How does recession influence the reaction of exchange rates to news?

- The Case for the United States and the United Kingdom -

<u>Abstract</u>

In this research the news model is tested. We estimated macroeconomic fundamentals and tested if the exchange rate was more sensible to news on the fundamentals during recession. We used ordinary least squares for our estimation. The results suggest that there is no stable relationship between news on fundamentals and the exchange rate.

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1. Introduction

In times of economic turmoil exchange rates might have a large impact on the economic activity of a country (Kohler, 2010). A weak pound for example makes it expensive for importing companies to buy goods resulting in a surplus on the current account balance (Kandil, 2009). Also the Eurozone crisis has shown to have a large impact on EU firms as a result of fluctuations in the exchange rate. Regarding to the Greece debt crisis one could argue that their large deficit have largely impacted the other members of the Eurozone. An article in Elsevier (Robin van der Kloor 2010) Robin van der Kloor clearly explains that the increased money supply to Greece by the European Central Bank has weakened the position of the Euro as a currency.

It would be interesting to investigate what factors determine this fluctuation in the exchange rates. Perhaps more interesting, is to understand how these changing exchange rates due to news on macroeconomic fundamentals differ in times of economic recession compared to times of positive economic growth?

This thesis seeks to investigate whether the exchange rate is more sensitive to news on macroeconomic fundamentals, which impact the exchange rate, during recession than in times of economic wealth. The main question to be answered in this research is defined as follows:

"How does recession influence the reaction of the UK/US exchange rate to news on macroeconomic fundamentals?"

Numerous research has been done in this area and there are various theoretical models that try to explain the relationship between news on macroeconomic fundamentals and exchange rates (e.g. Engels and West (2005), Yin and Li (2014) or Obstfeld and Rogoff (2000).

Besides the fact that various research has already been done on the field of exchange rates and news on macroeconomic fundamentals, the results seem to be rather mixed. Arguments for this could be due to other estimation models or other time horizons has been used, such as high frequency data used in the article of Galatti and Ho (2003) or monthly data used by Evans and Lyons (2005) for the modelling of news. Also, a review of the literature does not find similar research for the case of the US and the UK in particular, whereas the US dollar and UK pound

sterling are two dominant currencies in the world. Therefore, this research seeks to provide a contribution to the existing literature by focusing on these two countries.

The rest of this thesis is structured as follows: we first discuss the existing theoretical models vested in this area. This forms the basis of this current research. Subsequently, the methodology and the data which have been found are presented. After that I will provide an analysis of this particular data. Finally we hope to come to a conclusion where we hope to see that the fundamentals which determine the exchange rate is significantly influenced by the presence of a crisis. In this part also some limitations of this research and some recommendations for future research are given.

2. Literature Review

The main object of this thesis is to test whether the sensitivity of the exchange rate as a reaction on news in macroeconomic fundamentals is different during recession. We can look at this as being the *elasticity* of the exchange rate to news on macroeconomic fundamentals. This forms the basis of this research. This chapter will start off with a theoretical framework wherein the literature on the relationship between exchange rates and macroeconomic fundamentals is vested. Subsequently, an overview will be given on the important findings in the current research area and the empirical findings that relate these theoretical models to the findings in existing articles.

2.1 Theoretical Framework

The relationship between news and a subsequent reaction on the exchange rate is vested in different theories such as the Monetary Model as first described by David Hume (1741), the Rational Expectations hypotheses as first introduced by John Muth(1961) and the Efficient Market Hypothesis as developed by Fama (1970), each of which will be discussed individually in this section.

2.1.1 The Monetary Model

A frequently used model to investigate this relation is monetary model first introduced by David Hume (1741). The monetary model describes the relationship between changes in money supply, interest rate, GDP and the exchange rate. The model has been stated in a more modern context for the first time by Johnson (1977). Later on, the model has been widely tested and elaborated. Robert Dornbusch (1973) for example expanded the model by describing what the effects are when the government devaluate their currency. When it comes to the effects of news on the

fundamentals, Dornbusch (1983) has shown in later research that error variances of the exchange rate are partly explained by changes in macroeconomic fundamentals.

Furthermore, Edwards (1982) conducted a model that captures the fact that the errors in forecasts of the exchange rate is a function of determinants which are known in advance, constructed by the lagged forward rate, and new information. In his research Edwards allowed news to have a role in the estimation of exchange rate determination. Ehrmann and Fratzscher(2004) found that news on macroeconomic fundamentals are able to explain the magnitude of the exchange rate movement, but in a smaller extent than they can explain the direction.

Another much more important finding of Ehrmann and Fratzscher (2004) is the fact that news is more able to predict movements in exchange rates during times of high market uncertainty. So market conditions seem to be important for the determination of the exchange rate. Hardouvelis(1988) found that exchange rate movements where mainly driven by expected changes in the real interest rate and not by inflation. It also seems that, following the work of (Hakkio and Pearce, 1985), exchanges rates do not react to other measures of economic news than the unexpected change in the money stock. Another conclusion they made is that the exchange rate market seems to be efficient regarding to the money stock, since only unexpected changes leads to increased volatility of the exchange rate.

One of the most convenient theoretical models to use in this situation is the monetary model. It explains the relationship between the exchange rate, money supply, price indices and national income. From the model follows the equation: $S = \frac{M_0^S}{kP^*y}$. (Copeland, 1989). Thus the exchange rate S of a certain country is a function of: a given value of money supply in this country, M_0^S; a positive constant k which is different for every country; the price index of the foreign countryP^* and real national income y.

Given a certain money supply, national income will be relatively low during a contractionary period. If the price index of the foreign country stays unchanged, one would expect to see a higher value of S, since y takes a lower value. A higher value of S means more home currency is needed to get one unit of foreign currency, thus a depreciation of the home currency. During time money supply will not be constant in a country. However, one can still compare the growth rates and historical data of both money supply and national income to determine if the latter is relatively high or low.

Another equation that follows from the monetary model might help to give more insight on the position in the business cycle two countries are in, relative to each other.

$$S = \frac{M/M^*}{ky/k^*y^*}$$

In this equation two countries are considered with a flexible exchange rate regime. It can be seen that the exchange rate is being influenced by the money supplies of both countries relative to each other. This means that a decrease in the foreign money supply will have the same effect on the exchange rate as an increase of the money supply in the home country. The same reasoning goes for the national income y of both countries: given that the money supply ratio is constant, an increase in the national income at home will lead to an appreciation of the currency (given that the national income in the foreign country is constant). In the entire monetary model it is important to note that purchasing power parity is assumed to hold. This means the price index at home is equal to the price index abroad corrected for the exchange rate. Thus it says no arbitrage would be possible through the shipping of goods between countries.

The assumption that purchasing power parity holds, implies that prices are fully flexible. The prices and exchange rates should change immediately when a shock happens in their respective other. It is however not very certain that this assumption always holds in reality. A model that accounts for the fact that prices are not fully flexible in the short run is the Dornbusch model (Dornbusch, 1976). It assumes that prices are sticky in the short run, meaning they do not adjust immediately to shocks in other fundamentals. Just like the monetary model it uses macroeconomic variables from both the home country and the foreign country. This relationship is summarized in the following equation: $\Delta s = \alpha(y - y^*) + \beta(m - m^*) + \gamma(r - r^*) + \delta(\pi - \pi^*)$ (Cheung, Chinn, & Pascua, 2005). Thus it says that the change in the exchange rate is a function of the differences of output growth, money growth, interest rate and inflation between the two countries, where α, β, γ and δ are parameters to indicate the weight of every difference.

Neely and Sarno (2002) suggested that the relative simplicity of the monetary model could be the reason why it is not able to explain movements of the exchange rate very well. The problem with the monetary model is in fact that it essentially focuses only on equilibrium in 1 market, which is the money market. However, exchange rate behavior is also influenced by other markets, such as the goods, labor, and the foreign exchange- and bonds market. This elimination of markets is achieved by making assumptions on some properties in those markets: perfect substitutability of foreign and domestic assets, and the goods- and labor market are assumed to have fully flexible

prices which means that also in these markets movements away from equilibrium are always expected to move to its equilibrium level because of the law of supply and demand.

2.1.2 Rational Expectations

An important building block of the news model is that expectations of economic agents are rational. This theory was introduced first by John Muth (1961). He suggested that the expected value an agent have of a prospect is the same as the mathematical value of that prospect, given the information set at that moment. It also implies that economic agents do the best they can to forecast the future exchange rate.

Although expectations are rational, this does not mean that the expectations that agents have are correct. It only implies that the best choice is made, based on the information at the moment.

Formally this means:

$$s_{t-1}^e = E(s_t \mid I_{t-1}) = E_{t-1} s_t \tag{1}$$

where the lower case s represents the natural logarithm of the exchange rate.

However, in further work on rational expectations it seems that the RE hypotheses is very difficult to test (Copeland, 1986). Reason for this to be so is that RE always has to be tested in combination with another model. The problem with this is that you both need to test RE as the model within which these values are estimated. This implies that you can never test rational expectations on its own.

2.1.3 Efficient market Hypothesis

As described by Fama (1970) an efficient market is one in which all information available to the market is fully incorporated in prices of financial assets. Fama distinguished three types of efficient markets. The first being a *Weak-form* efficient market in which financial asset prices are set based on historical data. The second type is the *Semi-strong* efficient market, where prices reflect historical price patterns, and should respond to publically available information by adjusting financial asset prices. Thirdly there is the *Strong* efficient market, where financial asset prices reflect historical data, and adjust for public and private information that can influence the financial asset price. In line with the Semi- strong market efficiency hypothesis, any public news on one of the fundamentals should therefore instantaneously be reflected in exchange rate. This assumption is supported by Fama (1970), which found in empirical research that there is no evidence *against* the hypothesis of efficient markets.

In the context of exchange rates an efficient market can be describes as a market where the forward rate minus the spot rate is equal to the expectations that agents have in the previous period including a risk premium. Formally this can be represented by;

$$f_{t-1}^t - s_t = [E_{t-1} s_t - s_t] + \rho \qquad \qquad (2)$$

One issue that needs to be addressed, is whether a change in the exchange rate was formed by rational expectations, which is discussed earlier, or whether there was a under- or overreaction of the news on of the fundamentals due to the fact whether a country is in a recession or not. As Ali et al. (2010) put it: "Overreaction is a notion which suggests that, like human behavior, stock price also has a tendency to overreact to extremely good and bad news. This behavior is generally resulting from market participants who overreact to the arrival of the news but correct their behavior later". This can also be the case for our current study on exchange rates.

Grossman and Stiglitz (1976) stated the fact that collecting and analyzing information was costly. Because of these information costs, not all information that is available will be collected. And therefore, markets will never be efficient as in the sense of fully-efficient.

2.2 Empirical Findings

Now that a theoretical framework has been defined wherein the relationship between exchange rates and macroeconomic is vested, it is important to address the existing empirical research that has been conducted in this area. Much research has been done during the past decades.

A review of the current literature shows that there is no clear consensus on what defines the relationship between exchange rates and macroeconomic fundamentals. Engels and West (2005) suggest that changes in the exchange rate are highly correlated with news on macroeconomic fundamentals. Also, a recent study conducted by Yin and Li (2014) on macroeconomic variables of the US and Euro zone found out that there is a clear link between these variables and the fluctuations in the exchange rate and further argue that the findings should hold for other exchange rates as well.

Other research that has been done finds evidence *against* the relationship between exchange rate and macroeconomic fundamentals. Obstfeld and Rogoff (2000) for example found that most of the time the exchange rate does not move in accordance with news of these fundamentals, at least not in a stable pattern. Beside this Goodhart (1989) found that most of the movements of the

exchange rate occurred when there was no identified news at all. When it comes to the relationship between macroeconomic fundamental and news Flood and Rose (1995) found no strong relationship between the movements of the exchange rate and macroeconomic fundamentals. This would mean that dramatic shocks in the exchange rate can be accompanied by virtually no shifts of the fundamentals and vice versa. As such, it seems that exchange rate models which only rely on macroeconomic factors cannot explain reality very well. Furthermore, one could conclude from this that the choice of a certain exchange rate regime (e.g. floating, fixed) has no effect on the volatility of important macroeconomic fundamentals.

Again other studies conclude that the exchange rate is a random walk (Meese and Rogoff, 1983). They suggest that this random walk is better in explaining the pattern of the exchange rate then the existent macroeconomic models do. However, especially when observed in the long run it seems that the exchange rate tend to move around a long run average (Sweeney, 1996). In other words, a pattern in the movement of the exchange rate can be observed in the long run. From a theoretical point of view a fixed exchange rate regime would result in reduced volatility of the exchange rate, compared to a floating regime.

According to Flood and Rose (1997) the choice of such a regime should not solely depend on targets of certain macroeconomic factors, such as low unemployment or low inflation. The same conclusion comes from research done by Baxter and Stockman (1989), whom find that the choice of an exchange rate regime does not affect large macroeconomic variables and international trade flows. According to the above mentioned, one could conclude that the volatility of the exchange rate does not affect the fundamentals. This would imply that there is no relationship between the movements of the exchange rate and the fundamentals.

The literature furthermore provides interesting findings on the relationship between exchange rates and business cycles. Stockman (1998) finds that there is a connection between exchange rates and business cycles. The most significant relationship he found is the one between the exchange rate and a country's relative GDP. This implies that the exchange rate of a country will appreciate when its GDP is relatively higher than the other country[1]. Another conclusion drawn from his research is that this relation is a non-linear one (which is the reason why other models failed to see this relation) and it is mostly found within persistent movements. This latter feature of the relationship means that the exchange rate tends to move only with shocks which are long-lasting and do not disappear in the short-term.

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[1] It is important to note that throughout this paper the exchange rate is expressed as the amount of home currency (pond sterling) per unit of foreign currency (us dollar).

3. Model and hypotheses

In this research we will use the monetary model, as explained earlier. The monetary model is an attractive model because it assumes intuitive relations between macroeconomic fundamentals and the exchange rate (Copeland, 1989). When using the monetary model, demand for money is a function of real national income and interest. In fact we shall work with the following equation;

$$M_d = KPY, \text{ with } K > 0 \tag{3}$$

Which is also known as the Cambridge quantity equation. Here Y is real national income and K is a positive parameter which depends positively on the interest rate. We are working with a two country model with money supply of one country relative to the other, so we come to the following equation:

$$\frac{M_d}{M_d^*} = \frac{KPY}{K^*P^*Y^*} \tag{4}$$

When we take logs and assuming that supply is equal to money demand we have that :

$$(m - m^*) = (k - k^*) + (p - p^*) + (y - y^*) \tag{5}$$

We assume in our model that purchasing power parity (PPP) holds. This implies that the relative value of a currency must be the same in both countries. This can be represented by the exchange rate as follows; $S = \frac{P^*}{P}$, when we take the log of the exchange rate we can substitute this in **equation 3** to, after rearranging, have;

$$s_t = \alpha_0 + \alpha_1 \tilde{m}_t + \alpha_2 \tilde{y}_t + a_3 \tilde{r}_t \tag{6}$$

Here $\alpha_0 = (k - k^*)$. The interest rate differential is introduced in our model as: $\tilde{r}_t = (r - r^*)$. The reason that the interest rate comes into our model is because of the fact that we do not assume (un)covered interest rate parity. This means that the interest rate *does* have an influence on the exchange rate.

The next step is to corporate news into our model. We can recognize the unexpected component, which is interpreted as news, of the exchange rate changes by subtracting the expected values of our variables from our real values. These expected values will be computed by a VAR model.

$$E_{t-1} \, s_t = \alpha_0 + \alpha_1 E_{t-1} \tilde{m}_t + \alpha_2 E_{t-1} \tilde{y}_t + a_3 E_{t-1} \tilde{r}_t \tag{7}$$

Then subtracting **equation 6** from **equation 5**, this represents the news;

$$s_t - E_{t-1}\ s_t = \alpha_0 + (\alpha_1\tilde{m}_t - \alpha_1 E_{t-1}\tilde{m}_t) + (\alpha_2\tilde{y}_t - \alpha_2 E_{t-1}\tilde{y}_t) + (a_3\tilde{r}_t - a_3 E_{t-1}\tilde{r}_t) \quad \textbf{(8)}$$

We can refer to **equation 2** which represented efficient markets.

$$f_{t-1}^t - s_t = [E_{t-1}s_t - s_t] + \rho$$

where ρ is the risk premium which is assumed to be constant. Then substituting this equation in **equation 8** we can rewrite this into;

$$s_t - f_{t-1}^t = \rho + \alpha_1(X_{mt}) + \alpha_2(X_{yt}) + a_3(X_{rt}) + v_t, \quad v_t \sim N(0, v^2) \qquad \textbf{\textit{Model 1}}$$

In which rational expectations and efficient markets are represented. The differentials of the variables are written as X_{it}. So for example $\tilde{m}_t - E_{t-1}\tilde{m}_t$, will be represented by X_{mt}.

3.1 Elasticity of exchange rate to news on macroeconomic fundamentals

Now that we have derived our first model we can look at the relationship between the exchange rate and our macroeconomic fundamentals. Three macroeconomic fundamentals have been defined and are to be applied in model 1, as in line with the research done on the monetary model, which has been discussed in chapter 2.2.1, each of these three macroeconomic fundamentals will be discussed hereafter, starting with money supply.

3.1.1 Elasticity of exchange rate to news on money supply

We assume money supply to be positively related to the exchange rate, in the sense that it leads to an increase in the exchange rate (depreciation of the home currency[2]) when expected money supply is lower than real money supply. The reasoning behind this is when there is an excessive supply of money at the old price level then, based on the quantity theory of money, this means that the money balances of economic agents have to be reduced by more spending. This excess demand will drive up prices and the country's economy will be less competitive. As a result the home country's currency will have to depreciate.

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[2] We look at the UK as being the home country in this research

According to this intuitive theory the first hypothesis will test if news on money supply has a negative influence on the exchange rate. Hence,

$$H1: \quad \alpha_1 > 0$$

3.1.2 Elasticity of exchange rate to news on GDP

For economic activity, measured as the GDP of a country, we would expect this variable to be negatively related to the exchange rate (appreciation of the home currency). This is because when expected GDP of a country is higher than the real GDP, the price level must become lower according to the monetary model, resulting in excess supply of goods and excess demand for money. To restore equilibrium prices have to fall making the economy more competitive. Then the demand for domestic currency is very high in foreign currency markets, because the importing countries have to pay in domestic currency.

This will lead to a lower exchange rate (appreciation of the home currency). According to this second intuitive theory the first hypothesis will test if news on GDP has a negative influence on the exchange rate. Hence,

$$H2: \quad \alpha_2 < 0$$

3.1.3 Elasticity of exchange rate to news on the interest rate

It also follows that the interest rate influences the exchange rate. The interest is an intuitively logical variable to choose as a predictor for the exchange rate. In general one would expect the exchange rate to appreciate when the expected interest rate becomes higher than the real interest rate (as a result from an exogenous shock). Foreign investors will find it attractive to invest in the domestic country, since the return on their assets will be higher than in their country of origin. This means that demand for domestic currency will rise resulting in lower exchange rate. According to this intuitive theory the first hypothesis will test if news on the interest rate has a negative influence on the exchange rate. Hence,

$$H3: \quad a_3 < 0$$

3.2 Impact of recession on elasticity of exchange rate to news on macroeconomic fundamentals

Now that the hypotheses of model 1 has been defined we can now introduce the effect of recession on the model.

"Similarly, a good piece of news in bad times tends to increase the expected future dividends, but it also increases the discount investors require to hold the asset"[3]

So with the facts about government behavior and the citate above in mind. We can expand our model by including dummy variables representing the existence of a recession, 2 periods of negative growth. These dummy variables are expected to increase the elasticity of the exchange rate to news on the fundamentals. This can be represented by the following model with 2 dummy variables, one for the UK and one for the US. In our 2 country model we assume that a recession in the US has the opposite effects of a recession in the UK, and therefore the coefficients of the dummies to have opposite signs. We can represent this by the following model;

$$s_t - f_{t-1}^t = \rho + (\alpha_1 + \delta_1 D_{UKt} + \gamma_1 D_{USt})X_{mt} + (\alpha_2 + \delta_2 D_{UKt} + \gamma_2 D_{USt})X_{yt}$$

$$+ (\alpha_3 + \delta_3 D_{UKt} + \gamma_3 D_{USt})(X_{rt}) + v_t, \ v_t \sim N(0, v^2) \qquad \textbf{\textit{Model 2}}$$

3.2.1 Impact of recession on the elasticity of the exchange rate to news on money supply

During recessions governments tend to increase the money supply. In this way they encourage economic agents to spend more. However, the other side of the coin is that prices will rise and the country becomes less competitive relative to other countries. Then according to the monetary model, if real money supply is higher than the expected money supply the exchange rate has to rise (depreciation of the domestic currency). So news on money supply during recessions tend to have a positive influence on the exchange rate because when real money supply is higher than expected, the exchange rate has to rise even further.

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[3] pietro veronesi, 1999, stock market overreaction to bad news in good times: a rational expectations equilibrium model

According to this intuitive theory the hypothesis will test if recession has a significant influence on the elasticity of the exchange rate to news on money supply. Hence;

$$H4: \delta_1 > 0$$

$$H5: \gamma_1 < 0$$

3.2.2 Impact of recession on the elasticity of the exchange rate to news on GDP

GDP is expected to be lower during a recession caused by lower exports. Lower export means that the demand for the domestic currency is falling. Then following the monetary model, the exchange rate has to rise (depreciation of the home currency). If during a recession, real GDP turns out to be lower than expected, the exchange rate will rise even further. So regarding to this variable we test whether the exchange rate reacts more to news on money supply during a recession than in the absence of a recession. According to this intuitive theory the hypothesis will test if recession has a significant influence on the elasticity of the exchange rate to news on GDP. Hence;

$$H6: \delta_2 < 0$$

$$H7: \gamma_2 > 0$$

3.2.3 Impact of recession on the elasticity of the exchange rate to news on the interest rate

During recessions governments will lower the interest rate. In this way the opportunity costs of saving are higher and thus spending become relatively more attractive. On the other side, foreign investors will invest their money in their own country or invest in better alternatives in other countries because the return is lower, as the government has cut the interest rates. As a result we expect news on interest rates to have a negative influence on the exchange rate. So we will test whether the presence of a recession has a significant influence of the elasticity of the exchange rate to news on the interest rate. Regarding to this we will test the following hypothesis:

$$H8: \delta_3 < 0$$

$$H9: \gamma_3 > 0$$

3.2.4 Impact of a global recession on the elasticity of the exchange rate to news macroeconomic fundamentals

We now test a model in which we include a dummy for a global recession. In this way we look if such a dummy is of greater influence on the exchange rate than in the manner we tested for such an effect as in model 2. A global recession is defined (by the IMF) as a period in which GDP growth is lower than 3%. The IMF stated that there are 6 such recession; 1974-1975, 1980-1983, 1990-1993, 1998, 2001-2002, and 2008-2009. This can be represented by the following model.

$$s_t - f_{t-1}^t = \rho + (\alpha_1 + \tau_1 D_{crisis})X_{Mt} + (\alpha_2 + \tau_2 D_{crisis})X_{Yt} \qquad \textbf{\textit{Model 3}}$$

$$+ (\alpha_3 + \tau_3 D_{crisis})(X_{Rt}) + v_t, \qquad v_t \sim N(0, v^2)$$

We do not have any evidence in what manner a global recession effects the reaction of the exchange rate to news on macroeconomic fundamentals. This is dependent on the fact which country is more affected by a recession. Hence, we have the following hypothesis;

$$H10: \tau_1 \neq 0$$

$$H11: \tau_2 \neq 0$$

$$H12: \tau_3 \neq 0$$

3.3 Direct impact of recession on the exchange rate

After having tested whether the dummies for recession, for both countries, have an influence on the impact of news we go further by testing the dummies in an additive way. In other words we look if including recession in our news model **(model 1)** has an influence on the exchange rate in a direct manner. This can be represented by the following model;

$$s_t - f_{t-1}^t = \rho + \alpha_1(X_{mt}) + \alpha_2(X_{yt}) + a_3(X_{rt}) +$$

$$\theta_1 D_{UKt} + \varphi_1 D_{USt} + v_t, \qquad v_t \sim N(0, v^2) \qquad \textbf{\textit{Model 4}}$$

3.3.1 Impact of recession on the exchange rate

When there is a crisis in the UK we expect two things to happen. First thing that happens is on the capital market. Here foreign investors find it less attractive to invest their wealth in a country which is in a recession because of more uncertainty. This is followed by less demand for the pound, ultimately leading to a rise in the exchange rate (depreciation of the pound). Second to

happen is on the goods market. Because of inflation, economic agents have less to spend on goods from their own country and will start importing their goods because of lower prices abroad.

So supply of the home currency will increase, followed by an increase in the exchange rate (depreciation of the pound). A crisis in the US is expected to have the opposite effects.

This results in the following hypotheses for **model 4**;

$$H13: \theta_1 > 0$$

$$H14: \varphi_1 < 0$$

3.3.2 Impact of a global recession on the exchange rate

We finally test a model in which we test whether a global recession has influence on the exchange rate in a direct manner. In other words, we include the dummy in an additive manner in the regression model. The model we test in this case will look as follows:

$$s_t - f_{t-1}^t = \rho + \alpha_1(X_{mt}) + \alpha_2(X_{yt}) + a_3(X_{rt}) +$$

$$\tau_1 D_{crisis1} + v_t, \qquad v_t \sim N(0, v^2) \qquad \qquad \textbf{\textit{Model 5}}$$

For this model we do not have any expectations about whether the coefficient of the dummy should be negative or positive. The reason for this to be so is because a recession has a different impact on both countries. A global recession could have a larger effect on the US than it has on the UK, or the other way around. Therefore, we have the following hypotheses for model 4;

$$H15: \ \tau_4 \neq 0$$

4. Empirical estimation

This chapter provides information on the data and the methodology that has been adapted to test the previously mentioned hypotheses. First, sources of information and data collection methods are discussed. Second, an explanation on how our expected values of the fundamentals are estimated is given. Finally, we give an overview of our variables and how they are measured.

4.1 Data

The data that I use for my time series analyses are series on the exchange rate for the British pound/US dollar, real GDP, nominal interest rate and money supply (M1) both for the United States and the United Kingdom from the database of the OECD and database of the Federal Bank of Philadelphia. These data series are all quarterly based from the years 1979 to 2010. Data of the forward exchange rate comes from the database of the Bank of England.

There are four descriptions of money supply; M0 (currency in circulation), M1 (M0 + current accounts and deposits), M2 (M1+ savings accounts) , M3 (M1 + non-government deposits), and M4 (M1 + private sector bank deposits and money market investments).

The only problem is the fact that data on money supply, M1, is only available from 1986. However, for M4 data is available from 1970. Assuming that there is a relationship between m4 and m1, and this relationship is also present in the years of the missing data points we can make an estimate for m1. Change in M1 is regressed on the change in M4 which can be represented by the following, where v is the error term;

$$\Delta m1_t = c_0 + c_1 \Delta m4_t + v_t, \quad v_t \sim N(0, v^2)$$

4.2 Methodology

We will use time series analysis to understand how the combination of our various variables explains the determination of the exchange rate in the regression model. We estimate these models by using the ordinary least square method as both models are linear functions. However, there is no data on the expected values of our variables. A VAR(p) model can be used to estimate these expected values. A VAR model is a multivariate time series analysis where the variables are all dependent on past values of themselves and past values of the other variables. VAR models have been very useful for describing the (dynamic) behavior of economic time series and forecasting based on these series (Heij et al, 2004, pp. 656-681).

Such a VAR(p) model can be represented by the following equation, and ε_t is the error term :

$$Y_{t=} \alpha + \phi_1 y_{t-1} + \ldots + \phi_1 y_{t-p} + \varepsilon_t \ , \varepsilon_t \sim IID \ N(0, \Omega) \qquad \textbf{(8)}$$

Where Y_t is k x 1 column vector of the variables and ϕ_1 are k =3 matrices of the autoregressive coefficients.

So our column vector looks as follows:

$$Y_t = \begin{bmatrix} \tilde{y}_t \\ \tilde{r}_t \\ \tilde{m}_t \end{bmatrix}$$

It is possible that there are structural breaks in our model, during recessions. To account for this, we include dummies for recession in each country as exogenous variables in our VAR estimation, in an additive manner. This implies that the mean level of Y_t, which is not dependent on its lags exhibits a structural break during recession.

For choosing the appropriate lag length to include in our VAR(p) model we use the Aikake, Schwarz and Hannan-Quinn information criteria. Model selection criterion should weigh the fit of the model (as indicated by the loglikelihood) versus the parsimony of the model (as indicated by the number of parameters). As we can observe in table 2, the Schwarz criterion and the Hannan-Quinn both indicate an optimal lag-length of 2, and the Aikake criteria advices to include 6 lag in our model. In this VAR we use 2 lags. We also observe, with 2 lags, that the estimated VAR model is stationary. This can be seen from the AR roots table in which all roots have modulus less than 1(see appendix). In table 1 an overview is provided with all the variables and a description on what they stand for and how they are measured. To make things clear, we have the following models;

Model 1 $\qquad s_t - f_{t-1}^t = \rho + \alpha_1(X_{mt}) + \alpha_2(X_{yt}) + a_3(X_{rt}) + v_t, \qquad v_t \sim N(0, v^2)$

Model 2 $\qquad s_t - f_{t-1}^t = \rho + (\alpha_1 + \delta_1 D_{UKt} + \gamma_1 D_{USt}) X_{Mt} + (\alpha_2 + \delta_2 D_{UKt} + \gamma_2 D_{USt}) X_{Yt}$

$\qquad\qquad\qquad + (\alpha_3 + \delta_3 D_{UKt} + \gamma_3 D_{USt})(X_{Rt}) + v_t, \qquad v_t \sim N(0, v^2)$

Model 3 $\qquad s_t - f_{t-1}^t = \rho + (\alpha_1 + \tau_1 D_{crisis}) X_{Mt} + (\alpha_2 + \tau_2 D_{crisis}) X_{Yt}$

$\qquad\qquad\qquad + (\alpha_3 + \tau_3 D_{crisis})(X_{Rt}) + v_t, \qquad v_t \sim N(0, v^2)$

Model 4 $\qquad s_t - f_{t-1}^t = \rho + \alpha_1(X_{mt}) + \alpha_2(X_{yt}) + a_3(X_{rt}) +$

$\qquad\qquad\qquad \theta_1 D_{UKt} + \theta_2 D_{USt} + v_t, \qquad v_t \sim N(0, v^2)$

Model 5 $\qquad s_t - f_{t-1}^t = \rho + \alpha_1(X_{mt}) + \alpha_2(X_{yt}) + a_3(X_{rt}) +$

$\qquad\qquad\qquad \tau_4 D_{crisis} + v_t, \qquad v_t \sim N(0, v^2)$

Table 1. description of measurement variables

Dependent Variable	Indicator	Measurement	Description
Exchange rate	$\tilde{s}$	Logarithm	Logarithm of the differential between us/uk spot exchange rate minus the us/uk forward exchange rate
Independent Variable		**Measurement**	**Description**
Money supply	$\tilde{m}$	Logarithm	The logarithm of the differential between money supply growth of the United States and the United Kingdom, as measure by M1 (narrow money),.
Interest rate	$\tilde{r}$	Logarithm	The logarithm of the differential between the interest rate of the United States and the United Kingdom, as measure by nominal interest rate
GDP	$\tilde{y}$	Logarithm	The logarithm of the differential between gdp of the United States and the United Kingdom, as measured by real gdp
Recession world	Dcrisis	DUMMY	Dcrisis = 1 if there is a recession, Dcrisis = 0 if there is no recession
Recession United Kingdom	D_{UK}	DUMMY	D_{UK} = 1if there is a recession, D_{UK}= 0 if there is no recession
Recession United States	D_{US}	DUMMY	D_{US} = 11if there is a recession, D_{US}= 0 if there is no recession
Money suppy	X_{Mt}	Differential	Difference between real and expected money supply
GDP	X_{yt}	Differential	Difference between real and expected GDP
Interest rate	X_{rt}	Differential	Difference between real and expected interest

4.3 Descriptive statistics

We used the log differences of the (in)dependent variables for describing our time series. This is to account for the fact that, otherwise, there would be a bias in some sort of way because of the presence of a recession because of non-stationary data.

What we observe from these descriptive statistics is that during recession growth of money supply is lower than during non-crisis. A possible explanation is that governments tend to decrease money supply during a recession to reduce inflation. We also see GDP is lower during a recession which is intuitively logical. The fact that the interest rate is higher during crisis is intuitively less logical, given that in general governments tends to lower the interest rate in order to make people spend more. However, the fact that interest is defined as the log of the rate of the US minus the log of the rate of the UK, in combination with the fact that both countries are not in a recession at the same time, might be a possible explanation for this. Especially when one takes in mind that the rate of the United States is more important than the interest rate of the United Kingdom in the world economy.

Table 2. Desciptive statistics

	N	Mean	St. deviation	Min	Max
Money					
Recession	8	0.000716	0.055486	0.000000	0.442909
No recession	124	0.018971	0.473881	-1.566473	1.806922
GDP					
Recession	8	0.000207	0.002503	0.327566	0.033557
No recession	124	0.001288	0.010714	-0.040148	0.033557
Interest					
Recession	8	0.001113	0.012692	-0.067958	0.110128
No recession	124	0.000626	0.066187	-0.184063	0.235941

Source: own estimations

In the following plots of $\tilde{m}$, $\tilde{y}$, $\tilde{r}$ and $\tilde{s}$ over time, we can observe that for the plot of $\tilde{s}$ in most cases the spot rate minus the forward rate is negative. The reason for this to be so might be the fact that the forward rate is defines as the spot rate including a risk premium. The fact that we do not include a factor for the risk premium in our regression models is because we assumed earlier that the risk premium is a constant term. For $\tilde{m}$ we can observe that the series is trending upwards.

In other words, one can say that money supply of the US is growing at a faster rate than money supply of the UK. The same can be observed for GDP. The peaks and troughs for GDP are possibly caused by recessions or expansions. For the interest rate it seems that, as most values are negative, the interest rate for the UK grows faster than the rate of the US.

Source: own estimations

5. Results

In this section we will discuss our results and report what the impact of a crisis is on the determinants of the capital structure. We start with some descriptive statistics about our time series, then we come to the behavior of our VAR model and finally we discuss the results of our regression analysis and try to explain the reason why our regression behaves in the way it did.

5.1 VAR model

As can be seen in the table 3 below, the statistics of the VAR model itself does not very well in explaining the behavior of our variables. We executed a test on serial correlation, heteroskedasticity and normality. However, we reject all the null hypotheses for all these three tests. This does not influence the results for our final regression. In the end, what we are interested in are the expected values of our independent variables, derived from this VAR(1) model, to test our regression model.

Table 3. Behaviour of the VAR(1) model

	Null hypothese	*Test statistic (p-value)*	*Reject?*
Serial correlation (LM-test)	No serial correlation of residuals	24,312 (0,0038)	Yes
Heteroskedasticity (LM-test)	*Variance is the same for all observations*	*163,888 (0,0000)*	*Yes*
Normality (Jarque-Bera)	Residuals are normally distributed	247.4645 (0,0000)	Yes

p-values at 5% significance level

5.2 Regression results

Before running the OLS we have to check for the presence of heteroskedasticity. By running the Breusch-Pagan test on the residuals we obtain that the null hypotheses of homoscedasticity is accepted for all three models and we can run the regression. We also had to check whether the depending variable, s_t - f_{t-1}^t was stationary. There was no significant indication that the series was non-stationary. In table 4 an overview with the results of our estimation of the models is given.

Table 4. regression results

	Model 1	Model 2	Model 3	Model 4	Model 5
α_1	[-0.020] *(0,7517)*	[1.191] *(0,0145)***	[0,220] **(0,3329)**	[-0.215] *(0,7404)*	[-0.020676] *(0,7537)*
α_2	[12.263] *(0,0000)***	[14.750] **(0,2938)**	[11,513] **(0,1990)***	[10.592] *(0,0008)***	[12.26958] *(0,0001)***
α_3	[-1.045] *(0.0054)***	[-4.057] *(0,2779)*	[1,296] **(0,4189)**	[-1.211] *(0,0012)***	[-1.045577] *(0,0058)***
δ_1		[-0.234] *(0,7507)*			
δ_2		[-30.367] *(0.1203)***			
δ_3		[-1.858] *(0.5214)*			
γ_1		[-1.032] *(0.2457)*			
γ_2		[26.380] *(0.2534)*			
γ_3		[4.768] *(0.2699)*			
θ_1				[-0.323] *(0.0734)***	
θ_2				[0.206] *(0.3202)*	
τ_1			[-0,247] **(0,2662)**		
τ_2			[1,438] **(0,8768)**		
τ_3			[-2,486] **(0,1273)***		
τ_4					[0.000695] *(0,9942)*
R^2	0,187	0,246		0,218	0,201
Observations	125	125		125	125

All of our models include a constant term. *, ** and ***Indicate significance levels of 10%, 5% and 1%, respectively. Coefficient in [], P-value for 2-sided t-test in ()

$\alpha_1, \alpha_2, \alpha_3$ are the coefficients of news on money supply, GDP and interest rate respectively
$\delta_1, \delta_2, \delta_3$ are the coefficients of the dummy (UK) for money supply, GDP and interest rate respectively
$\gamma_1, \gamma_{2,}\gamma_3$ are the coefficients of the dummy (US) for money supply, GDP and interest rate respectively
θ_1, θ_2 are the coefficients of the dummy for UK and US respectively
τ_1, τ_2, τ_3 are the coefficients of a global recession for money supply, GDP and interest rate respectively
τ_4 is the coefficient of a global recession

For model 2 we observe that the dummy for crisis in the UK has a significant influence on GDP. In other words, the exchange rate seems to be more sensible to news on GDP during recessions than in non-rural periods. However, the fact that the sign of the coefficient of GDP itself is opposite from what we expected it to be, still makes us reject the null hypotheses of $\alpha_2 < 0$. So the exchange rate does not seem to be more elastic to changes in news on GDP. Furthermore, there is significant relationship between news on money supply and recession, as α_1 is significant at a 1% significance level. In other words, the exchange rate elasticity to news on money supply is increased due to recession. The sign of α_1 also changed in the opposite direction.

For model 3 we see that GDP is significant at a 10% level. We also observe that a global recession has a significant influence on the interest rate. So the exchange rate is more sensible to news on the interest rate caused by a global recession.

For model 4 and 5, with the dummies included in an additive way, we observe that only the dummy for the UK is significant. Still we reject the null hypotheses because the sign of the coefficient is not as we expected it to be. Also a global recession does not seem to have any significant influence on the exchange rate.

When it comes to the values of the coefficients, we see that including dummies makes the change of the depending variable larger in effect to a change in one of the three fundamentals. As can be seen in table 3 all three variables, α_1, α_2, α_3, have a larger coefficient than in absence of a crisis, especially the coefficient of money supply and the interest rate. The other side is that α_1 changes in direction and α_2 and α_3 both become insignificant.

What we can conclude from this is that our expectation that the exchange rate is more sensible to news during recessions is partly true. However, not significant enough to accept all our hypotheses. This is summarized in table 5.

Table 5. Hypotheses

	Model 1	Model 2	Model 3	Model 4	Model 5
$H1:\ \alpha_1 > 0$	R	NR	R	R	R
$H2:\ \ \alpha_2 < 0$	R	R	R	R	R
$H3:\ \ a_3 < 0$	NR	R	R	NR	NR
$H4: \delta_1 > 0$		R			
$H5: \gamma_1 < \ 0$		R			
$H6: \delta_2 < 0$		NR			
$H7: \gamma_2 > \ 0$		R			
$H8: \delta_3 < 0$		R			
$H9: \gamma_3 > \ 0$		R			
$H10: : \ \tau_1 \neq 0$			R		
$H11: : \ \ \tau_2 \neq 0$			R		
$H12: : \ \ \tau_3 \neq 0$			NR		
$H13:\ \theta_1 > 0$				R	
$H14:\ \varphi_1 < 0$				R	
$H15:\ \tau_4 \neq 0$					R

R= rejected, NR= not rejected

5.3 Discussion

As can be concluded from the previous paragraph the results are not in line with the expectations according to the news model, except for the interest rate. The fact that the interest has a significant effect on the exchange rate is consistent with the literature, which often finds a strong correlation between these two (e.g. Hakkio, 1986). Furthermore, when we look at the impact of recession to the reaction of the exchange rate to news on the fundamentals we observed that only news on money supply has a significant influence on the exchange rate. The fact that all three macroeconomic fundamentals are larger in effect during recession as observed by the absolute value of the coefficients is also in line with what we found in the literature (Stockman, 1998).

However, only money supply has a significant influence on the exchange rate during recession and the other macroeconomic fundamentals have no significant effects or have an opposite sign, which is against the expectations we have derived from the news model. And also from the

literature (Ehrmann and Fratzscher, 2004) we would expect that news is *more* able to predict movements in exchange rates during times of high market uncertainty.

The fact that the results are not in line with the model we have used in this research are possibly caused by the fact that this model does not account for the countercyclical behavior governments have in times of recession, resulting in opposite movements of the macroeconomic fundamentals. This is called "leaning against the wind", where governments take measures to prevent the exchange rate to reach a predetermined value of the exchange rate. (Leonardo Gambacorta & Federico M. Signoretti, 2013).

5.4 Summary

In this section we tested whether the elasticity of the exchange rate was greater during a recession to news on our fundamentals by including dummy variables. We found no significant impact of a recession on the elasticity of the exchange rate to GDP and the interest rate. What we did find is that the reaction of the exchange rate to money supply was significant during a recession. All other variables were not significant or the sign of the coefficient was not correct which made us reject the larger part of our hypotheses. Also a global recession does not seem to have a significant influence on our fundamental.

6. Conclusion

Many research on the determination of exchange rates focuses on the macroeconomic fundamentals which are responsible for exchange rate volatility and found that there is empirical evidence of a relationship between these fundamentals and business cycles as discussed in chapter 2.2. In this thesis we tested whether those fundamentals are more sensitive to news during a recession than it is in the absence of a recession.

We executed an OLS regression in which the independent variables present the news. Then, we introduced a dummy variable capturing the existence of a recession. We found that even in our simple model, with no recession included, the news model does not very well in capturing the exchange rate movements. Coefficients where insignificant or the sign of the coefficient was not in accordance with our expectations. The only fundamental that correctly represented our expectations was the interest rate. After including dummy variables for recession we found that the only fundamental for which news has a significant influence on the exchange rate is the money supply, GDP and the interest rate both became insignificant. So we can conclude from this that the exchange rate seems not to be more sensible to news during a recession that in the absence of such a recession, at least not in a sustainable manner.

The first reason for the bad performance of the monetary model might be the fact that movements of the exchange rate are order-flow driven, which might be buy- or seller initiated. Recent work of Evans and Lyons (2003) and Love and Payne (2002) suggested that such an information processing system is not related to our macroeconomic fundamentals.

The second reason why the news model might not be very useful to explain exchange rate movements is the fact that we assumed rational expectations. Rational expectations are the building block of our model. However, lot of empirical work found evidence against the presence of rational expectations. For example, Hartley (1983) found little evidence in of favor rational expectations being consistent in the exchange rate market.

Another reason for the "failure" of the news model might be the presence of bubbles during recession. A bubble might be seen as an impediment in the model, which allows the exchange rate to substantially move away from equilibrium. The problem with such a bubble is that it is self-enforcing. In other words, the exchange rate keeps moving away from equilibrium until the bubble burst (Copeland, 1989).

6.1 Limitations

In this research we used the news model to describe the influence of fundamentals on the exchange rate. The news model might be too simplistic in the modelling of macroeconomic effects. The fact that it only uses three fundamentals as determinants of the exchange rate might cause that this is not sufficiently enough to make a good estimation of the relationship between the fundamentals an exchange rate.

The second critical note on this research is the fact we only did an ordinary least squares estimation, while in reality the relationship between our variables might be from another sort of nature, i.e. non-linear.

Another important thing to point out is that every recession might have its own characteristics in how it influences the macroeconomic fundamentals. In this research we assumed that the effect of a recession was the same for all years, and thus used only one dummy, to look for the effects on our fundamentals which might not be very realistic.

The last thing to account for, is the fact that we assumed the risk premium to be constant. However, this might not be the case in reality, as Hansen and Hodrick (1983) suggest. Furthermore, the risk premium might depend on several factors, like the economic or political situation in a country for what we did not have accounted for (Saad, 2011).

6.2 Recommendation for future research

I suggest that in future research the model should be expanded with more factors as determinants of the exchange rate, because the monetary model is too simplistic to cover the whole story as pointed out earlier. Also a time-varying risk premium should be included. In this way a regression model can be build which is more able to reflect the real world than is done by the current model. Maybe it would be better if all recession periods are investigated separately by looking at the specific characteristics of that specific recession. The last suggestion would be to do research for more countries. By doing the same sort of research for more counties, the relationship between news on macroeconomic fundamentals and the exchange rate could be covered more thoroughly.

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Appendix

Table 1a. information criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	149.0752	NA	3.29e-05	-1.807422	-1.630707	-1.735644
1	607.9490	882.2218	9.92e-08	-7.612245	-7.258815*	-7.468689*
2	615.1084	13.48748	1.02e-07	-7.588496	-7.058351	-7.373163
3	627.0232	21.98475	9.80e-08	-7.626106	-6.919246	-7.338995
4	638.6300	20.96714	9.48e-08	-7.659742	-6.776167	-7.300854
5	645.5952	12.31265	9.74e-08	-7.633487	-6.573197	-7.202821
6	657.7319	20.98466*	9.38e-08*	-7.673959*	-6.436954	-7.171516
7	659.3197	2.683978	1.03e-07	-7.578319	-6.164599	-7.004097
8	663.8194	7.431694	1.10e-07	-7.520250	-5.929815	-6.874251

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

HQ: Hannan-Quinn information criterion

Graph 2a. AR roots graph

Inverse Roots of AR Characteristic Polynomial