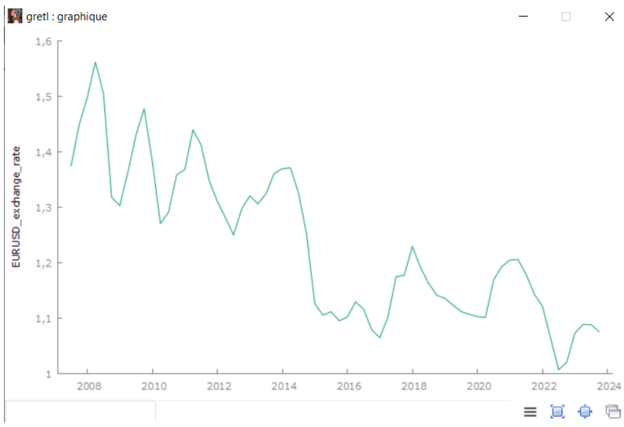


Figure 1: EUR-USD Exchange rate evolution from 2007:3 to 2023:4

Krugman contests the validity of the Mundell-Fleming model in periods of crisis, firstly because of the presence of **rigidities on the foreign exchange markets**. Indeed, the Mundell-Fleming model is based on the assumption that exchange rates are completely flexible under a floating exchange rate regime. However, Krugman argues that real exchange rates may be subject to rigidities, particularly during periods of financial crisis, due to increased uncertainty and volatility on the foreign exchange markets.

Furthermore, the Mundell-Fleming model assumes that external imbalances will correct themselves automatically through exchange rate adjustments. However, Krugman points out that **exchange rate adjustments** may be slow or insufficient to restore external equilibrium, particularly during periods of crisis when adjustments may be hampered by liquidity constraints or problems with the credibility of economic policies.

Finally, Krugman highlights the role of expectations and **irrational behaviour** on the part of economic agents in financial markets, which can lead to results that differ from those predicted by the Mundell-Fleming model. During periods of crisis, panic and overreaction on the part of investors can amplify exchange rate fluctuations, thereby overturning the results of the model.

These results by Paul Krugman in *"Balance Sheets, the Transfer Problem, and Financial crises"* and *"Reconsidering the Asian crisis"* have made us question the significance of the model we arrived at at the end of the first part of this project.
As a matter of fact, when plotting the EUR-USD Exchange rate graph, we observe that the differential increased in periods of crisis (the subprimes, the sovereign debt, the brexit, the Covid-19, and the important stock market loss in 2022 - with -19,10 % of the S&P 100).
Moreover, a study from the Federal Reserve Bank of St. Louis found out that the treasury yields in periods of crisis have a high volatility, reflecting investors' rising risk aversion, and the capital flows to assets considered safer. Hence, if adopt Krugman's point of view, we should not consider this explanatory variable in period of crisis, as its high volatility makes our model less significant.

We are therefore going to include a Dummy Variable in our multiple regression model to be able to discriminate crisis quarters from our data sample.
Thus, our set of quarters of crisis A is the following:

$A = [\ 2007:3; 2008:4\ ] \cup [\ 2010:2; 2012:2\ ] \cup [\ 2015:1; 2016:2\ ] \cup [\ 2020:1; 2023:2\ ]$

The justification for this choice of dates is simple. These were periods where the implied volatility of EURUSD At-The-Money options was higher than average, notably during times of crisis (Subprime crisis 2007, COVID-19 in 2020, etc.). (cf Bibliography)
Using the theory, we obtain the following model :

$$\text{Exchange} = a_0 + a_1 \times \text{Interest} + a_3 \times \text{Inflation} + a_4 \times \text{Treasury} + b_0 \times D + b_1 \times D \times \text{Treasury}$$

Let q_i be a quarter from the sample between 2007 and 2024. If $q_i \in A$ then $D = 0$ (the quarter is in a period of crisis), otherwise, if $q_i \notin A$ then $D = 1$ (the quarter is not in a period of crisis). Using gretl, we obtain the following regression models for the 2 samples: (for more details, see the Appendix)
For $D = 0$:

$$\boxed{(\hat{y}) = 1.417 + 0.038 \times x_{1,t-1} + 0.048 \times x_{3,t-1} - 0.204 \times x_{4,t-1} + \epsilon_t} \tag{2}$$

For $D = 1$:

$$\boxed{(\hat{y}) = 1.417 + 0.038 \times x_{1,t-1} + 0.048 \times x_{3,t-1} - 0.204 \times x_{4,t-1} + 0.037 \times D_t \times x_{4,t-1} + 0.025 \times D_t + \epsilon_t} \tag{3}$$

with $R^2 = 0.84$ and $F^*(5, 58) = 61.777$ with $T = 65$.

Hence we can tell that this model is relevant because R^2 and F^* are high, thus, most of the level of the EUR-USD exchange rate differential can be explained by this model, and the model is globally significant.

Now let's interpret the coefficients b_0 and b_1 :

- b_0 represents the average increase of the EUR-USD exchange rate when we are not in a quarter of crisis regardless of the explanatory variables. Hence when we are in a quarter of crisis and all variables are 0, the EUR-USD exchange rate increases by 0.025 from the previous model.

- We interpret b_1 by differentiating the EUR-USD exchange rate in terms of the explanatory variables:

When $D = 1$: $\frac{\delta y_t}{\delta x_{3,t}} = a_4 + b_1 = -0.167$

When $D = 0$: $\frac{\delta y_t}{\delta x_{3,t}} = a_4 = -0.204$

Hence b_1 measures the change in marginal effect of the treasury yield differential between the US and Europe due to not being in a quarter of crisis.

2.1.1 Joint Test: (Fisher)

Model form Part 1:

$$\boxed{(\hat{y}) = 1.437 + 0.05 \times x_{1,t} + 0.052 \times x_{2,t} - 0.195 \times x_{3,t}} \tag{4}$$

New model:

$$\boxed{(\hat{y}) = 1.417 + 0.038 \times x_{1,t-1} + 0.048 \times x_{3,t-1} - 0.204 \times x_{4,t-1} + 0.03 \times D_t \times x_{4,t-1} + 0.025 \times D_t} \tag{5}$$

To test the homogeneity of the coefficients between the two samples, we will implement a Joint test of restriction:

$$\begin{cases} H_0 : a_1 = \bar{a_1} \\ a_3 = \bar{a_3} \\ a_4 = \bar{a_4} \end{cases}$$

H_1: at least one coefficient from the 1st model is different from the one in the second model.

With the RSS being the following:

- For the model from part 1 : RSS = 0.264
- For the model including the Dummy variables: RSS(D) = 0.192

$$F^* = \left[\frac{\text{RSS(D)} - \text{RSS}}{4-3}\right] \div \left[\frac{\text{RSS(D)}}{65-4-1}\right] = \left[\frac{0.264 - 0.192}{1}\right] \div \left[\frac{0.192}{60}\right] = 22.5$$

$$F^{0.5}_{(1,60)} = 4 < F^* \quad \text{hence we reject } H_0.$$

So the coefficients are not homogeneous between the 2 groups at the 5% level of risk.

If the coefficients of the explanatory variables are not homogeneous between the two groups, it implies that the effect of those variables on the response variable is not consistent across the groups. This confirms Krugman's critic that we discussed above.

Hence, we can conclude that, for the model that we tested using the Mundell-Flemming model, Krugman's critic does apply as the EUR-USD exchange rates and explanatory variables relationship do not remain stable across periods of crisis. Hence, the introduction of our a dummy variable to discriminate the treasury yield variable in periods of crisis is relevant to obtain a reliable model using Mundell-Flemming's theory.

3 Model Selection

We compute all the possible regressions using the following explanatory variables, interest rate, inflation rate and Unemployment rate and Treasury yield differentials
also with a Dummy variable applied to the treasury yield differential (=1 if quarter not in a period of crisis, 0 otherwise)
The first step is to select one by one every explanatory variables, and build all the possible different models (31 in total) using all the variables. Then we estimate those models using the OLS model on Gretl and we collect the ones which were globally significant by comparing $F*$ to F^{α}_{n-k-1} . Finally, we select the Schwartz Criterions of these models and select the smallest one.
The model with the smallest one is the following :

$$\boxed{(\hat{y}) = 1.412 + 0.038 \times x_{1,t-1} + 0.048 \times x_{3,t-1} - 0.204 \times x_{4,t} + 0.03 \times D_t \times x_{4,t} + 0.025 \times D_t} \tag{6}$$

It is the model that we found when deleting the unemployment variable and discriminating the crisis periods. This enhances the fact that adding a dummy variable increased the significance of the model, and that Krugman's Critic is relevant in the context of our project.

Let's now interprete the coefficients:

$$F^*(4, 60) = 75.43 > F^{\alpha}_{65-4-1} = F^{5\%}_{60} = 2.62$$

Hence, the model is globally significant at a level of risk $\alpha = 5\%$.
Additionally,

Variable	Calculated t^*	Critical $t^{5\%}_{60}$
a_1	2.6	1.96
a_3	6.366	1.96
a_4	10.92	1.96
b_0	1.43	1.96
b_1	1.42	1.96

We observe that all the explanatory variables are significantly different from 0 and that the model is globally significant, confirming Krugman's Critic.

4 Prediction

We want to estimate the last value of the EUR-USD exchange rate using our model (for the 4th quarter of 2023). To do so, as we have lagged explanatory variables (X_t has an impact on Y_{t+1}), we delete the values between 2023:2 to 2023:4 from our model, and generate an OLS estimation using only the values of our explanatory variables from 2007:1 to 2023:2 (so T= 63). It gives us the following results :

$$\boxed{\hat{y}_t = 1.4187 + 0.0389 \times X_{1,t-1} + 0.0472 \times X_{3,t-1} - 0.2045 \times X_{4,t-1} + 0.03921 \times B_{0,t-1} + 0.0258 \times TD_{t-1} + \epsilon_t} \tag{7}$$

As the dummy variable for this quarter is 0, then we have the following table for the values of the explanatory variables for 2023:3 : Interest diffenrential = 0.83 ; Inflation differential = 0.5 ; Treasury differential = 1.719; and the Dummy variable = 0.

Using the values of the explanatory variables that we know for 2023:2 ; we get EUR-USD exchange rates =1.123. It is quite close to the empirical value which is 1.0751.

Let's now compute a confidence interval for y_t . Hence we have :

$$\hat{CI_{2023:2}} = \left[y_{t+h} \pm t^{\frac{\alpha}{2}}_{t-k-1} * \sqrt{\hat{\sigma^2_\epsilon} * (X^T_{t+h} * (X^T X)^{-1} * X_{t+h} + 1)} \right]$$
$$= \left[y_{t+h} + / - 1,96 * \sqrt{0,0031 * (0,11 + 1)} \right] = [y_{t+h} \pm 1,115] = [0,008; 2,23]$$

We observe that the empirical level of the EUR-USD exchange rate is within the confidence interval that we calculated at a 5% level of risk. However, we could argue that this confidence interval is quite large for an exchange rate, and hence not very precise even considering the number of observations. To make is smaller, we could increase the number of observation or the level of risk.

5 Multicolinearity

The new model returns the following coefficient of determination: $R^2 = 0,839624$

The variance inflation factor (VIF) returns the following : $VIF = \frac{1}{1-R^2} = 6,235 > 1$

Hence there is near multicolinearity. Although the level of multicolinearity is not critical (i.e. it's under 10), it could suggests that the variance of the estimated regression coefficients is inflated due to high correlation among the independent variables.

One method to correct this multicollinearity is to drop one of the variables. When we look at the correlation matrix, we observe that the highest covariance is between the treasury yield differential (X_3) and the interest rate differential (X_1) and the treasury yield differential.

Hence, we build another model without the treasury yield differential : $y_t = 1,234 - 0,083x_{1,t-1} + 0,018x_{3,t-1}$; and we calculate the VIF : $R^2 = 0,469$ so we have $VIF^* = 1,883 > 1$
Eventhough there is still a little amount of near multicolinearity in this model, we observe that dropping this variable (and thus the dummy variable aswell) reduces it. Thus, this variable is less relevant to the model than the others (it is a little redundant). But as the level of multicolinearity with the model with the Dummy variable is not high, we will keep it as it enable us to discriminate the periods of crisis.

6 Auto-correlation & Heteroscedasticity :

6.1 A) Auto-correlation :

6.1.1 Correction of the auto-correlation

Figure 2: Residual vs Time

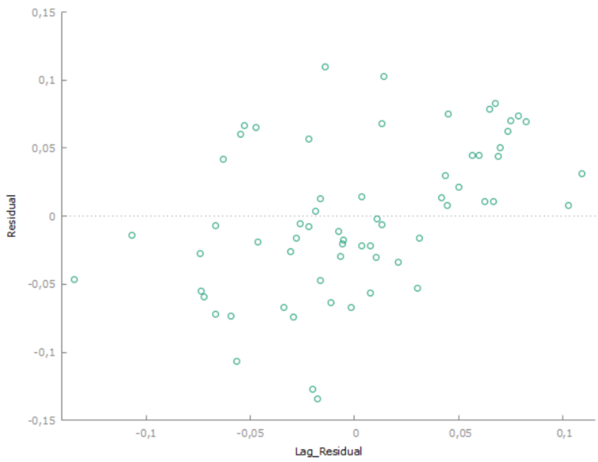


Figure 3: Residual vs Lag Residual

Looking at the Residual vs Time plot, we can think that we have a slightly positive correlation as the residual is positive or negative along successive quarters. This hypothesis is corroborated by the Residual vs Lag Residual plot. Indeed, we observe that most of the points are concentrated around a upward sloping regression line. It would not be surprising that we have this as we use lag variables in our model, which might increase the correlation between the error terms.
This means that in the following equation $e_t = \phi e_{t-1} + V_t$ with $\phi \in [-1; 1]$; $\phi > 0$.

6.1.2 Test for the absence of first-order autocorrelation for the errors

We realise a Durbin-Watson test in order to test for 1st order serial auto-correlation. We have the following equation of the first order auto-correlation of error : $\epsilon_t = \rho * \epsilon_{t-1} + V_t$ with $\rho \in [-1; 1]$
Hence, to assess the correlation between the past and the present residual, we test the following hypothesis : $H_0 : \rho = 0$ and $H_1 : \rho \neq 0$.

When computing the Durbin-Watson statistic on gretl, we obtain $DW = 1,01708$.
From the statistic table we get the following data :

d_L	d_U	$1 - d_U$	$1 - d_L$
1,47	1,73	2,27	2,53

Table 1: Durbin-Watson test

We observe that our Durbin-Watson statistics stands between 0 and d_L, hence H_0 is rejected at a 5% level of risk and $\rho > 0$. Indeed, this test shows that, as we observed on the graph, there is positive auto-correlation in our model, which means that the residual in t is correlated from the one in t-1.

To corroborate our hypothesis that the residual and the lag residual are positively auto-correlated, we will implement a Breush-Godfrey test to determine if there is serial correlation between e_t and its past values.

First we have this estimated residual from the OLS estimation of our model : $e_t = y_t - \hat{y_t}$ Then, we compute the auxiliary equation:

$$e_t = a_0 + a_1 x_{1,t-1} + a_3 x_{3,t-1} + a_4 x_{4,t-1} + b_0 * D + b_1 * D * x_{3,t-1} + \rho e_{t-1} + V_t$$

Hence we test the following hypothesis : $H_0 : \rho = 0$ and $H_1 : \rho \neq 0$

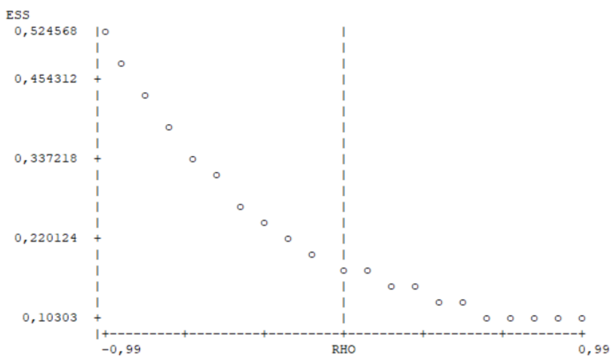
Then we compute F*, the statistic of the Fisher test which will tell us how much significance we loose between the two models: $F^*(1, 57) = 12,8966$; et $F_5^{5\%} = 4 < F^*(1, 57)$. So we reject H_0 at a 5% level of risk. Hence we conclude that errors are correlated, which means that the assumption of the independance of the residuals is violated. Thus there are significative statistical proofs that there is serial auto-correlation in our model, which questions the validity of its OLS results and conclusions.

6.1.3 Correction of the auto-correlation

We will now realise a GLS estimations and correct the auto-correlation using the Hildreth-Lu correction method.
Firstly we start by extracting ρ from the OLS and use it to create a transformed model. To do so we generate the transformed variables and obtain the following transformed model :

$$\begin{aligned}
Y_t &= \text{EURUSD exchange rate} - \rho \cdot \text{EURUSD_exchange_rate}(-1) \\
X_{1,t-1} &= \text{Interest_Rate_Diff}(-1) - \rho \cdot \text{Interest_Rate_Diff}(-2) \\
X_{3,t-1} &= \text{Inflation_Rate_Diff}(-1) - \rho \cdot \text{Inflation_Rate_Diff}(-2) \\
X_{4,t-1} &= \text{Treasury_Differential}(-1) - \rho \cdot \text{Treasury_Differential}(-2) \\
D_{t-1} &= \text{Dummy_Diff_HighVolYears}(-1) - \rho \cdot \text{Dummy_Diff_HighVolYears}(-2) \\
TD_{t-1} &= \text{T_D}(-1) - \rho \cdot \text{T_D}(-2)
\end{aligned}$$

Now we correct the coefficients : $a_i = \frac{coeff_i}{(1-\rho)}$
From the Durbin-Watson test, we know that the auto-correlation between the present and past residuals is positive, hence $\rho > 0$. Thus we estimate the equation using the variables in quasi-difference where $\rho = 0,1; 0,2; ...; 0,9$. The gretl code gives us the following results :



The corrected model for $\rho = 0,93$ is thus :

Table 2: Model 20: Hildreth-Lu Regression results

Variables	***Coefficient***	***Std. Error***	***t-ratio***	***p-value***
const	1.22315	0.0796725	15.35	6.56e–022.
Interest_Rate_Diff_1	0.0225264	0.0171645	1.312	0.1947
Inflation_Rate_Diff_1	0.0342668	0.00759764	4.510	3.28e–05.
Treasury_Differential_1	−0.0548318	0.0297867	−1.841	0.0709
D_t_1	0.00341692	0.0241645	0.1414	0.8881
TD_t_1	−0.0132505	0.0175717	−0.7541	0.4539

Statistic	**Value**	**Statistic**	**Value**
Sum squared resid	0.101196	S.E. of regression	0.042135
R^2	0.906079	Adjusted R^2	0.897840
$F(5,57)$	4.620611	P-value(F)	0.001313
ρ	0.202484	Durbin-Watson	1.466383

We see that the estimation of the quasi-different model throws that only 2 of our variables are significant (Inflation rate and Treasury yield differential). We acknowledge this as a possibility since standard errors tend to augment in Quasi-Different models.
When we compare the two models, we observe that the R^2 in the corrected model is much higher than in the original model. Thus,

6.2 B) Heteroscedasticity :

6.2.1 Residual vs EUR-USD exchange rate plot

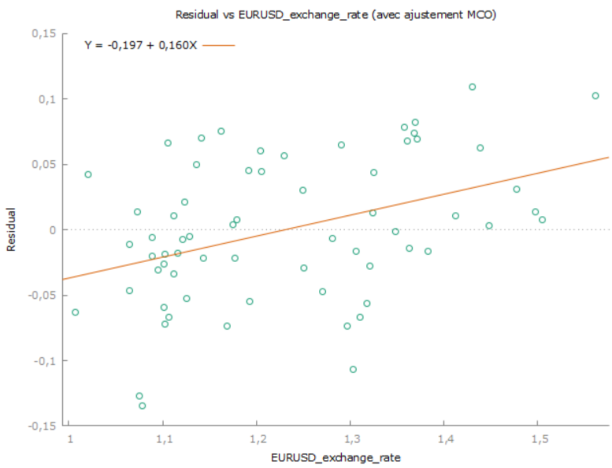


Figure 4: Residual vs EUR-USD exchange rate differential

It is not that obvious, but we can observe on the graph of the Residual in terms of the EUR-USD exchange rate differential, we can observe that difference between the points seems larger when the residual and the explained variable are small, and smaller as the value of those variables increase. This might suggest the presence of heteroscedasticity in our model.

6.2.2 White Test

We perform a White test to see if our intuition is in fact accurate. We write the auxiliary equation (with the residual that we found from the OLS estimation of the 1st model):
$e_t^2 = \beta_0 + \beta_1 * x_{1,t-1} + \delta_1 * x_{1,t-1}^2 + \beta_1 * x_{1,t-1} + \delta_2 * x_{2,t-1}^2 + \beta_3 * x_{3,t-1} + \delta_3 * x_{3,t-1}^2 + V_t$

We have the following hypothesis: $H_0 : \beta_1 = \delta_1 = \beta_2 = \delta_2 = \beta_3 = \delta_3$ and H_1 : at least one coefficient is $\neq 0$.
Our test statistic is the following : $LM = n \times R^2 = 65 * 0.083636 = 5.436 < \chi_5^2(1-\alpha) = 11.07$
Thus the homoscedasticity hypothesis (H_0) is not rejected at a 5% level of risk. This shows that our intuition was wrong and that we do not have heteroscedasticity in our model. Hence the variance of the error term does not varies significantly across observations : $E(\sigma_\epsilon^2) \neq \sigma_\epsilon^2$

6.2.3 Godfrey-Quandt test

We will now realise a Godfrey-Quandt test. From what we have seen in the graph, we will omit 25% of our observations which means 16 observations between the 24th and the 40th variable. We obtain 2 different results from 2 different samples (Sample 1 from 2007:4 to 2013:2 and Sample 2 from 2013:3 to 2023:4): (cf Appendix)
$n_1 = 24$; $RSS_1 = 0,0603663$; and $df_1 = 19$.
$n_2 = 26$; $RSS_2 = 0,030436$; and $df_2 = 21$.
Hence we have $F^* = (RSS_1/df_1)/(RSS_2/df_2) = 2,192 > F(df_1, df_2) = 2,05$.
Thus the Heteroscedasticity hypothesis is rejected at a significant level $\alpha = 5\%$. This result corroborates what we found with the White Test.

6.2.4 Correction of Heteroscedasticity

From the White Test, we observe that a_3 has the largest t-ratio : $|t_3^*| = 1,565$. Thus, we will consider that only the treasury yield rate differential brings heteroscedasticity to our model in this multiplicative form: $\hat{\sigma^2} = k^2 \times x_{3,t-1}$.
Now we compute the new OLS regression with each sides of the model divided by $\sqrt{x_{3,t-1}}$; and we obtain the following results :

Table 3: Model 42: MCO results using observations from 2007:3–2023:4

Variables	***Coefficient***	***Std. Error***	***t-ratio***	***p-value***
CT	1.38975	0.0205872	67.51	4.22e–053 ***
Interest	0.0240832	0.0168474	1.429	0.1587
Inflation	0.0436505	0.0089952	4.905	9.17e–06 ***
Treasury	−0.177946	0.0222648	−7.992	1.15e–010 ***
Dummy	0.0632648	0.0290704	3.017	0.0039 ***
ID	0.0644026	0.0227963	0.2825	0.7787

Statistic	**Value**	**Statistic**	**Value**
Sum squared resid	0.290538	S.E. of regression	0.074039
R^2	0.9984	Adjusted R^2	0.9953
$F(6, 63)$	5584/78	P-value(F)	2.24e-72

Let's now compare the orginal model and the transformed one:
We start by computing the variance of each coefficients using their t-statistic.

Table 4: Combined Model Statistics

	Standard Deviation		Coefficient	
	Original	Transformed	Original	Transformed
X_1	0.0146	0.0168	0.038	0.024
X_3	0.0075	0.009	0.048	0.044
X_4	0.0187	0.0223	-0.204	-0.178
D	0.0259	0.0209	0.037	0.063
TD	0.0176	0.0227	0.025	0.0064

We observe that the standard error of the coefficient of the transformed model are slightly higher than the ones from the original model. This is coherent, as the method we used aims to create a model which has more error than the previous one.
On the contrary, we observe that the coefficients have slightly decreased in the transformed model. Moreover, we observe that the R^2 is higher in the transformed model than in the original model, showing that there is a higher share of the EUR-USD exchange rate differential explained by the transformed model.

7 Conclusion

In this project, we scrutinized our model, rigorously tested it, and determined the most optimal version.

One observation that stood out from the onset was the accuracy of Paul Krugman's critiques of the Mundell-Fleming model. In particular, the inclusion of dummy variables to account for periods of high volatility led to a more accurate model. We anticipate that if our model incorporated other explanatory variables more closely related to capital markets, such as the prices of indexes or commodities, the impact of the dummy variables might have been even more pronounced.

After selecting an optimal model, we forecasted the last observation, which fell within the 95% confidence interval.

The incorporation of lagged variables in our model revealed the presence of auto-correlation, which we addressed in section 6.1.1.

We conducted two tests for heteroscedasticity: the White test and the Godfrey-Quandt test. Both tests supported the hypothesis that the variances of the error terms across our observations were constant, thereby refuting the presence of heteroscedasticity in the model.

As we did not observe heteroscedasticity, we did not need to correct for it. Consequently, our final model is as follows:

$$\boxed{\hat{y}_t = 1.223 + 0.023 \times X_{1,t-1} + 0.034 \times X_{3,t-1} - 0.055 \times X_{4,t-1} + 0.003 \times B_{0,t-1} - 0.013 \times TD_{t-1} + \epsilon_t} \tag{8}$$

8 Appendix

8.0.1 Correction of the Auto-correlation

Table 5: Model 18: OLS Regression results with newly created variables

Variables	*Coefficient*	*Std. Error*	*t-ratio*	*p-value*
const	0.699813	0.0174144	40.19	4.84e–044.
X1_t_1	0.0164100	0.0196360	0.8357	0.4067
X3_t_1	0.0351644	0.00877998	4.005	0.0002
X4_t_1	−0.151360	0.0278279	−5.439	1.12e–06.
D_t_1	0.0340820	0.0299331	1.139	0.2595
TD_t_1	0.00393887	0.0209416	0.1881	0.8515

Statistic	**Value**	**Statistic**	**Value**
Mean dependent var	0.622054	S.D. dependent var	0.076472
Sum squared resid	0.132591	S.E. of regression	0.047813
R^2	0.640115	Adjusted R^2	0.609090
$F(5, 58)$	20.63248	P-value(F)	8.87e–12

8.0.2 White test results

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Modèle 12: MCO, utilisant les observations 2007:4-2023:4 (T = 65)
Variable dépendante: SQ_Residual

                      coefficient    éc. type    t de Student  p. critique
  ---------------------------------------------------------------------
  const                0,00356767   0,00103074     3,461        0,0010    ***
  Interest_Rate_Di~   -2,75804e-06  0,000329660   -0,008366     0,9934
  Inflation_Rate_D~   -2,39081e-05  0,000299280   -0,07989      0,9366
  Treasury_Differe~   -0,000763303  0,000487585   -1,565        0,1228
  Dummy_Diff_Hig~_1   -0,000969719  0,00199706    -0,4856       0,6291
  T_D_1                0,00225976   0,00163921     1,379        0,1732

Moyenne var. dép.     0,002960   Éc. type var. dép.    0,003766
Somme carrés résidus  0,000832   Éc. type régression   0,003755
R2                    0,083636   R2 ajusté             0,005978
F(5, 59)              1,076980   P. critique (F)       0,382447
Log de vraisemblance  273,9247   Critère d'Akaike     -535,8495
Critère de Schwarz   -522,8032   Hannan-Quinn         -530,7019
rho                  -0,046433   Durbin-Watson         1,893392
```

Figure 5: White Test results

8.0.3 GQ Test results

Modèle 36: MCO, utilisant les observations 2007:4-2013:2 (T = 23)
Variable dépendante: EURUSD_exchange_rate

	coefficient	éc. type	t de Student	p. critique	
const	1,34284	0,0445870	30,12	3,42e-016	***
Interest_Rate_Di~	-0,0266225	0,0331851	-0,8022	0,4335	
Inflation_Rate~_1	0,0705185	0,0160812	4,385	0,0004	***
Treasury_Diffe~_1	-0,0248004	0,0636759	-0,3895	0,7018	
Dummy_Diff_Hig~_1	0,0734356	0,0411462	1,785	0,0922	*
T_D_1	-0,207175	0,104544	-1,982	0,0639	*

Moyenne var. dép.	1,371417	Éc. type var. dép.	0,085590
Somme carrés résidus	0,060366	Éc. type régression	0,059590
R2	0,625434	R2 ajusté	0,515267
F(5, 17)	5,677167	P. critique (F)	0,002945
Log de vraisemblance	35,70684	Critère d'Akaike	-59,41367
Critère de Schwarz	-52,60071	Hannan-Quinn	-57,70023
rho	0,312068	Durbin-Watson	1,343389

Figure 6: GQ test : OLS estimation for the Sample 1

Modèle 37: MCO, utilisant les observations 2017:2-2023:3 (T = 26)
Variable dépendante: EURUSD_exchange_rate

	coefficient	éc. type	t de Student	p. critique	
const	1,27435	0,0729031	17,48	1,39e-013	***
Interest_Rate_Di~	0,0161448	0,0295410	0,5465	0,5908	
Inflation_Rate~_1	0,0358350	0,0106095	3,378	0,0030	***
Treasury_Diffe~_1	-0,110812	0,0510714	-2,170	0,0422	**
Dummy_Diff_Hig~_1	-0,0481844	0,128374	-0,3753	0,7114	
T_D_1	0,0543129	0,0657550	0,8260	0,4186	

Moyenne var. dép.	1,131554	Éc. type var. dép.	0,056493
Somme carrés résidus	0,030436	Éc. type régression	0,039010
R2	0,618530	R2 ajusté	0,523162
F(5, 20)	6,485747	P. critique (F)	0,000978
Log de vraisemblance	50,86040	Critère d'Akaike	-89,72079
Critère de Schwarz	-82,17221	Hannan-Quinn	-87,54707
rho	0,556981	Durbin-Watson	0,847878

Figure 7: GQ test : OLS estimation for the Sample 2

[H]

8.0.4 Bibliography

Krugman, P. (1999). Balance Sheets, the Transfer Problem, and Financial Crises. *International Tax and Public Finance*, 6(4), pp.459–472.

Krugman, P. (2000). Reconsidering the Asian Crisis. *Study document of the MIT department.*

Bansal, E., Phatak, Y., Gupta, I.C. and Jain, R. (2009). *Transcending Horizons Through Innovative Global Practices.* [online] *Google Books.* Excel Books India. Available at: https://books.google.fr/books?hl=fr&lr=&id=Wm4IWv RpLkKqYNA#v=onepage&q=exchange%20rate&f=false [Accessed 18 Mar. 2024].

Eichler, S. (2012). The impact of banking and sovereign debt crisis risk in the eurozone on the euro/US dollar exchange rate. *Applied Financial Economics*, 22(15), pp.1215–1232. doi:https://doi.org/10.1080/09603107.2011.646064.

https://www.cmegroup.com/education/featured-reports/macroeconomic-drivers-of-the-us-dollar-euro-exchange-rate.html