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Determinants of Exchange Rates: An Empirical Analysis

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Abstract

This research focuses on the possible lag relationship among exchange rates. The period considered (2000-2013) comprises the Financial Crisis and therefore it was divided into two distinct periods: before and during the crisis. Before the crisis, the returns of Sweden and the Euro Zone seem to have impact on the British, Korean and Australian ones. During the crisis, there is evidence of the Euro and Sterling Pound influence on the Australian and New Zealand Dollar. Interestingly, the Swedish Krona is significant, in both periods, for the Korean Won, leading to deepen their common “technological profile” or the significance of major companies of both countries on Sweden’s returns. Carry trade is also presented as a possible justification for the Australian Dollar’s importance.

Keywords: Exchange rates, Financial Crisis, Carry Trade, Lag relationship in returns, In-sample significance.

1) Introduction

1.1) Research motivation: The role of exchange rates in the financial world comprises financial markets, business strategy or policy-makers' decisions. Regarding financial markets, *Forex* is traded over-the-counter, and its liquidity and low transaction costs are advantages compared to other asset classes, which justifies the utility of forecast models, or a particular variable, for exchange rates. The business strategy is also influenced by the value of currencies, namely in relative value of cash flows. Thus, the path of exchange rates is relevant in order to define operations, under a short-term perspective, or to define a strategy, under a long-term perspective¹. Finally, policy-makers are also interested in this topic since the results of its policies are influenced by the behaviour of exchange rates².

One of the main contributions for this research was the paper by Rapach, Strauss and Guofu (2013) regarding stock returns predictability. This innovative approach includes other countries' lagged returns in the predictability regression of return, in order to identify causality, and the US stock returns are pointed out as having the leading role in most of other countries' returns. Additionally, this model also includes dividend yield and interest rates to control for country risk. The significance of the US coefficient is supported by its relevance in financial system and by information frictions, which implies that US equity index captures the market sentiment earlier than the remaining indices.

Considering the significant results obtained in the abovementioned research, as well as its economic intuition, the motivation of this research is to apply the same lead-lag approach to exchange rates. Even though exchange rates regressors are included in a

¹ Regarding operations, the definition of delivery terms or currencies are examples of topics at which exchange rates' forecast can be useful, while the definition of markets to explore, in a longer time horizon, should take into account this variable.

² These are the cases of interest rates, in the perspective of Central Banks, or fiscal policy, in the case of government.

model, which considers other control variables, the purpose of this research is not to find a forecast model to fit returns behaviour accurately. The purpose is to find causality in variables, which might be included in sophisticated forecast models.

1.2) Literature review: Meese and Rogoff (1983) studied the accuracy of structural models to forecast nominal exchange rates, which include money supply, short-term interest rate differentials, output gap, long-term inflation differentials and difference in cumulative trade balances between US and foreign countries. The results pointed a failure of structural models to outperform the random walk in out-of-sample, which was considered as the benchmark³. In the same way, Rossi (2013) summarized recent studies concerning exchange rates predictability, using also the random walk as benchmark. Some variables were identified as inefficient for this effect, such as Purchasing Power Parity (PPP) or Uncovered Interest Rate Parity (UIP), while others, such as the Taylor Rule, the Net Foreign Assets⁴ or Commodity prices may provide some improvements (this concepts are detailed in note 1). However, the main problem of these predictors is the data frequency. Since most of these variables are directed to macroeconomic forecasts, with a long-term horizon, the time frequency is monthly or quarterly. According to the Research Motivation, and as will be deepened later on in Data Description, the purpose of this paper is to identify exchange rates, under in-sample perspective, that have a leading role for the remaining exchange rates, with a focus on a financial perspective.

Considering that the aforementioned literature is not useful for the purpose of the research, other alternatives were analysed, in order to complement the basis of the model, which is the use of the exchange rate as a predictor for the others. Chen and Ang

³ Both univariate time series and multivariate VAR were considered, using a frequency from one to twelve months.

⁴ This indicator is used later on, in section 5

(2013) provided a study about the yield curve, which may have influence in pricing kernel⁵. Carry is the most typical predictor used to represent the yield curve, but other indicators are proposed. The intuition is that it can represent the agents' perception, both investors and policy-makers, about long-term inflation and money policy targets. The model consists in cross-sectional predictability in a panel of currencies, and uses risk premium as the dependent variable. Term spread and level are presented as relevant predictors, where the results point to the conclusions that currencies with large changes in interest rate levels tend to appreciate (positive relation) and currencies with steep term spread tend to depreciate (negative relation). As occurs in Rapach, Strauss and Guofu's (2013) model, these variables may control, in some way, the country's risk.

The literature about this type of causality is limited. The *Safe Haven* effect may be one of the conclusions from this research, as presented in Rinaldo and Söderlind (2007). In addition, Rapach, Strauss and Guofu (2013) identified causality in stocks, highlighting US as the main driver of the remaining returns. The main reason is the economic preponderance, so the conclusions from this analysis may follow the same idea, with the reference currencies in the world having predictive power for the remaining exchange rate returns.

2) Data and variables

2.1) Countries, time horizon and frequency: The research assumes an US investor's perspective, as the reference in financial market, since the USD appreciation or depreciation has an immediate impact on the police markers' decisions, companies' activity or the overall financial market, so it is more intuitive to consider that prism.

⁵ Pricing Kernel reflects the factors that drives countries' risk.

The countries or economic blocks considered for the research implies a detailed selection since, unlike to other assets' analysis, the exchange rates present some idiosyncrasies that can pervert the final results. A relevant point in this analysis is addressed by Rogoff, Husain, Mody, Brooks and Oomes (2004). On the one hand, these authors highlight the difference between fixed and float regimes. In the former, the variation in exchange rates may be a consequence of macroeconomic policies, so the value of the currency is not accurately captured, while in the case of float rates, the behavior is expected to be more linked to the true value. On the other hand, even though some countries may announce a certain regime (*De Jure* regime), it may not be verified in exchange rate behaviour. Hence, the Natural Classification is proposed to classify the *De Facto* regimes⁶, and the countries selected, and respective code, are:

Table 1: Countries Selected and respective codes

Norway	Sweden	Denmark	Poland	Switzerland	United Kingdom	Euro Zone
NO	SE	DK	PL	CH	UK	EU
Canada	Brazil	South Africa	Japan	South Korea	Australia	New Zealand
CA	BR	ZA	JP	KR	AU	NZ

Regarding the time horizon, some problems were intended to be avoided. First, it should comprise the period of Euro Zone as a Monetary Union, given its importance in Forex trading. Second, it should exclude a turbulent period in Asian currencies, as consequence of the Asian crash in 1997, which had strong implications on exchange rates. Therefore, the period between 1/1/2000 and 27/9/2013 was selected. The weekly frequency was chosen, considering the research's aim (short-run returns), the variables included (exchange rates are available within this frequency) and time horizon (too short to consider a larger frequency).

⁶ The selection criteria is deeply explained in Note 2

The main problem of choosing exchange rates is the limitation of available countries. As mentioned before, several countries, with economic preponderance in financial markets, are totally or partially excluded. Most of Asian countries (except South Korea and Japan) do not have float exchange rates and most of the European countries are included in Euro Zone.

2.2) Real Exchange Rate: The literature points out to some persistence of the Meese and Rogoff puzzle, in the sense that existent structural models do not outperform the random walk in Nominal Exchange Rates (NER) forecast. Additionally, PPP suggests that Real Exchange Rate (RER) has no variation, what is not empirically supported, at least in short horizons, as Nikolaou (2006), for instance, suggests. Based on these two facts (unpredictability of NER and variation in RER), RER could be considered as the variable to forecast, instead of NER as used in most literature. Moreover, real exchange rates exclude the price effects, making this variable easier to model since it is not affected by the noise of prices.

The RER is computed based as⁷:

$$(1)R_t = \frac{N_t P_{t,US}}{P_{t,i}} = \frac{N_t}{P_{t,i/US}}$$

where R and N stand for Real and Nominal exchange rates, respectively, at time t, between the US and country-i, while $P_{t,US}$ and $P_{t,i}$ are relative to Price Index in the US and country-i, respectively.

NER were obtained from Bloomberg, considering the last price value, on a weekly basis. The problem of the forward looking bias is inexistent since the closing time is the same for every security (US closing time).

⁷ The discussion about methodology is made in note 3.

A discussion about the price index measure, to compute RER, is made in Ellis (2001), where the Consumer Price Index (CPI) is suggested as the typical indicator to be used, given the large data existence for all countries. Accordingly, and even though in the case of competitiveness measure other indicators are recommended in the abovementioned literature (producer price or unit labor cost), I opted for CPI since this estimation focus mainly on financial markets models, rather than productivity models. The computations and assumptions are detailed in Note 4. Then, the CPI for each week was calculated as:

$$(3) \text{CPI}_t = \text{CPI}_{t-1}(\Delta\text{CPI} + 1)$$

However, the CPI considered in these computations is relative to the US, so the price change in the US have also to be considered:

$$(4) P_{t,i/US} = \frac{\text{CPI}_{t-1,i}(1 + \Delta\text{CPI}_i)}{\text{CPI}_{t-1,US}(1 + \Delta\text{CPI}_{US})}, \text{ so } P_{t-1,i/US} = P_{t,i/US} \frac{(1 + \Delta\text{CPI}_{US})}{(1 + \Delta\text{CPI}_i)}$$

Having the relative prices for each country, the computation of the RER are now possible, using equation (1).

Considering that the basis of this research is the augmented prediction regression suggested by Rapach, Strauss and Guofu (2013), the returns of RER were considered as the dependent variable, which were computed as:

$$(5) r_t = \log \frac{\text{RER}_t}{\text{RER}_{t-1}}$$

Finally, the same literature calculates the excess returns, using each country's three-month Treasury bill. Nevertheless, the return measures the appreciation or depreciation

of USD against other currency, so, for every return, the US Government Bonds with 3 months of maturity was considered as risk free⁸.

Hence, the RER is the focus of this research. For financial markets, the high frequency is extremely useful, since it provides a more continuous perception, which is not provided by most of the mentioned literature. Regarding the business strategy, the high frequency is useful for short-term matters, while the inclusion of inflation gives a better perception about the intrinsic value of currencies. For policy-makers, the real factor of this variable is also important, but the time-frequency is not the most used in its models, which usually include macro variables that are only available on a quarterly or yearly frequency.

2.3) Yield curve variables: As mentioned in the literature review, Chen and Ang (2013) present two predictors that, representing an important factor of each country's risk, are significant in exchange rate forecasting. Despite the differences between both models (in variables to forecast and the model used⁹), term spread and level of yield curve were considered as an interesting indicator to control each country's risk in this case. Hence, the formulas indicated in the study were considered to compute these indicators:

$$(6) \Delta \text{interest rate levels } (L) = \frac{\Delta(y_t + r_t)}{2} \text{ and } \Delta \text{term spread } (T) = \Delta(y_t - r_t)$$

Where y is the long-term interest are and r is the short-term interest rate.

Contrary to what is indicated in the abovementioned study, the short-term interest rate considered was the 1 year government bonds, while for the long-term was the 10 years government bond (tickers are presented in Note 5). The time horizon was the one

⁸ This risk-free rate is in annual basis, so it was converted into weekly basis by dividing by 12 months and, then, by 4 weeks.

⁹ In fact, the study uses risk premium as dependent variable and cross-sectional predictability in a panel of currencies.

previously mentioned, with the same weekly frequency, and the data was obtained from Bloomberg.

Despite the similarities between both indicators, they present different conclusions. On the one hand, the interest rate level represents the absolute value of interest rates or, in other words, describes the parallel movements of the yield curve. On the other, the term spread indicates the difference between short and long maturities, or the slope of the yield curve¹⁰.

Table 2: Correlations among variables

	US	NO	SE	DK	PL	CH	UK	EU	CA	BR	ZA	JP	KR	AU	NZ
Term-Level	0,29	0,01	0,26	-0,05	0,17	-0,24	0,00	0,17	-0,10	-0,63	0,00	0,74	0,17	0,02	0,07
Term-RER		0,02	-0,04	-0,01	-0,14	-0,07	0,14	0,04	0,08	-0,08	0,06	0,16	0,03	0,21	0,01
Change-RER		0,07	-0,07	-0,02	-0,10	0,06	0,03	0,04	-0,19	-0,11	0,07	0,02	-0,06	0,05	-0,25

From Table 1 some interesting conclusion can be taken. The correlation among explanatory variables were performed, in order to identify potential problems of multicollinearity. Thus, it is possible to observe that, for the majority of countries, the level of correlation is low. The only exceptions are Brazil (-0.63) and Japan (0.74), which present significant correlation between Level and Term variables¹¹. Notice that the yield variables do not present significant correlation with RER, whose lagged returns are also explanatory variables. All in all, the purpose of the inclusion of these yield variables is to control for country risk, and not to increase the significance of the model.

¹⁰ Even though the yield curve does not have a linear format, this difference expresses a similar idea.

¹¹ The main problem of multicollinearity is that significant variables may loss its significance by including high correlated variables. In this case, it does not affect the coefficient of RER lagged returns, so is not relevant for the results.

3) Univariate Time Series - Linear Model

The intention of this research is to find causality of some exchange rate returns on the movement of others. Thus, the proper methodology is a regression, rather than correlation, which simply measures the degree of linear association between two variables¹² and disregards the inclusion of further regressors.

3.1) Model description: As described in the Introduction, Rapach, Strauss and Guofu (2013) proposed a model that, by including the lagged returns of other countries, allows the causality relationship to be tested. The same idea is considered in this research, but adapted to exchange rates. In addition, the other variables identified by the literature as relevant for exchange rate predictability – Term spread and Level – are also included. Initially, only one lag of each of the four variables is considered (country-i, country-j, term-i and level-i), but some adjustments are made later on. Thus, the first model proposed is:

$$(7) r_{i,t+1} = \beta_0 + \beta_i r_{i,t} + \beta_j r_{j,t} + \beta_L L_{i,t} + \beta_T T_{i,t}$$

Where r is the return of RER, T is the change in term spread and L is the change in interest rate level, as defined in section 2.

The mentioned literature is based on OLS estimators, which are considered BLUE¹³, and those estimators are applied in this case as well. The model is estimated for the 14 selected countries, using the same 14 countries as predictors. The period considered starts in 14/1/2000 and ends in 27/9/2013, including 715 observations. Despite the importance of yield curve variables and country-i lagged return, the main variable focused in country-j's return, which reveals the possible causality in returns. However,

¹² Brooks, 2008, p. 28.

¹³ Brooks (pp. 44-46) mentions that OLS is assumed to be Best Linear Unbiased Estimators, which is the result of certain assumptions. While some are assumed to hold, others (homoscedasticity and inexistence of autocorrelation in errors) are approached later on.

before analysing the results, some adjustments to the model are made, in order to guarantee the adequateness of the estimators.

The validity of the OLS estimators implies that heteroskedasticity and autocorrelation in the errors is not observed, otherwise the estimators would not be efficient and consistent. The first problem is controlled through White's heteroskedasticity robust standard errors (see more details in note 6). The second problem can be detected through the Breusch-Godfrey test¹⁴ and solved with the inclusion of certain variables that were previously ignored and are significant for the model (to control for autocorrelation). This procedure is described in more detail in note 7. Having these issues solved, the model was estimated, with the additional variables considered. A detailed analysis of the results will now be presented.

3.2) Correlations: Before analysing the causality in real exchange rates, the correlation among these indicators is calculated in order to identify potential conclusions from the proposed model. Thus, the four more significant correlations for each country are presented in Table A.1.

First of all, the correlations are positive in most of the cases, being Japan the only exception, but with low significance. The second conclusion is that there is a strong correlation among European countries, which is consistent with the regional proximity. A third conclusion, Australia is identified as the most correlated with most of the non-European countries. The fourth conclusion, which is also consistent with regional proximity, is that New Zealand and Australia are correlated with the same countries (Canada and Sweden), besides the correlation between both. Finally, the non-European

¹⁴ The same literature suggests this test, which have as advantage the joint significance test for the autocorrelation between errors term and several other lags.

countries have weak correlation with the countries considered, what can be justified by the inexistence of countries of the same continent.

Having this first approach, the regional factor was identified as a potential justification for the model results. The next step is a linear regression, which has as the main advantage the possibility to identify causality.

3.3) Results: Causality is identified through the coefficient of country-j, both in terms of significance and absolute value. For the former, a significance test was performed, in order to understand whether the estimated coefficients, based on certain assumptions and a certain sample, are close to reality. In case of significant coefficients, the distinction is made by considering the different level of significance¹⁵. The final results are presented in Table A.2 and a summary of significant coefficients in Table A.3. This subsection aims to identify regressors that can potentially explain some RER returns, as well as regressands which may be significantly explained.

From both tables, some considerations can be made. First of all, 13 of the 14 countries were identified as significant regressors for, at least, one country, while 9 countries were identified as being significantly regressed¹⁶. Specifically, 32 significant relations (17 at 10% significance, 12 at 5% and 2 at 1%) were found. In addition, some countries can be clearly defined as regressors or regressand, and the only exception is KR, which is significant in both cases. The three more relevant regressors (SE, DK and EU) are significant for exactly the same five countries (CH, UK, KR, AU, NZ), where UK and AU are the most significantly regressed by them¹⁷.

¹⁵ The significance levels considered were 1%, 5% and 10%.

¹⁶ From this analysis, it is possible to identify those countries which are not relevant in any case, using the same criteria as in rankings: NO, PL, BR, ZA and JP.

¹⁷ Considering a significant level of less than 5%.

3.4) Crisis influence: The Financial Crisis, which began to emerge somewhere in 2007, led authorities to avoid the mistakes made in the Great Depression, when currencies depreciated sharply and international trade was decimated. According to Weber and Wyploz (2009), Central Banks' policy focused on *quantitative easing*, with the intention to contradict the lack of liquidity in the market. Additionally, it is noticed that, in contrast to what occurred in 1930s, exchange rates are, nowadays for most of currencies, subject to market sentiment, so Government have not the same influence as before.

This context raises interesting questions, and identifies the period that started with the financial markets collapse as a potential source of the significant results. An interesting question is raised by Weber and Wyploz (2009), in what concerns the discussion on over- and undervaluation of certain currencies, given its current account position. In addition, Kohler (2010) points that this crisis has presented different characteristics from the previous (with lower magnitude and widespread), mainly in correlation among asset classes, and also within asset classes. For these two reasons, isolate Financial Crisis, which still persists currently, can lead to curious conclusions.

The period was defined by the Lehman-Brothers collapse in 15/9/2008, since it represents the beginning of the crisis in financial markets. In other words, within this period, markets of several securities registered an uncommon volatility and huge losses. Thus, the intention of this analysis is to verify the difference in causality between the periods before and during crisis. Despite the recent recovery in financial markets, it has not been solid yet, so the crisis period was considered until 27/9/2013.

Concerning OLS estimation validity, the same methodology was used. Nevertheless, for autocorrelation correction, in some cases, the included variables are not the same, since

the problem was not detected in the same variables. Then, it was possible to estimate an identical model as expressed in equation 7. The results and a summary for period before the crisis (model 1.2) are presented in Tables 4 and 5. The same statistics for the crisis period (model 1.3) are presented on Tables 6 and 7.

3.5) Comparative analysis: The overall period results provided some interesting conclusions. However, in order to verify the influence of crisis on those results, as a consequence of increasing correlations during financial turbulence, the sub-periods before and after the Lehman-Brothers Collapse were analysed.

Table 3: Summary for the three periods (number of significance regressors and regressands)

		Regressors														
		NO	SE	DK	PL	CH	UK	EU	CA	BR	ZA	JP	KR	AU	NZ	Total
Significance level	Period	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
*		0 1 1	0 3 1	3 0 0	3 0 1	0 0 1	0 0 0	2 1 0	2 2 0	1 1 0	2 0 1	0 0 1	3 0 2	1 0 0	0 1 0	17 8 9
**		0 0 0	4 4 1	1 0 3	0 0 1	1 0 0	0 0 0	3 2 0	1 1 0	0 1 0	0 2 0	1 0 0	1 0 5	0 0 0	1 0 0	13 8 12
***		0 0 0	1 1 0	1 1 0	0 0 0	0 1 0	0 1 0	0 0 1	0 0 0	0 0 0	0 0 0	0 0 1	0 0 0	0 0 0	0 0 0	2 5 1
		0 1 1	5 8 2	5 1 3	3 0 2	1 1 1	0 1 0	5 3 1	3 3 0	1 2 0	2 2 1	1 0 2	4 0 7	1 0 0	1 1 0	32 21 22

		Regressands														
		NO	SE	DK	PL	CH	UK	EU	CA	BR	ZA	JP	KR	AU	NZ	Total
Significance level	Period	1 2 3	1 3 2	1 3 2	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 3 2	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
*		1 0 0	1 0 0	0 0 1	0 0 0	4 2 2	0 2 0	1 0 0	0 0 1	0 0 0	0 1 0	2 0 0	3 1 1	3 1 3	2 1 1	17 8 9
**		0 1 0	0 0 1	0 1 0	0 0 0	3 0 0	3 0 0	0 1 1	0 0 0	0 0 1	0 0 0	0 1 0	2 2 1	3 2 5	2 0 3	13 8 12
***		0 0 0	0 1 0	0 0 0	0 0 0	0 0 0	1 4 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 0	0 0 1	1 0 0	0 0 0	2 5 1
		1 1 0	1 1 1	0 1 1	0 0 0	7 2 2	4 6 0	1 1 1	0 0 1	0 0 1	0 1 0	2 1 0	5 3 3	7 3 8	4 1 4	32 21 22

The table above gives a wider perspective, and three initial conclusions can be highlighted. First, the overall period presents 32 significant coefficients, while the period before and after present 21 and 22, respectively. This fact is not consistent with an expected higher correlation among securities during the crisis, as well as a higher numbers of significant coefficients, but may be due to the different and longer sample period used in overall period. The second general conclusion concerns the mean of the

significant coefficients, where the overall period presents a value of 0.128, while before and after the values are 0.102 and 0.232, respectively. In this case, the impact of the crisis is more visible, with a considerably higher coefficient. Finally, the period before the crisis contains 5 coefficient significant at 1%, 4 of them occurring with the UK as regressand.

Having an overall perspective of the three periods, the focus turns to particular countries, which have relevance as regressors or regressands. Thus, three main conclusions should be highlighted about regressors. The first conclusion regards the Swedish Krona, given its significance for 8 countries within the period before the crisis. In contrast, during the crisis, it is only significant for Australia and South Korea, the only countries that are consistently regressed in the three periods by SE. The second conclusion is identical for the Euro and Danish Krone, since both currencies are significant for the same 5 countries in the overall period¹⁸. By observing the results, it is possible to conclude that, except for the UK, these countries are significant exclusively during the crisis period, what leads to the idea that financial turbulence explains its role. This similar path is potentially explained by the strong correlation between the two countries (0.99), what, however, did not result in a causality relationship. The third conclusion about regressors is the significance of the Korean Won during the crisis period (significant for 7 countries), which is not observable in period 2.

The regressands analysis aims to identify currencies whose behaviour can be modelled by other currency's returns. The first evidence occurs with Swiss Franc, even though the significance is only present in the overall period. Contrarily, the Korean Won is significantly explained by 5 countries in the overall period. However, the analysis of the two sub-periods is not conclusive, since for DK and JP the crisis seems to be the main

¹⁸ Despite different significance levels, they are significant for CHF, GBP, KRW, AUD and NZD in overall period.

reason, while for SE and ZA, the period before the crisis is significant at a 5%. The third conclusion is the success of the model to explain the UK returns before the crisis, considering that 4 countries are significant at a 1% significance level. Finally, the crisis also had a great impact, with similar magnitude, on Australia and New Zealand, since most of the significant coefficients in the overall period are also significant during the crisis period.

The results summarized above are largely conclusive about which countries are significant for the model before and after the crisis. Accordingly, Sweden presents capacity to explain several countries' returns before the crisis period, while Denmark and the Euro Zone are relevant during the crisis period. The UK case is extremely interesting, but it is inconclusive about which regressor is more accurate. Evidence was also found that the crisis had impact on Australian and New Zealand returns. The main contribution of this analysis, besides the results, is the recognition that a turbulent period as Financial Crisis could not be ignored, and would influence the results and, thus, the conclusions about countries' causality. A deeper analysis will be presented latter on, in order to identify in more detail the causality found in the linear model.

4) Multivariate Time Series - VAR

The Linear Regression Model identified several significant relationships among the exchange rates, for the three periods analysed. As previously mentioned, certain countries were pointed out as significant regressors and/or regressands. This conclusion implies that the regressors are exogenous since, in most cases, its values are generated outside the model. Moreover, certain countries are significantly explained by more than one exchange rate, what may be consequence of the individual test and "hidden information" behind some of those coefficients. These two potential problems expose

the Linear Model's limitations, since it is not flexible enough to consider a large number of regressors (due to autocorrelation or efficiency of the model), and do not consider variables as, simultaneously, regressors and regressand. For these reasons, a Vector Autoregressive Model (VAR) was adopted, in order to include more variables as explanatory (both exogenous and endogenous), and to conclude about the regressors which are truly significant¹⁹.

4.1) Model description: A VAR Model was performed for each period, and the inclusion of countries was restricted in order to have the model as efficient as possible. The methodology used is described in note 8, concerning the selection criteria for variables, as well as the carry and equity variables included to control for other events not detected by the model. This procedure avoids a drawback of VAR, which is existence of several parameters and the consequent loss of degrees of freedom in estimation. Consequently, it changes the intrinsic meaning of VAR, which considers all the variables as, simultaneously, regressors and regressands. Despite this fact, the results remain accurate, so the model will be mentioned as a VAR.

As occurred with the Linear Model, the VAR Model also may generate inefficient estimations if the OLS properties are not guaranteed. Regarding autocorrelation, the same procedure used in Linear Model is applied. However, in this case, the inclusion of one more lag of an endogenous variable implies more lags for the remaining endogenous variables, which penalizes the efficiency of the model, so this process was limited. In addition, lags of the exogenous variable were also used to control this problem. Regarding heteroskedasticity, the procedure was distinct from the used in Linear Model, as is explained in note 9.

¹⁹ All the methodology used had as support Brooks (2008), pp 273-276 and 290-314.

Having the initial model performed, and the problems controlled, the results are analysed. In order to have a more efficient model, the irrelevant regressors were excluded from the sample, respecting the following criteria: a) Not significant for any endogenous variable; and b) Not relevant to control autocorrelation. Then, a new model was estimated, resulting in final coefficient values. Finally, it is possible to compare the results between the Linear Model and the VAR, concluding about which regressors are truly significant.

4.2) Results: The initial purpose of the research was to use the overall period and, then, identify the most significant relationships among exchange rates. Nevertheless, it was firstly suggested that the Financial Crisis may have altered the causality until then, so the whole period was divided in before (period 2) and during the crisis (period 3). The Linear Models have already shown that results are different. On the stage, the intention is to understand if, with a more sophisticated model, the results are the same.

Before the Crisis (period 2): This period excludes the financial turbulence, when the correlation among asset classes and within asset classes is stronger, and try to illustrate a “normal” behaviour of exchange rates. Again, I firstly selected the relevant regressands as endogenous variables, and then the significant regressors for them. As endogenous variables I included UK, South Korea and Australia, while as exogenous countries I chose Sweden, Switzerland, Euro Zone and Canada. Then the model was performed, from which the following conclusion can be highlighted (since there is no relevant change in regressands, I focus on regressors):

Table 4: VAR Model. Coefficients before the Financial Crisis

		Regressands		
		RUK	RKR	RAU
Lagged Regressands	RUK-1	-0,13	0,06	-0,07
	RKR-1	-0,04	0,01	0,00
	RAU-1	0,04	-0,05	-0,09
Regressors	RSE-1	0,15	0,20	0,24
	RCH-1	0,26	0,12	0,04
	REU-1	-0,24	-0,29	-0,21
	RCA-1	0,05	0,07	0,16

- a) Canada loses its significance for the UK and SK, and keeps for AU (0.16). This fact is not only due to hetereskedasticity, since the coefficients for the UK and SK changed from 0.102 and 0.093 to 0.05 and 0.07, respectively. Thus, the inclusion of the three variables simultaneously shows that Canada is the most powerful to explains AU returns.
- b) Sweden is the only regressor that remains significant for the endogenous variables (0.151 for UK, 0.196 for KR and 0.24 for AU).
- c) Nevertheless, the Euro Zone presents the highest coefficients for UK and KR (-0.242 and -0.288). Interestingly, both coefficients are negative, contrary to the remaining.
- d) Finally, it is interesting to notice that the Euro Zone and Switzerland have almost symmetric coefficients for the UK (-0.242 and 0.263, respectively).
- e) Besides the cross-significance, I would highlight the relevant role of Australia Carry and Level for the three endogenous variables during the period before the crisis, having the former a negative impact and the latter a positive (Table A.9).

During the Crisis (period 3): As in the Linear Model, this period illustrates the relationship among exchange rates during most part of the Financial Crisis. For this period, a slight different approach was applied to select variables. First, I considered the most relevant regressands, which are explained by more than one regressor:

South Korea, Australia and New Zealand. Then, I selected the regressors which were significant for them (only ignoring the less significant): Sweden, Euro Zone, Japan and UK²⁰. Notice that South Korea is used as explained and explanatory variable, so its significance for Australia and New Zealand is controlled.

Table 5: VAR Model. Coefficients during the Financial Crisis

		Regressands		
		RKR	RAU	RNZ
Lagged Regres.	RKR(-1)	0,13	0,30	0,35
	RAU(-1)	-0,20	-0,35	-0,21
	RNZ(-1)	-0,02	-0,02	-0,10
Regressors	RSE(-1)	0,21	0,07	0,09
	REU(-1)	0,11	0,31	0,25
	RUK(-2)	0,02	-0,18	-0,16
	RJP(-1)	0,11	-0,06	-0,10

- a) South Korea is no longer significantly explained by Japan, becoming Sweden and Australia its reference “return drivers”, with a coefficient of 0.213 and 0.2, respectively. On the one hand, Sweden assumes now a stronger impact, considering the previous coefficient of 0.146. On the other, Australia, which was not significant previously, assumes a relevant role.
- b) For Australia and New Zealand as endogenous variables, the results do not change significantly, since most of the countries (South Korea, Euro Zone and UK) remain significant. The main change is the relevance of Australia to explain New Zealand returns, with a considerable coefficient of -0.213.
- c) Interestingly, Australia’s effect on New Zealand and South Korea is negative, what can lead to unexpected conclusions, since the most expected sign, given the geographical factor, would be positive.
- d) The UK is an uncommon case in this research since it presents strong significance with two lags for Australia and New Zealand. Even though the

²⁰ For this specific case, it was found significance at lag-2.

intuition is the same, it would be interesting to understand why the UK's returns have a delayed effect on these exchange rates, compared to the other relationships.

- e) Other important conclusions, which are not the main focus of this research, are related to the variables to control specific risk (see table A.9). In this case, both Level and Carry Poland are significant for all the endogenous variables, so they may present a representative behaviour of market sentiment, since Poland was not included on this final model.
- f) Finally, S&P500, as representative of equity market, only has significance with three lags (three weeks). This result is surprising, since the correlation among asset classes were expected to increase, namely the contemporaneous. However, this effect may have been extracted from other returns.

Table 6: Overall significance (Adjusted R-squared)

Regressands	Before the Crisis (Period 2)			During the Crisis (Period 3)		
	UK	KR	AU	KR	AU	NZ
Linear	0.017	0.005	0.010	0.076	0.073	0.057
VAR	0.044	0.052	0.047	0.233	0.250	0.205

Through the values presented, it is possible to conclude that the VAR Model has higher significance than Linear Model for every period, and for every country. One potential explanation is the non-corrected heteroskedasticity, which misrepresents the value of significance. In addition, it is possible to conclude that the Financial Crisis, represented by period 3, may have affected the significance of the model, as a consequence of the increasing cross-correlation²¹. Moreover, the inclusion of carry and equity variables

²¹ Notice that in the VAR model were considered additional variables such as equity returns (S&P 500) and Carry, what also contributed to the level of significance.

may have benefited the overall significance (see Table A.9). The comparison between both models, in terms of coefficients, is presented in Table A.8.

5) Discussion of empirical results

The innovative approach for exchange rate models resulted in some interesting and significant relationships among the included countries. Nevertheless, these results may have been influenced by the sample used, or even other events that were not captured by the model. Therefore, an analysis about the intuition of the coefficients – both magnitude and sign - is complementary to the technical computation. In that sense, several indicators were considered, in order to suggest some justifications of the results obtained.

The initial approach to compute the model was the entire period between 1/14/2000 and 9/27/2013. However, I considered that the Financial Crisis, and the consequence turbulence in every asset class, may have influenced the coefficients. Hence, for this analysis, I focus on the results before (period 2) and during the crisis (period 3), from where the main conclusions are:

Table 7: Summary of the results

		Before Crisis			During Crisis			
		Regressands			Regressands			
		RUK	RKR	RAU	RKR	RAU	RNZ	
Lagged Regress.	RUK(-1)	-0,13	0,06	-0,07	RKR(-1)	0,13	0,30	0,35
	RKR(-1)	-0,04	0,01	0,00	RAU(-1)	-0,20	-0,35	-0,21
	RAU(-1)	0,04	-0,05	-0,09	RNZ(-1)	-0,02	-0,02	-0,10
Regressors	RSE(-1)	0,15	0,20	0,24	RSE(-1)	0,21	0,07	0,09
	RCH(-1)	0,26	0,12	0,04	REU(-1)	0,11	0,31	0,25
	REU(-1)	-0,24	-0,29	-0,21	RUK(-2)	0,02	-0,18	-0,16
	RCA(-1)	0,05	0,07	0,16	RJP(-1)	0,11	-0,06	-0,10

5.1) International Trade: This indicator summarizes the exports and imports of one country to another²². The same countries as included in the model were considered, with the addition of four other relevant markets: US, China, India and Indonesia²³. There are some literature arguing that imbalances in this indicator may contain information about the future path of exchange rates²⁴. In this case, net exports or the overall trade among countries are used to have some intuition their relationship.

United Kingdom: In the case of the UK, there were found significant coefficients for the period before the crisis. The coefficient of Euro (-0.242) is easily explained by the importance of the international trade with this economic block, which has represented 40% of the total trade, during the whole period (Figure 1). In addition, the current imbalance of more than 1% of GDP with the Euro Area is a potential explanation for the negative relationship. The negative coefficient indicates that when EUR appreciated 1pp, the GBP depreciated 0.242pp (*ceteris paribus*). Considering that EUR had appreciated over almost the whole period and GBP had appreciated always less than EUR, this coefficient makes sense. One potential reason is the intention by UK authorities to gain some competitiveness against EUR, even though the overall variation had been positive (led by other factors)²⁵. Another potential explanation is the preference of investors to buy EUR and sell GBP, given the overall economic environment or specific events on each economy (namely the persistent deficit of UK). Regarding Sweden and Switzerland, international trade does not seem to give any consistent explanation for the coefficients, given the reduced weight of both economies in UK trade.

²² Notice that this is not the same as current account, since does not include net primary and secondary income.

²³ Given its significant GDP and the existence of Southern Asian Countries, Indonesia could have some influence.

²⁴ Gourinchas and Rey (2007)

²⁵ Notice that this intervention does not breach the free floating, since is made through monetary policy, which indirectly influences the relative value of GBP.

Republic of Korea/ South Korea: During the period between 2000 and 2008 (collapse of the Lehman Brothers), South Korea presented a current surplus between 1.5% and 3.5%, with the exception of 2008, when the crisis was more severe. In addition, the openness of its economy had consistently increased over that period, with the total trade moving from 60% to 90% of GDP. Regarding the partners (Figure 2), the results obtained are consistent with the economic dimension. However, the most interesting point visible in this chart is the increasing dominance of China, as occurs with other countries, during the whole period, which has substituted Japan and the US as the main partners of South Korea. This fact is approached by Weber and Wyplosz (2009), which highlight the benefits that China has had with the KRW depreciation until crisis erosion, since most of the Chinese exports incorporates imported manufactures, and South Korea is one of the main sources. This document does not suggest that China is the cause of the KRW behaviour, but it is reasonable to consider that the trade with China has encouraged its depreciation. The exports' annual growth is consistent with this perspective, since the level to China achieved 22% until the Financial Crisis, while for the Euro Area and US it grew 13% and 3%, respectively.

As mentioned before, Sweden has a significant positive coefficient in both periods. However, this significance is not illustrated in trade between both countries, since Sweden represents less than 2% of total trade and the balance does not have a consistent path (it becomes negative from 2008 onwards). The coefficient of Euro (-0.288) is a consequence of the strong appreciation of EUR, while KRW had appreciated slightly. This fact is in accordance with the Korean policy of gaining external competitiveness during the 2000's, which is reported in an Economic Review report by Bank of Tokyo – Mitsubishi UFJ in 2010. This strategy focused on a strong incentive to certain industries (deepened later on), supported by a depreciation of KRW. In that sense, the negative

ceteris paribus effect of EUR can be potentially explained by the Korean's strategy, also supported by the constant surpluses in net exports with the Euro Area during that period (close to 2% of Korean GDP from 2004 to 2008). In addition, it may also be related to the increasing influence of China, as mentioned before.

Australia: Australia registered negative net exports, with some exceptions, above 2% of GDP before the crisis, inverting the trend after the Crisis. The trade with Euro Area contributed significantly for this situation, since the deficit has always exceeded 2% of GDP (Figure 3). As occurred with the previous countries, Euro Area, Japan, USA and China are the most significant partners, with New Zealand, UK and South Korea having a weight close to 5% each (Figure 4). However, the weight of international trade on GDP never exceeds 50%. Thus, the significance of Sweden (0.245) and Canada (0.159) during the period before the crisis is not explainable by these analysis, while during the crisis some intuition seems to be present. The strong positive correlation across securities is typical during turbulent periods, and this fact is visible in the Euro (0.307) and Korean Won (0.296) coefficients. The Euro influence is explainable by its dimension in international trade, besides the abovementioned deficit, while the KRW impact may be related to a regional effect. Nevertheless, these significant coefficients may also be related to the decline in its relative importance in favour of China²⁶, since AUD did not depreciate significantly against these currencies, so the competitiveness improvements was not attained though devaluation.

New Zealand: I found some in-sample significance for NZD during the crisis period, and some of the reasons may be related to international trade position. New Zealand had presented chronic net exports deficits until the crisis, almost always above 3%, as may

²⁶ More evident in Euro Area, where the share decreased from 12,5% to 9%, while China's position raised moved from 13,5% to 19% within the same period.

be observed in Figure 5. With the crisis, this imbalance seems to have been corrected, with the achievement of two consecutive years of positive accounts (2010 and 2011). This imbalance shows a slight inversion of the previous trend. The Euro coefficient (0.248) is fairly justifiable by the weight of the trade with this economic block (Figure 6), while South Korean coefficient (0.353) is more difficult to justify, mainly due to its large value. Nevertheless, and as pointed out in the South Korea analysis, its policy also resorts to currency depreciation, to achieve a more competitive position, which seems to be in accordance with the NZ behaviour.

5.2) Equity market and economic linkages: The previous analysis has suggested that the dimension of certain economies or their policies may have influenced the results. In this topic, the possibility that some countries, which apparently do not have a visible relationship, may have particular similarities is raised. Rapach, Strauss and Guofu (2013), in a context of equities relationship, found not only the US as the main “return-driver”, but also the significance of Sweden and Switzerland. Considering the small dimension of these economies, it was argued that market concentration could be a potential justification since shocks on fundamentals are quickly impounded into large companies and, in case of market concentration, that effect is more highlighted. This event is known as information frictions. Naturally, the impact on equities is more evident, but it gives an idea of the exposure to the financial system. Figure 7 shows the market capitalization measured in GDP, as an average for each period, from where it is possible to observe the large value, during the period before the crisis, in Sweden (111%), Switzerland (250%), UK (139%), South Africa (200%) and Australia (119%). Interestingly, most of these countries were found significant, as regressors or regressands, in the model proposed. Thus, the exposure to the equity market, represented by this indicator, can justify these narrower relationships. Regarding market

concentration, I present the data from 2007, which is the turning point between the two periods, in Figure 8. Consistently with the argumentation of the abovementioned document, Sweden (35%) and Switzerland (50%) present high values.

Apart from the information frictions, the economic similarities may also contribute to explain the exchange rate path. In particular, if countries are specialized in certain industries, they are subject to the same trends in those markets, and their exchange rates will reflect that.

Figure 9 presents the industry breakdown in terms of Market Cap of 2007, based on top 10 companies previously used, from where some interesting relationships can be observed. First of all, the dimension of the Financial Sector is significant in Australia (80%), UK (53%) and Canada (76%), which is typically a strongly cyclical industry. As presented before, Australia is significantly regressed by Canada (0.159) before the crisis and by the UK (-0,182) during the crisis. In case of Canada, the weight of the Financial Sector is enormous, as well as in Australia, so both countries have benefited from the prosperous period until the crisis, what can potentially explain this similar, even slight, path in exchange rates. However, the causality of Canada on Australia, and not the inverse, is more difficult to explain. The second point is the significant weight of the Technological Sector in Sweden (47%), Switzerland (44%) and South Korea (53%). Indeed, Sweden is the most consistent coefficient, namely for South Korea, with positive values in before and during the crisis periods. This means that an appreciation of SEK against USD in a certain period, led to an appreciation of KRW in the following period.

Regarding this last point, I observed the investment in R&D to confirm the technological profile of those countries. The results in Figure 10 confirm that both

Sweden and Korea have had a strong investment in this area during the last decade. However, while Swedish investment remains stable, the Korean suffered a sharp increase. In the latter case, it is clearly related to the country's focus on the export profile, by depreciating the currency and invest in value-added products, as is mentioned in Economic Review report by Bank of Tokyo – Mitsubishi UFJ in 2010. Figure 11 provides the weight of high-technology exports in manufactured exports, and the conclusions are interesting. While South Korea has stable values (with a decline in crisis), the indicator suffers a continuous decline in Sweden, moving from 18% in 2002 to 13% in 2011. Before using these two facts, I analysed the Swedish companies' profile, namely in terms of Employees in each sector in 2010. The distribution of employees, of each industry, by Sweden and Abroad is presented in Figure 12. The strategy of Swedish companies to invest abroad becomes clear, with a notable discrepancy in Fabricated Metal Products and Computer and Electronics Industries (percentage of almost 80% of employees in abroad). In addition, if the same analysis is made to the largest Swedish companies, the conclusion is the same. All in all, if these four figures are simultaneously considered, two main potential explanations can be raised: a) The investment in R&D by Sweden is directed to foreign investment, since the results have not been visible in terms of exports, and the technological industry is the most relevant in top companies (who is benefiting from Swedish investment?); b) South Korea is one of the benefiter of this strategy since, besides its investment in R&D, the *know-how* from "Swedish multinational" companies, even in small dimension (given the number of employees in Figure 13 and its small amount comparing to the other economies), may have been crucial to this path. In addition, it is notable the larger amount of allocated employees to services, which may be associated to R&D. With that

purpose, I picked Ericsson²⁷, a Swedish company, as representative of this potential trend and analysed its position in a geographical perspective²⁸. Figures 14 and 15 show indicators that give an impression about this idea: While assets, between 2007 and 2009, do not allow any conclusion, the revenues' weight has increased, specifically for the rest of North East Asia, which is mainly composed by Japan and South Korea.

This last paragraph raised the idea that Sweden coefficient significance on South Korea may be supported on a sort of “technological effect”. In order to deepen this possibility, a Linear Model was regressed, by including the same companies of both countries²⁹ used in Figures 12, considering KR as regressand and SE as regressor. This procedure is present in Note 10. The main conclusions, for both periods, are: a) Before crisis, the only significant company is Samsung (Korean) (0.025 at 10% significance), with all the remaining Swedish and Korean companies' stocks being non-significant; b) During crisis, where the cross-correlation in asset classes increases, the KOSPI (-0.18 at 5%) and Samsung (-0.07 at 10%) were significant, while Ericsson has significance at 10% (0.06), and Nordea and SEB-Skand (both Swedish) are the significant at 1% and 5%, curiously both from Banking Sector.

Concluding, this introductory approach of using technological companies to explain South Korea's returns were not entirely successful (even though Samsung had had some significance before crisis and Ericsson after the crisis), since the SE coefficient remained, or even increased, and the main result being natural (banks are more expected to be the most cyclical companies during Financial Crisis). Nevertheless, this procedure may bring future results since, as the bank's returns significance showed, it was strongly affected by crisis.

²⁷ ERICB SS Equity; Described as a Technological company.

²⁸ Data from bloomberg terminal

5.3) Income and Capital flows: The “Net Income from Abroad” indicator reflects the transaction that involves incomes from labour (migrants) or capital (from financial and nonfinancial claims). Thus, an inflow is expected to appreciate a currency, while an outflow to depreciate. The variation of this indicator may be due to two factors. First, it may be a consequence of the economic environment: since income from capital and labour increases, it has the same positive effect on countries which have a chronic surplus. This is the case of the CHF coefficient (0.263) on UK before the crisis, where the former have an average of 6% and the latter 1% of GDP, being the countries with a highest indicator, which justifies the positive sign. Second, during adverse situations, labour and capital (more flexible) tend to move to countries with safer conditions (*Safe Haven* countries), or to the origin. This might be the case of the UK coefficients for Australia (-0.19) and New Zealand (-0.16), which have an average net inflows of -4% and -4.2% during Financial Crisis, respectively³⁰. Hence, this might have been consequence of the reallocation from these countries to the UK (the origin of the capital) and of a deleveraging process.

The “Foreign Direct Investment (FDI) Inflow” is a potential tool to explain the relevance of certain countries, and also the link between them. In Figure 16 it is possible to observe the weight of FDI in certain economies, more evident during the period before the crisis. Sweden, UK and Switzerland have had high levels, so the capital transferred to these countries may influence the behavior of exchange rates. The relationship among countries would reinforce this analysis, in order to understand if the trade flow between two countries is consistent with the coefficients. All in all, These two indicators have been tested by several studies, and the results were not the most

³⁰ This values are based on World Bank data base.

favorable³¹. Nevertheless, this procedure only aimed to make a complementary analysis, and not use them as variables.

5.4) Carry Trade with AUD and NZD: The most common carry trade strategy consists in a long-short position on two interest rates. By investing in a certain interest rate, the increasing demand on that currency leads to its appreciation, while the shorted currency tends to depreciate. Nevertheless, this causality is contemporaneous, so the same intuition is not applied in the model. In this case, a currency appreciation is an incentive to purchase foreign assets, which are relatively cheaper. In other words, if a certain currency appreciates, investors tend to sell a position in, for instance, Government bonds of that country and buy the same asset of the other country. Hence, the currency of the country that corresponds to the long-position is expected to appreciate, led by the previous appreciation. The most relevant indicators to define this strategy are return (yield) and risk (volatility), so I present the summarized statistics for these two indicators for the countries that were found significant in Tables A.10 and A.11. For the period before the crisis, the most attractive long-positions are Australia, New Zealand and the UK, while for short-positions (with low funding cost) are Sweden, Switzerland and Euro. Accordingly, carry trades including the abovementioned long and short positions would naturally lead to a positive coefficient, as occurs in most of cases (see Table 7). This effect is mostly visible in the CH coefficient (0.263) on the UK, which represented a potential trade given the low risk of both countries' securities. In addition, the SE coefficients on the UK and AU may have also been influenced by this fact. The carry trade paradigm has completely changed with the Financial Crisis; see Bilson (2013). In this small reflection, the author mentions that long-positions in carry trade were less attractive due to *quantitative easing* applied by the major

³¹ Rossi 2013 summarizes several studies regarding exchange rates, and mentions these two indicators as not successful explanatory variables comparing to random walk.

economies, which decreased the return in its Government bonds. As an alternative to this less attractive risk-free long-positions (UK is the most evident case), he points out countries such as Australia, New Zealand or Mexico, which however present a significantly high currency fluctuation. Despite this risk, New Zealand and, with more strength, Australia have presented good indicators in terms of Sovereign risk (AA+ and AAA, respectively, by S&P), which can minimize the investors' fears. John Weavers³² reinforces this idea for Australia, which was an exception in *quantitative easing* policy in Triple-A countries, mentioning that a significant investment in a Government bond issue in November have come from foreign investors.

The previous facts sustain the idea that carry trade is a potential explanation for some of the coefficients found, namely during the crisis. Besides USD and JPY, the most representative currency for short-position is EUR, and it presents coefficient estimates of 0.31 and 0.25, for AU and NZ, respectively, consistent with the previously mentioned perspective. Regarding the UK coefficients (-0.18 and -0.16, respectively), a different approach has to be applied. As mentioned, the UK was no longer attractive as long-position so, possibly, investors have reallocated its capital applied in UK Government bonds to Australia and New Zealand. Thus, the depreciation of GBP and the consequent appreciation of AUD and NZD may be justified by this movement in financial markets³³. In fact, during this period, the RER of GBP has depreciated 0.5% against USD, while AUD and NZD have appreciated 11% and 46%, respectively. Regarding the KR coefficients for both AUD and NZD, they are difficult to explain by carry trade, and seem to have been a coincidence of two distinct facts. While the AU and NZ have benefited from the abovementioned event, the KR, which have sharply depreciated its currency in the period before crisis (not exclusively against USD), had a

³² Article in Reuters "Carry trade helps Australia deepen bond market" 26/11/2013

³³ The significance of UK is only verified at lag-2 what leads to the same interpretation given the short time frequency used.

more stable situation after the crisis erosion. Finally, AU was found significant for NZ (-0.21) and this is consistent with the same argumentation developed in UK coefficient to AU and NZ.

In addition, the Net Foreign Assets is pointed out by Gourinchas and Rey (2007) as an exchange rates predictor. Figure 17 presents this indicator for the countries now analysed. Before the crisis, it was mentioned that AU, NZ and UK were the most attractive countries to buy in carry trade, which corresponds to a negative Net Foreign Assets. The figure is consistent with this view, even though the indicator considers several other investments besides Government bonds (associated with carry trade). Naturally, the UK value is much lower given its dimension in economic and financial terms. In the same way, the countries that were pointed out as potential short-positions (SE, CH) or even Japan and US, have positive indicators, which suggest that the value of foreign assets held by resident investors (includes Government bonds of AU, NZ and UK) is higher than the value of local assets held by non-residents (local Government bonds, for instance). With the crisis erosion, this indicator suffered a slight inversion, as a consequence of deleveraging in the economy. Nevertheless, those values remain significant for the AU and NZ, while, for the UK, they became positive, which is consistent with the previous argument. Notice that the EU has an insignificant value, which is acceptable given its huge dimension.

6) Conclusion

This research looked for causality among returns of Real Exchange Rates, with financial markets as the main target. Having exposed interesting results, they were also dissected, in order to identify possible facts that may have influenced them. Nevertheless, the arguments proposed can be speculative, and its accuracy difficult to prove. However,

given its apparent reasonability, I considered them as a good fit to the reality of financial markets.

6.1) Research contribution: The main contributor for this research was the work of Rapach, Strauss and Guofu (2013). This document proposes a lead-lag relationship of stock returns, being US the main driver. The results were not similar in the case of this research, perhaps due to limited securities available or to distinct idiosyncrasies of this asset class. However, the innovation is evident in what concerns exchange rates, given the significance found in certain cases. In addition, I limited the misrepresentation of the approach due to Financial Crisis by assuming two distinct periods. The procedure was successful since both periods presented different results. The use of a more sophisticated model (VAR), with the addition of other variables, assured that some limitations of Linear Models would be corrected. Finally, I picked the most representative regressors and regressands and tried to build a solid argument. I proposed not only structural facts (International Trade, economic structure in industries), but also more specific events (monetary policy, changes in economic environment and the crisis) to justify the performance of exchange rates. All in all, this research does not propose a consolidated model, but gives a first step to the inclusion of other countries' exchange rate returns in forecast models.

6.2) Main findings: The first model intended to identify causality in countries individually and, then, applied a VAR model which considered the significant countries simultaneously. After identifying the most relevant results, I proposed some interpretations that could have partially justified the coefficients calculated.

The UK was found as significantly regressed by CH, EU, and SE during the period before the crisis. The EU, with a coefficient of -0.24, is representative in UK's

International Trade (40%) and is responsible for the high deficit presented by UK. During an appreciation of the EUR against USD, the path of GBP was more moderate, what is justifiable by its imbalances with the EU. Regarding CH (0.26) and SE (0.15) impacts, one plausible justification found was the exposure of the three countries to financial markets, expressed by market cap in percentage of GDP and market concentration. These results are more conclusive for CH than for SE (what is consistent with the magnitude of the coefficient), but a deeper analysis would be required to verify the accuracy of this argument. In addition, the indicator “Net Income from Abroad” provides similar results for the UK and CH before the crisis, since both countries present a positively high value, possibly meaning that both are subject to this flow to sustain their currencies’ value. Finally, the carry trade was also identified as a possible explanation, namely for CH coefficient since, until the Financial Crisis and *quantitative easing* policy, long position in GBP and short in CHF was a common strategy.

South Korea presented in-sample evidence as being regressed by SE and EU before the crisis, and AU and SE during the crisis. The EU coefficient (-0.29) before the crisis might have similar justification to the UK. Indeed, the EUR had a significantly higher appreciation against the USD when comparing to the KRW. One of the potential explanations is the Korean’s strategy to redirect its exporter’s profile to China, through exchange rates and technological competitiveness policies. Thus, it is natural that the *ceteris paribus* effect from Euro is negative, having its weight in Korean’s main partners decreasing. The SE coefficient is strongly significant for both periods, so it is one of the most interesting results of this research. Given its irrelevant position in Korean’s Trade, I tried to find other connections between those countries. The focus of both economies in the Technological Sector was found as the main common factor, so I included significant companies’ stocks of both countries to explain KR, in a Linear

Model, to verify whether Technological companies were significant and they indeed replace the significance of SE. The results are quite interesting when it comes to Swedish companies, but only during the crisis, with Ericsson (Swedish technological company) being significant at a 10% significance level. However, they do not explain the significance of SEK on KRW returns since the SE coefficient remained with the same value. The AU coefficient during the crisis was the most difficult to explain, and no sustained argumentation was found.

Finally, I would joint Australia and New Zealand in the same conclusion given its natural connection, the similar results and its exposure to the same factors. The Euro Zone impact on both countries, during the crisis period, was supported by two distinct facts. On the one hand, EU have represented a significant proportion of International Trade for both economies (over 10%) and its dimension in the global economy is unquestionable. On the other, carry trade may have influenced this strong relationship since Australia and, in slighter evidence, New Zealand, were presented as having been an attractive investment, while EU, given its low funding cost, would be used in a short-position.

As occurred in Rapach, Strauss and Guofu (2013), US was identified as the main *returns' driver*. The same evidence, even slighter, was found in EU coefficient, being significant in both periods for more than one country.

6.3) Drawbacks: As mentioned since the beginning, the purpose of this research is to find in-sample evidence that some exchange rates have been significantly explained by others. Obviously this procedure requires the inclusion of more variables, to guarantee that exchange rates' significance, as regressors, is not a consequence of hidden information. That was attained through the inclusion of its own lags, yield variables

(level and term), carry variable and global equity index. Nevertheless, these control variables might not have been the most accurate, given the variety of forces that influence exchange rates. In some cases, this is due to the frequency used; in others, to dispersion from the main goal of the research. In the same way, this procedure does not test for out-of-sample accuracy, since it would require the construction of a complete forecast model, and that is not in accordance with the aim of this research.

The approach focused on one-lag relationship, in spite of some exceptions to control for autocorrelation, representing a “reaction” of one week. Considering the high liquidity and turnover in the Forex market, the information is expected to process more quickly than in other markets, so this frequency might be considered as appropriate. Even though I control this possibility in some cases, I might have ignored significant coefficients with longer horizon.

Finally, the in-sample evidence may have been influenced by the period considered, which has been affected by abnormal events, such as the Financial Crisis or the sharp depreciation of the USD. For the former, I have adjusted the procedure by considering two periods (before and during crisis). The coefficients might have been biased by other events that were not considered in the model and the crisis beginning is difficult to define, so the results might be distinct under other assumptions. Regarding the latter, I could have considered other currency-basis that could present a more stable pattern.

6.4) Future research: The previous drawbacks identified in the research are a good starting point to suggest future research. Accordingly, other periods could be used, other variables included and other events to justify the results. In addition, the results’ accuracy will only be truly tested when considered in complete model. The out-of-

sample test is crucial to compare with the existing models and verify whether some exchange rates, such as EUR/USD or SEK/USD, can be considered as predictors.

Despite the innovation in modelling, other events, which have been identified during this research, might assume a great preponderance in exchange rate path in the future. The most evident case is China, in what concerns to South Korea, but it can be extended to other countries that have experienced an increasing influence of China in its economies. This is also dependent on the exchange rate regime adopted by this economic giant (nowadays it is fixed).

Another procedure was introduced in this research, concerning the impact of Swedish companies' stocks on Korean's exchange rates. The main intuition was the similarities in main industries (in this case, it was the technological), but there are several other approaches that can lead to interesting results.

Finally, extensive literature suggest the application of other type of models besides the ones used in this research. Suarez and Lopez (2008) indicate that nonlinearity of exchange rates might be the cause of failure of most forecast models. Teräsvirta (1994) provides interesting results based on Smooth Transition Autoregressions.

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