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Explaining the dynamics of exchange rate volatility

An application to the Swedish Krona exchange rate vis-á-vis EUR and USD

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Contents

Abstract

This research examines the volatility of the Swedish krona in regards to the Euro and US-dollar exchange rate, using both daily and monthly data ranging from the beginning of 2000 until 2022. Using this time span allows us to update previous literature on exchange rate volatility, and also incorporates recent economic events such as the great financial crisis of 2008, the 2020 covid-pandemic and the geopolitical uncertainty in Europe following Russia's invasion of Ukraine. In order to model the volatility of the exchange rate, Generalized Auto Regressive Conditional Heteroskedasticity (GARCH) models are used in order to account for dependencies in the error term. The research also incorporates Exponential GARCH (EGARCH) models that allow for the effect of positive and negative developments in the return of the exchange rate impacting volatility differently (Positive price shocks affect the volatility differently compared to negative). We extend the ARCH and GARCH models with explanatory variables that are grounded in previous literature as well as economic theory. The daily variables used in this paper are the volatility index, financial condition index, a proxy for hedge-fund positioning, a constructed news proxy and also controlled for the rate of return of the EUR/USD exchange rate. Over a monthly basis, we study the monetary aggregates of the US, Eurozone, and Sweden in addition to inflation and the Bloomberg economic sentiment index.

This paper finds that there are several ARCH, GARCH, and E-GARCH effects present in the exchange rate volatility for both EUR/SEK and USD/SEK for both frequencies, suggesting that negative and positive price developments affect the volatility differently and that the exchange rates exhibit conditional heteroskedasticity. In terms of explanatory long-run variables we find a significant positive relationship between monthly US monetary policy and a proxy for overall market sentiment to affect exchange rate volatility. For the daily frequency, this paper finds a strong negative relationship between EUR/USD return and volatility for both EUR/SEK and USD/SEK.

Keywords: Exchange rates, Volatility, GARCH.

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1 Introduction

The foreign exchange (FX) market has become the largest capital market in the world with daily volumes of around 6.6 trillion US dollars (Bank for International Settlements, 2019). The FX Markets has seen leaps in terms of technological development with more sophisticated transaction methods such as algorithmic trading, electronic trading and high-frequency trading. The impact of exchange rate depreciation and appreciation has been a widely researched topic and researchers have also directed their efforts toward finding different macroeconomic and financial variables that affect the *level* of the exchange rate. Due to the importance of exchange rates, it is paramount to understand not only the determinants of exchange rate *levels* but also the determinants of *volatility* in exchange rates. This paper will model the dynamic behaviour of exchange rate volatility by incorporating Generalized Conditional Autoregressive heteroskedasticity models for both daily and monthly frequencies as well as investigate whether certain economic variables that theory, or previous literature, have found to have an impact on the exchange rate volatility actually does in a Swedish Krona context.

Since the breakdown of the Bretton Woods system in the early 1970s, the exchange rates of countries that abandoned the fixed-rate system not only experienced variance in the level of the exchange rate, but an overall increase in volatility as well (Meese, 1990). This has opened another avenue of research, namely, explaining exchange rate volatility.

Exchange rate volatility is defined as the rate at which the exchange rate changes over time. The larger the change over time, the larger the volatility. Volatility in asset classes is a measurement of risk, and is an important determinant for investors when evaluating, pricing and deciding on investments. Volatile exchange rates can hinder international corporates' ability to trade since when corporates have costs in one currency, and said currency appreciates or depreciates, corporates will experience a change in their cash flows in relation to what was expected at the beginning of a contract. This is referred to as *exchange rate risk*, that is, the probability of decreasing business margins due to changes in the exchange rate.

Furthermore, the exchange rate volatility's effects are not limited to corporates but extends to governments and households as well, whose return on purchases and investments are affected when exposed to exchange rate risk (Lessard and Lightstone, 1986). In regards to international investments, the exchange rate volatility is crucial for decision-making, where the rate of return of a given investment abroad is reliant on the evolution of the currency said investment was made in. Moreover, evidence suggests that high exchange rate volatility circumstances hamper the positive relationship between exchange rate depreciation and total investment(Harchaoui et al., 2005). For this reason, the management and monitoring of exchange rate volatility are of high importance for economic growth, investments and price stability in a country. Moreover, explaining, and understanding exchange rate volatility is therefore of great importance for all corporates with an international presence, investment firms and investors allocating capital abroad and last but not least, public institutions such as central banks whose main function it is to manage price stability.

While most previous research investigates the effects the exchange rate volatility has on macro and other financial variables, there is a small school of literature on the volatility's determinants where instead of looking at *ex-post* effects of exchange rate volatility we turn to the *ex-ante* effects that help determine said volatility. This paper will not only offer an update to the existing literature with new up-to-date data but also offer additional insight into exchange rate volatility in a world that has rapidly become more integrated, globalised and technologically advanced by for example incorporating a proxy for hedge fund positioning. Trends such as these could have had a substantial impact on the dynamic behaviour of exchange rates.

This paper will explain the dynamic behaviour of exchange rate volatility by modelling Generalised Auto-regressive Conditional Heteroskedasticity (GARCH) type models of the exchange rate of the Swedish Krona vis-a-vis the Euro and US-dollar over a period from 2000 to 2021. The models allow us to investigate the variance (volatility) of the exchange rate and whether it is serially autocorrelated and follows an autoregressive, and moving average process. This, in turn, allows us to investigate whether the volatility in the series is heteroskedastic. If this is the case, it means that the volatility in the current period is dependent on the volatility in the previous periods. Additionally, we will also incorporate additional macroeconomic, and financial variables that either previous research or economic theory have suggested have an impact on exchange rate volatility. This will be done in two frequencies to both ensure the integrity of the models and control for certain variables only gathered for daily/monthly frequencies. First daily data will be used in order to capture more high-frequency volatility and the associated variables that might only affect it over the short-term, thereafter, monthly data is used to investigate long-run volatility as well as variables that act over longer time horizons. Finally, we expand the general GARCH model to incorporate asymmetric effects of price shocks by running an exponential-GARCH model as well. The results from which will be discussed in terms of theory and empiricism.

The paper is split into 7 sections. First, in section 2 the paper will offer a review of the current literature on exchange rate volatility. In section 3 the paper proceeds by covering the choice of explanatory variables as well as offering an account of the theory for which we use to discuss our results. In sections 4 and 5 an overview of the data is given and subsequently a review of the model selection and specification. Section 6 gives an account of the results followed by a discussion and we conclude in section 7 by summarising the results as they have been discussed.

2 Theory and Empirics

The literature on the determinants of exchange rates has been extensively researched since exchange rates experienced an increase in volatility after the 1970s, following the breakdown of the Bretton-woods system. The research on exchange rate volatility is relatively underdeveloped and outdated but is mainly split into two types. One stream of literature is based in macroeconomic theory and the other is founded in empiricism. In this section, an account of both will be given.

After the breakdown of the Bretton woods system in which countries pegged their exchange rate to gold in order to maintain the rates within 1% of each other a plethora of new theoretic literature arose on the subject of exchange rate dynamics. Most famously by Dornbusch (1976) but also and more recently by Calderón and Kubota (2018). In Dornbusch's original paper he derives a model of exchange rate dynamics explaining the increase in exchange rate volatility. Dornbusch grounds his model in the IS-LM model originally developed by Keynes and extends it further by assuming price stickiness in the goods market and keeping prices in the currency market flexible by assuming that financial markets are able to adjust instantaneously via the UIP condition (Uncovered interest rate parity condition). Although Dornbusch does not investigate specific determinants he concludes that by looking at a permanent increase in the money supply that volatility arises as a result of the stickiness causing the short term rates to "overshoot" its long term equilibrium level (Dornbusch, 1976). Calderón and Kubota (2018) revived the original literature and argued in line with (Dornbusch, 1976), that with perfect capital mobility, both real and nominal exchange rate fluctuations stem from nominal shocks in the short run. The paper uses a panel regression, modelling the real exchange rate (RER) volatility in 82 countries, both emerging and industrial economies from the end of the Bretton Woods system in 1975 to 2013. The paper more precisely investigates if and to what extent international trade and financial integration decreases the volatility of the real exchange rate. Furthermore, the paper introduces *The Redux Model* to investigate this relationship, accounting for restrictions on cross-border transactions and accounting for the public sector. *The Redux Model*, in short, is a break-off model from the Mundell-Flemming-Dornbusch model that is micro-founded. Conversely, the Redux Model allows researchers to model the dynamic effects of monetary policy shocks on economic variables such as the exchange rates and output whilst still accounting for the law of one price and purchasing power parity (PPP). In the regression, the dependent variable, the volatility of the real exchange rate, is measured as the standard deviations of the real exchange rate. This is computed using monthly data and in line with previous research as well as the Redux Model, Calderón and Kubota (2018) found that degree of openness has a negative effect on the volatility whilst financial openness has a positive effect. (Calderón and Kubota, 2018)

Turning to the empirical stream of literature, research have mainly utilised two econometric models. Most notably, Morana (2009) and Bilson (1984) both uses versions of a vector autoregression(VAR) whilst Stanèík (2007), Grydaki and Fountas (2010) and Thai Hung (2018) opted for models within the autoregressive conditional heteroskedasticity(ARCH) family of models.

John Bilson uses Dornbusch's model by incorporating a vector autoregression model 10 years after Dornbusch's original paper. The model yielded mixed results, although a more general model specification lent some support to Dornbusch's original one. Bilson however, deemed the results problematic, concluding that Dornbusch's model was too "simplistic" (Bilson, 1984). Later on, Morana (2009) pointed to a lack of empirical evidence within the literature and subsequently attempted to offer some insight into the long-run determinants of exchange rate volatility for the G7 countries. Morana studies a 26 year period from 1980 to 2006 using a fractionally integrated factor vector autoregressive model, or FI-F-VAR for short. The choice of model allows Morana to investigate dependencies across countries and variables. The paper finds that short- and medium-term macroeconomic variables are only *weakly* linked to exchange rate volatility, however, over the long term the paper finds that inflation volatility is affected by output and money growth volatility (Morana, 2009).

More recently, researchers have turned to ARCH-type models in their efforts of explaining exchange rate volatility, a paper published in the Czech Journal of Economics and Finance by Stanèík (2007) addresses the question of exchange rate volatility determinants in the case of new EU members. Stanèík uses a threshold autoregressive conditional heteroskedasticity model (or TARCH) to analyse the determinants of exchange-rate volatility. Stanèík included what is referred to as a leverage term, the purpose of which is to allow for asymmetries in volatility often referred to as *leverage effects*. In short, this allows for the often observed fact that volatility has a negative relationship to asset prices, in the case of Stanèík's study, it also captures the effects of "good" and "bad" price developments. Moreover, Stanèík constructed a variable aimed at capturing economic news using interest rate differentials in line with Frenkel (1982).

Continuing, Thai Hung (2018) Attempts to investigate volatility spillovers for foreign exchange rate in Eastern and Central European countries from 2000 until 2017 and their linkages. Thai Hung (2018) modelled an Exponential Generalised Conditional Heteroskedasticity (EGARCH) model to capture the asymmetric effects, much like Stanèík, of good and bad price developments and its effect on foreign exchange rate volatility. The EGARCH model used by Hung is similar to the TARCH model previously used by Stanèík (2007). The list of countries used in the study was the CEEs-5 countries, namely Hungary, the Czech Republic, Croatia, Romania and Poland. Hung found that whether the shocks to the foreign exchange rate are positive or negative does indeed impact the volatility differently, concluding that there is some kind of asymmetric effect. Other efforts made by Grydaki and Fountas (2010) find that the volatility in both money supply and inflation can help explain long- and short-term exchange rate volatility in three Latin American countries over 30 years from 1979 to 2009. Grydaki and Fountas (2010) used a multivariate GARCH in which they include the previously omitted co variances of the determinants (Grydaki and Fountas, 2010).

Because of the varying usage of models in the literature, Kamal et al. (2012) evaluated the forecasting performance of several conditional heteroskedasticity models such as Threshold-GARCH, Exponential-GARCH, GARCH-Mean in the context of the foreign exchange market. The paper found that the best volatility forecasting model for the data used in the paper was an Exponential-GARCH model (Kamal et al., 2012).

2.1 Contribution to the literature.

In relation to the current literature we offer new insights and an update of the current literature in regards to major economic events that have occurred over the past 20 years.

3 Theoretical Background: Determinants of exchange rate volatility

Previous research models the exchange rate volatility from two main perspectives, one that models past values of the series volatility to try to predict its future by incorporating models that accounts for some kind of heteroskedasticity in the error term such as ARCH and EGARCH models. The second branch of research incorporates explanatory variables in the regressions that are theoretically or empirically suggested to have an impact on exchange rate volatility. In this section, we describe the determinants that our model takes into account and explain the reason for their inclusion.

3.1 Heteroskedasticity in the volatility

Many financial variables tend to have a volatility that is *not* constant over time. For example, by looking at the EUR/SEK exchange rate from 2000 to 2022 in figure 1.

Figure 1: EUR/SEK exchange rate

We see that the volatility between the years 2002 and 2006 is characterized as a period of relatively low volatility, subsequently we see a big spike during the great financial crisis of 2008 and the period thereafter exhibiting quite high volatility. We also note that the series appear to have periods of sustained appreciation and depreciation with no tendency to revert to their mean. This type of phenomenon, where a past volatility series influences its current volatility, is called conditionally heteroskedasticity and can be modeled as suggested by Engle (1982):

$$\varepsilon_t = V_t\sqrt{\alpha_0 + \alpha_1\varepsilon_{t-1}^2} \tag{1}$$

Where ε_t is the variance (volatility), V_t is a white noise process, and α_0 and α_1 are constants. From equation 1 we can clearly see the conditional heteroskedasticity that past values of the variance affect its presence if α_1 is different from zero. Intuitively, this means that a volatility shock of a series is remembered and, depending on the sign of α, the shock persists for several periods after the shock.

3.2 Asymmetric effects of shocks

Aside from the fact that some financial variables tend to exhibit conditional heteroskedasticity (volatility clustering), some also tend to react differently to "good" and "bad" news. Therefore, negative price shocks affect the volatility of a series differently than positive price shocks do. This phenomenon, that volatility increases when prices fall and vice versa, is known in financial econometrics as the *leverage effect*. Previous research such as Thai Hung (2018) and Kamal et al. (2012) suggest that exchange rate volatility may have some form of leverage effect. However, the variables that drive exchange rate volatility are not easily defined by previous research.

Above dependencies incorporate the values of the volatility of the exchange rate, this research also uses several economic and financial variables that, with the help of previous research or economic theory, may help explain exchange rate volatility and are presented below:

3.3 Monetary policy

Central banks, that are increasing (decreasing) the supply of money, by changing their monetary policies, cause the currency to depreciate (appreciate). In equilibrium, the cash provided by the central bank is equal to the money demanded by all agents within the economy. Factors like interest rates, prices, and income have an effect on the demand for money. Wherever interest rates increase, the opportunity cost of holding money over different interest-bearing assets change. Higher income will increase the products being bought therefore more money is needed. Once more money is demanded in a certain country, the demand for interest-bearing assets increases and people buy such assets at lower rates as a result of it. Hence, monetary policy choices by the Swedish central bank affects the Swedish interest rate, and this, in turn, affects/clears the exchange rate market. However changes within the monetary aggregate effects exchange rates may be seen through the lens of the interest rate parity (IRP) condition:

$$i + 1 = (\frac{1}{E}) \cdot (1 + i^*)E^e \Rightarrow i = i^* + \frac{(E^e - E)}{E} \tag{2}$$

We denote i as the interest rate in the country of origin, i* the interest rate abroad and E the exchange rate. If the interest rate domestically rises (i rises) and the interest rate abroad is fixed, we expect the national currency to depreciate. The IRP model suggests that an increase in the money supply causes a long-term depreciation of the currency and that the change from one level to another is could be volatile before a new equilibrium is met (Exchange Rate Overreaction).

This suggests that there are interrelationships between money supply and the dynamics of currencies. The above analysis is based on the change in aggregate exchange rates from one level to another, but what about the volatility of exchange rates? Carrera et al. (2002) points out that a shock to any kind of monetary aggregate is associated with greater exchange rate volatility, which agrees with the results of Dornbusch (1976) and Grydaki and Fountas (2010).

In a paper on the case of Turkey, the author uses the following dependent variables; real effective exchange rate, FDI (Foreign Direct Investment), government expenditure, and GDP (Kılıçarslan, 2018). Continuing, in a paper published by the OECD the following variables were used, relative prices, interest- and inflation rate expectations, the current account, and the risk premium of foreign currency (Hacche et al., 1983). Lastly in Stanèík (2007) he looks at three main determinants of exchange rate volatility, economic openness, unpredictable circumstances for which he uses the news as an instrument, and the types of exchange rate regime.

3.4 Market uncertainty, financial conditions

During times of uncertainty, be it in capital markets or geopolitics, investors tend to rebalance their asset holdings and even reallocate their currency holdings to safe heavenly assets, as suggested by (Cho et al., 2016).

The Swedish krona could see increased volatility as investor risk appetite increases, suggesting that investors are reducing their exposure to the krona relative to other 'safer' currencies such as the euro or the dollar. To reflect investors' risk appetite, we consider the CBOE Volatility Index, which is a measure of implied volatility in the stock-options market. Assuming that world stock markets move homogeneously, the VIX, which is a measure of the implied volatility of the US stock market, captures this effect. Research by Kambouroudis and McMillan (2016) includes the CBOE volatility index as an explanatory variable in the GARCH model specifications, noting that the inclusion of VIX strengthens the model's predictive capabilities, and suggesting that VIX should be included in forecasting regression models. Another variable also contains a *financial stress index*, which captures the general stress on the bond, stock and money markets. The differences between these variables is that the latter captures the financial stress in the overall market and is a proxy for the availability, and cost, of credit. Whereas VIX captures investor sentiment in the stock market.

3.5 Economic News

In line with Stanèík (2007), economic news might increase the volatility in financial variables, and depending on if the news is considered to be positive and negative might have different effect on the increase in volatility. News that the market already expects to be released should not have any effect on either the level, nor the volatility in the exchange rate, since the financial market is forward looking and accounts for all available information at that time. Therefore, it is the *unanticipated* news that might have an affect on the volatility. In line with Frenkel (1982), we model the unanticipated news by using a proxy of the differences between the differences in interest rates and its expectations from the previous period as can be seen in equation 3.

$$NEWS_i = (i - i^*)_t - E_{t-1}(i - i^*)_t \tag{3}$$

3.6 Inflation

Some research has suggested a relationship between inflation. For this reason we also include inflation. Inflation has a clear impact on the real exchange rate and effects stemming from rising inflation might affect exchange rate volatility through the real exchange rate and therefore it might also capture the effect of inflation volatility. This is clear when looking at the relationship between the real exchange rate and inflation (Hacche et al., 1983).

$$RER = \frac{EP*}{P} \tag{4}$$

Here the real exchange rate is determined by the the nominal exchange rate E as well as domestic and foreign prices denoted $P*$ and P respectively.

3.7 Hedge-fund positioning

As mentioned in the introduction, the exponential growth rate of the technological sector has increased the fraction of electronic and algorithmic executions in all financial markets, foreign exchange included. Hedge-funds and their positioning could be seen as a speculative bet on the Swedish krona. These bets are usually set by a set of quantitative rules run by a computer. These types of speculative flows could have an impact on exchange rate volatility since the flows are usually set at a very high frequency in which the computers buy/sell the Swedish krona instantly when some set of rules are in play. Research by Kenourgios et al. (2015) suggests that hedge-fund flow in currencies depend on the interest rate differential, high-interest currencies have a higher buy-side demand compared to low-interest rate currencies. Kenourgios et al. (2015) finds that this behavior could predict future return in the exchange rate. Continuing, this could also mean that Hedge-fund positions *herd* and hedge-fund flows in and out of currencies could have an increasing effect on exchange rate volatility.

4 Data

Daily and monthly data on the nominal exchange rate of SEK vis-a-vis EUR and USD from the beginning of 2000 to 2022 are used in this study. Exchange rate data is collected from Bloomberg. Using this period allows our research to update the existing literature on the determinants of exchange rate volatility, and also empirically consider major financial events such as the 2008 crash, the 2012 euro crisis and the recent Covid-19 Pandemic. In the following, some of the dependent variables are only collected monthly, in these cases we calculate the monthly average of exchange rate returns, which allows us to perform the regression. Arguably this would not affect the reliability of the result as the average captures the changes in volatility in each period, this can also reduce the short-term noise of volatility and also allow us to look at long-run determinants of exchange rate volatility. By plotting

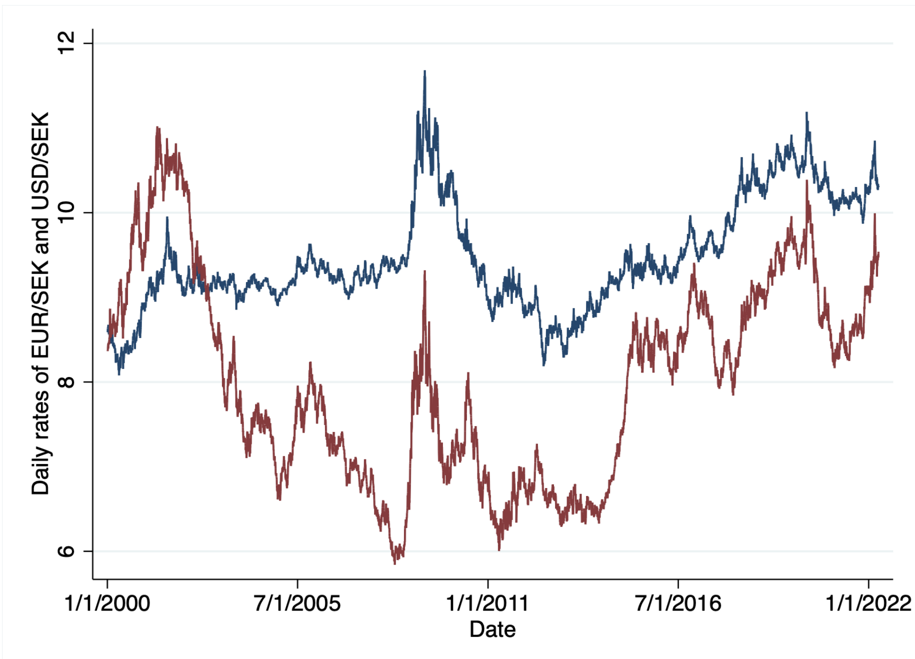

Figure 2: EUR/SEK rate in blue and USD/SEK rate in red.

the EUR/SEK and USD/SEK exchange rate in figure 2, we can clearly see some kind of unit-root process in the USD/SEK exchange rate as well as suggesting some kind of cointegrating relationship between the two. Continuing, the EUR/SEK series tend to have some degree of mean reversion, and we perform more rigorous tests to check whether the series is unit root non-stationary. Lastly, As evident from EUR/SEK, there seems to be some volatility clustering, which is suggested by previous research who are conducting models such as ARCH / GARCH to account for conditional heteroskedasticity.

Continuing, we test whether EUR/SEK and USD/SEK are random walks by running a

Table 1: Dicky Fuller test for Unit root

		Dicky-Fuller Critical Values			
Variable	Test-statistic	1%	5%	10%	Approximate P-value
EUR/SEK	-3.595**	-3.960	-3.410	-3.120	0.0302
USD/SEK	-2.115	-3.960	-3.410	-3.120	0.5375

dickey-fuller test for the daily frequency data, where the null-hypothesis is that a *unit root* is present in a autoregressive(AR)-type model. The results are presented in table 1 above. From the dickey-fuller test, we fail to reject the null hypothesis of a unit-root process for the EUR/SEK and USD/SEK exchange rate for the 0.01 confidence level, suggesting that the series is a unit-root process which entails that we must model its returns instead. Hence, when running the regressions and modeling the volatility, it will be based on the percentage-return of the nominal exchange rate.

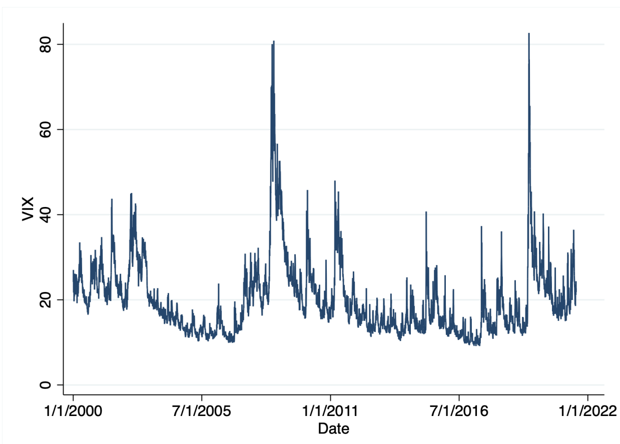

Figure 3: VIX

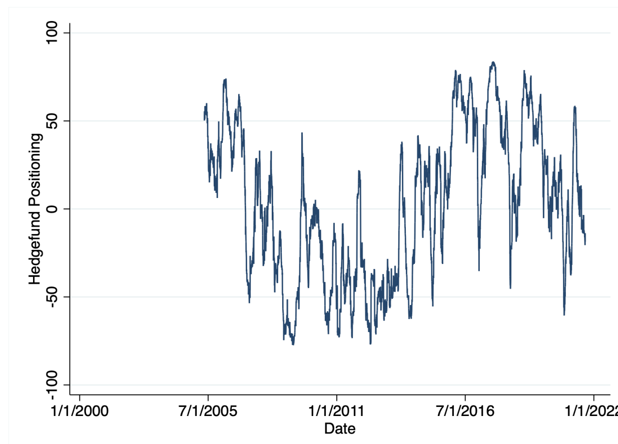

Figure 4: Hedgefund Positioning

In relation to the daily frequency variables, the volatility index, VIX, is gathered from Bloomberg. Looking at figure 3, VIX clearly has some degree of mean reversion and sometimes large spikes during times of financial turmoils such as during 2008, 2001 and 2020, allowing us to capture effect of changing investor risk sentiment. In VIX our previous statement about volatility clustering can be further proven as we see spikes in VIX during the same periods, especially in the USD/SEK rate, which is not surprising considering VIX is based on the American index, S&P 500. The hedge fund positioning variable in this study is derived from Citi's PAIN indicator and is calculated from correlations between FX hedge fund performance and exchange rates in Sweden. The Citi FX PAIN Index is designed to reflect tight market conditions in the Swedish Krona, with a figure of -100 will indicate that

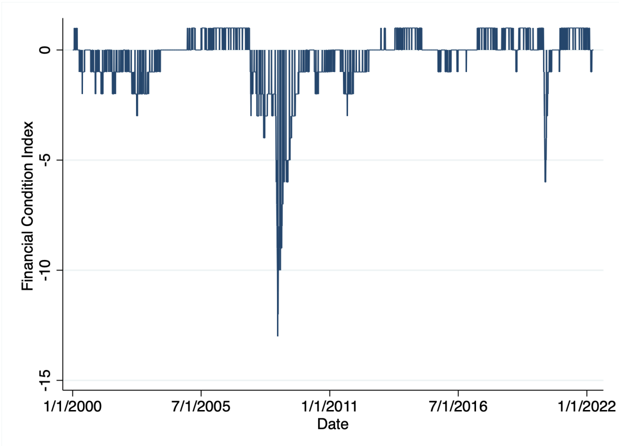

Figure 5: Financial Condition index

Figure 6: EUR/USD RATE

all hedge funds are short the Swedish Krona, while a figure of 0 means that there is the same amount of short and long positions there. A positive value of 100 means that there are only long positions against the Swedish Krona.

Data on EUR/USD is also gathered from Bloomberg. Relating to financial condition index, which we use to capture overall market stress shows no sign of trending by looking at figure 5 and is clearly mean reverting although some volatility clustering is clear around 2008 and 2020. As previously mentioned what we aim to capture with this variable is market uncertainty. As a measure this variable captures far more than just market volatility (as in the case of VIX). Therefore, this variables serves as a complement to VIX in order to control for changing market conditions more accurately and not only the implied volatility in the stock market. In line with Frenkel (1982), the proxy for economic news is calculated by taking the differential in the 5y Swedish bond yield at time t_i in relation to to either the Euro-zone or USA 5y bond yield, and then subtracting the expected bond yield differential standing at t_{i-1}. The bond yield is as most of our data gathered from Bloomberg, and is the corresponding yield of the 5-year governmental bond. Since we don't have data on the expected bond yield, we calculate a proxy for this by specifying the expected bond yield t_{i-1} as the sum of the bond yield for the 2- and 5-year governmental bond yield squared, and then dividing by the prevailing 2-year bond yield such as:

$$E_{ti-1} = \frac{(2YBY_{ti} + 5YBY_{ti})^2}{2YBY_{ti}} \tag{5}$$

By squaring the sum of the 2- and 5 year bond yield and then dividing it with the 2year yield we will get the real difference between the two. This captures, arguably, the expected differences between the two maturities during each time period. Hence, we are able to create a variable which is a proxy for the expected 5y bond yield which will changes as economic news are published by central banks.

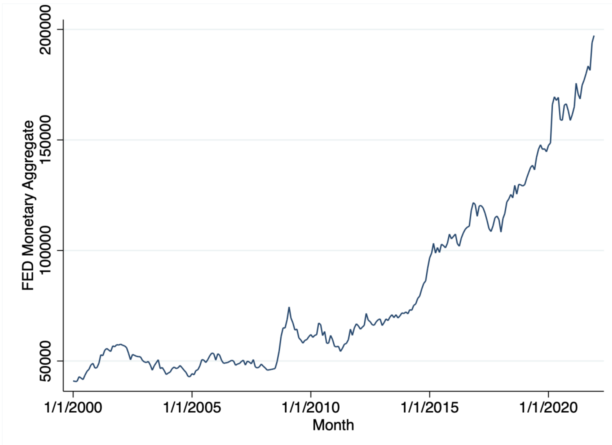

Figure 7: FED Monetary Aggregate

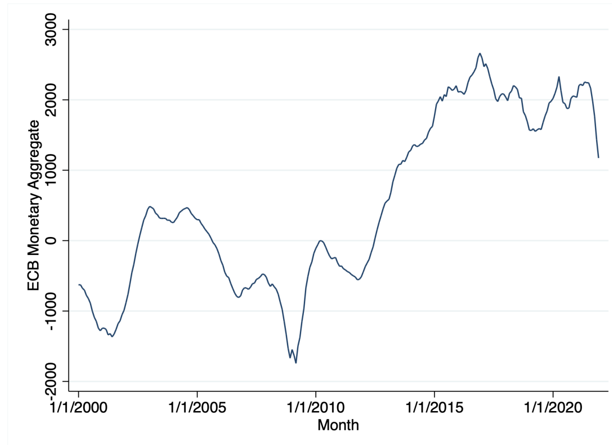

Figure 8: ECB Monetary Aggregate

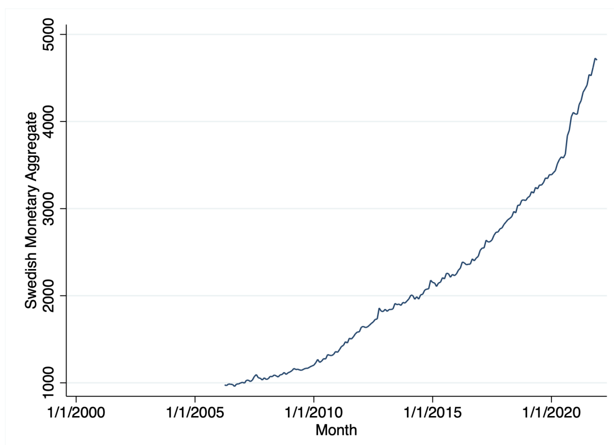

Figure 9: Swedish Riksbank Monetary Aggregate

Continuing to the monthly frequency regressions, since the foreign exchange rate is calculated on a daily basis, we use the monthly average of the exchange rate by using:

$$e = \frac{\sum_{t=0}^{N} e_t}{N} \tag{6}$$

By looking at monetary aggregates for the US, Euro and Swedish economies respectively it is clear that there are is no discernible mean reversion and all four seem to exhibit some form of trend stationarity. As can be seen in figures 7, 8 and 9 above. The monetary aggregates are gathered from official data sources such as *Statistiska centralbyrån* (SCB) for the Swedish data, ECB's statistical data-center for the European case and for the FED we use the official website for the federal reserve. Consumer price index (CPI) is gathered from the Swedish official site SCB, where we clearly see strong signs of mean reversion, and interestingly a upward break in 2022. Lastly, The Economic Sentiment Index measures monthly business and consumer confidence and is calculated by Bloomberg using monthly business survey data in sectors such as manufacturing, retail and construction and also includes consumer surveys. The Economic Sentiment Index has a mean of 100 and a standard deviation of 10 and appears to show some degree of mean reversion. Episodes of a very strong economy are indicated by a score of 110 or more, and a score below 90 equals a much weaker than normal economy.

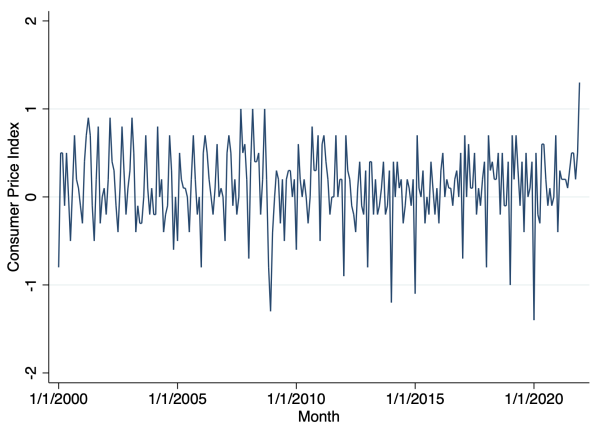

Figure 10: CPI

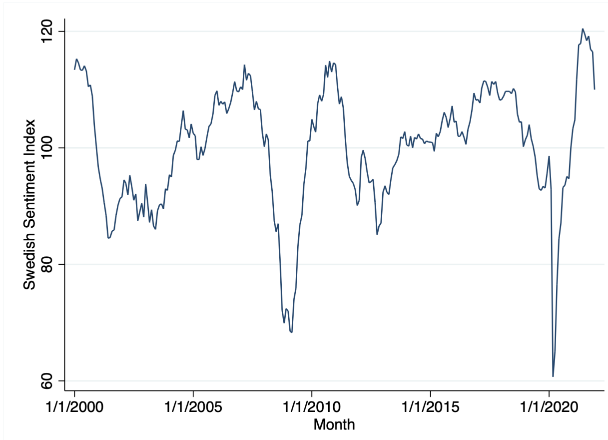

Figure 11: Sentiment Index

For all explanatory variables, we also perform a Dickey-Fuller test to check for stationary, (See Appendix). The null hypothesis of non-stationarity failed to be rejected for the proxy for hedge-fund positioning, EUR/USD, all monetary aggregate variables and the sentiment index. For the non-stationary variables we calculate the percentage change of the variable instead as:

$$\%\Delta_t = \log\left(\frac{X_t}{X_{t-1}}\right) \tag{7}$$

Continuing, this implies that, much like the USD/SEK exchange rate we must model this as stochastic process in order for it to provide meaningful results. This will be specified further in the next section.

5 Model selection

Concluding that the data on the exchange rate is a unit-root process on the 0.01 level in section 4, we start by calculating the percentage daily and monthly return for both dependent variables EUR/SEK and USD/SEK as the following:

$$EURSEKReturn_t = \log\left(\frac{EURSEK_t}{EURSEK_{t-1}}\right) \tag{8}$$

$$USDSEKReturn_t = \log\left(\frac{USDSEK_t}{USDSEK_{t-1}}\right) \tag{9}$$

Continuing, by looking figures 12 and 13 below of the daily returns for EUR/SEK and USD/SEK, the series indeed looks mean-reverting, and there exists some periods of high and low volatility, the dickey-fuller test statistics strengthens this result. We also note some large spikes in both series and that both volatility clusters tend to happen during similar dates for the two exchange pairs, where the period 2008 and the following years experienced a higher return volatility and some spike in the return during the beginning of the covid-19 pandemic in 2020.

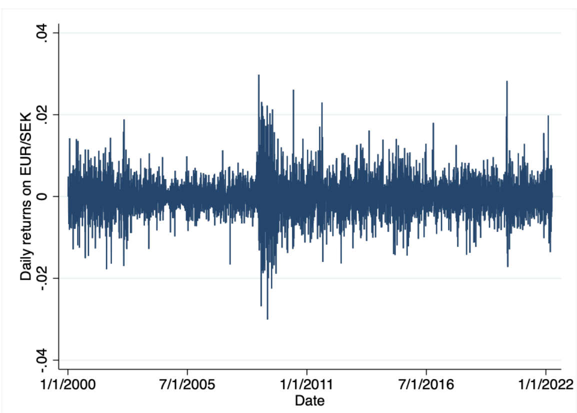

Figure 12: EUR/SEK return

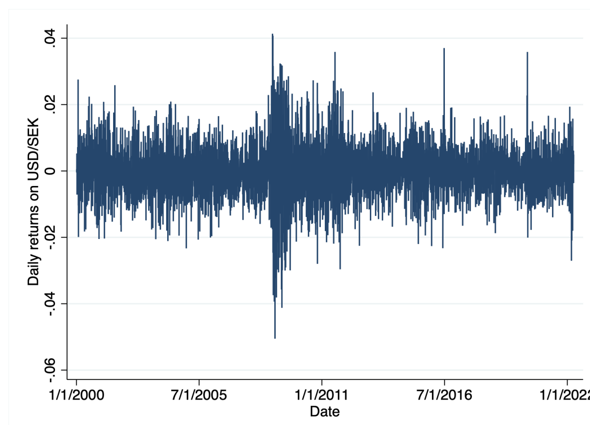

Figure 13: USD/SEK return

Moreover, by plotting a histogram of the daily return of the two series in figure 14 we note that the mean is around zero, and that the return of USD/SEK have fatter tails compared to EUR/SEK, suggesting that during 2000 to 2022 the return volatility was higher for USD/SEK than EUR/SEK. Continuing with the histogram analysis, it appears that there is some conditional heteroskedasticity in return for both EUR/SEK and USD/SEK, as both histograms suggest that the distribution is *leptokurtic*, suggesting that the kurtosis is equal to or greater than that of the normal distribution, 3. The larger the kurtosis, the greater the probability

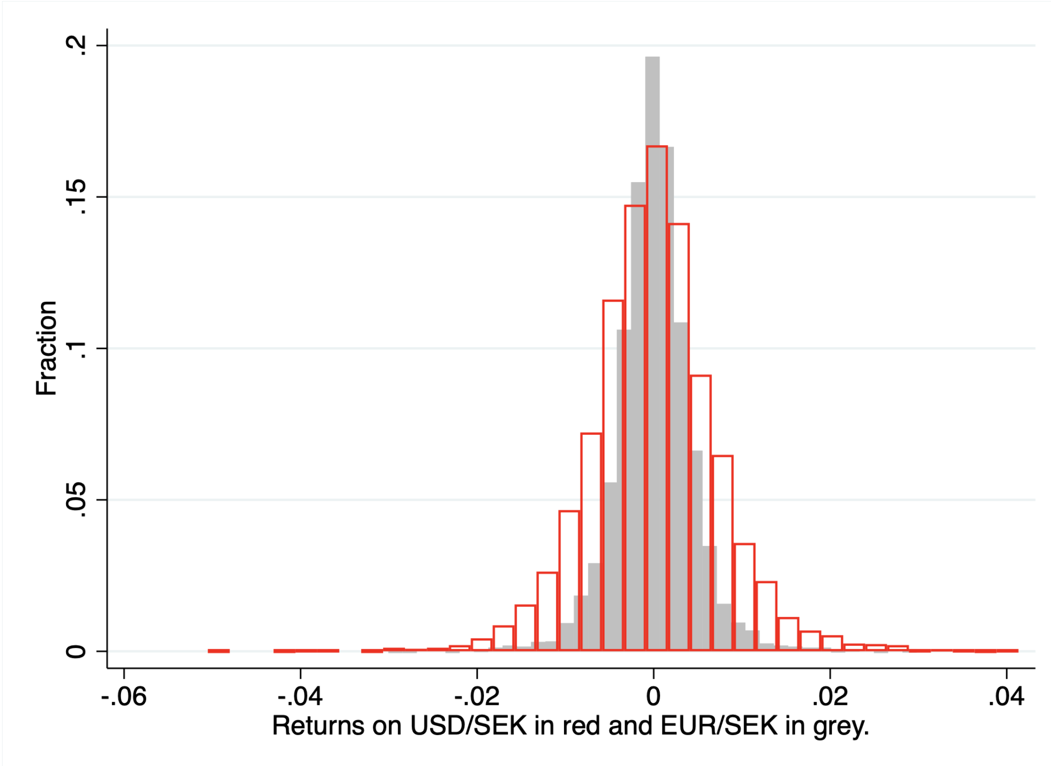

Figure 14: Histogram of the returns on USD/SEK and EUR/SEK.

of *tail events*. This can be seen from the fact that the tails of both distributions are quite large, increasing the probability of extreme events. A Leptokurtic distribution in this context means that one should expect a higher percentage return deviation for both USD/SEK than EUR/SEK, hence high volatility. A more formal test for heteroskedasticity is performed later in this section.

The aim of this research is to investigate the behavior, and determinants of EUR/SEK and USD/SEK volatility. We model the volatility using models that account for *conditional heteroskedasticity*. First, we model the volatility consistent with Bollerslev (1986), a Generalized Auto Regressive Conditional Heteroskedasticity model (GARCH):

$$\varepsilon_t = V_t \sqrt{h_t} \tag{10}$$

where

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i h_{t-i} \tag{11}$$

Here, ε_t is in our case the volatility, V_t is a white noise process that are independent of ε_{t-1},

α_i and β_i are constants such that $\alpha_i > 0$ and $0 \leq \beta_i \leq 1$. The GARCH(p,q) model allows for both an autoregressive term and a moving average term to model the variance / volatility in the series.

This model allows us to capture the volatility of the exchange rate, because if the value of ε_{t1} is deviating from zero, it means that $\alpha_i \varepsilon_{ti}^2$ is relatively large, the variance of the residual will also tend to be large.

In order for the study to properly identify and correctly specify conditioned heteroskedasticity, we start by modeling a ARMA(P,Q) model of the percentage return of EUR/SEK and USD/SEK. When deciding on how many lags to include in the ARIMA model, we will compare the models Akaike information criterion (AIC) and Bayesian/Schwarz information criterion Score, these different scores tries to quantify the model's statistical quality. The AIC is calculated from the maximum likelihood estimate of each model (Akaike, 1974).

Having defined the model in accordance with Engle (1982), we use Engles' ARCH test for the conditional heteroskedasticity of the exchange rate percentage return by estimating the mean equation and then computing the residuals as deviations from the mean. Calculating the residuals in this way allows us to estimate the autoregressive, AR(1), generalized AR, MA(1), and LM estimates for the residuals. We test the squared residuals of the specified ARIMA(P,Q) model for conditional heteroskedasticity. The ARCH(1) and GARCH(1) estimates for the residuals are shown in Table 2, while the ARCH(1) LM estimates for lag 1 to 4 are shown in Table 3.

By looking at Table 2 we conclude that both EUR/SEK and USD/SEK exchange rate return exhibit ARCH(1) and GARCH(1) in the residuals. Table 3 suggests that the LM test is significant for all lags included, 1 to 4.

Table 2: *ARCH and GARCH estimates.*

	(1) EURSEK		(2) USDSEK	
main				
_constants	0.0000460	(0.0000506)	-0.0000213	(0.0000926)
ARCH				
arch	0.126***	(0.00907)	0.149***	(0.0141)
garch	1.075***	(0.0559)	0.813***	(0.0690)
_constants	-0.00000394***	(0.000000914)	0.00000227	(0.00000325)
N	5812		5812	

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: *LM-Estimates for EUR/SEK ARCH(1) and UDS/SEK ARCH(1).*

	EUR/SEK ARCH(1)			USD/SEK ARCH(1)		
Lags(p)	Chi2	df	Prob >Chi2	Chi2	df	Prob >Chi2
1	29.142	1	0.0000	149.084	1	0.0000
2	139.010	2	0.0000	259.835	2	0.0000
3	114.087	3	0.0000	229.000	3	0.0000
4	79.710	4	0.0000	178.821	4	0.0000

H0: No ARCH effects vs. H1: ARCH(p) disturbances

In line with Bollerslev (1986), when deciding on the order of GARCH/EGARCH processes, a GARCH(1,1) model sufficiently mimics higher order GARCH(p,q) models and is therefore relatively consistent. Furthermore, we will expand the GARCH model by also incorporating the explanatory variables outlined in section 3.

In addition to the model specification above, we model an Exponential-GARCH, or E-GARCH which, according to Thai Hung (2018) and Kamal et al. (2012) found that negative price shocks of the exchange rate impacts the volatility of the series differently compared to positive price shocks. Another reasoning for including E-GARCH in this research is that the regular GARCH models do not account for negative coefficients. The E-GARCH allows for this by specifying the following model, in line with Nelson (1991), the model is specified as:

$$ln(h_t) = \alpha_0 + \alpha_1 \left(\frac{\varepsilon_{t-1}}{h_{t-1}^{0.5}} \right) + \lambda \left| \frac{\varepsilon_{t-1}}{h_{t-1}^{0.5}} \right| + \beta_1 \cdot ln(h_{t-1}) \tag{12}$$

Where the conditional variance is in a log linear form, therefore, no matter the "size" of h_t, the value of h_t can never be negative. α is the asymmetry parameter and if α_1 is less then zero, a negative price shock generates higher volatility than a positive price shock. λ is the size parameter, that measures the magnitude of depreciation around the mean. This model specification allows for negative coefficients unlike the standard GARCH model which places a positivity constraint on the coefficients. Moreover, another advantage of the E-GARCH model is that it uses the level of standardized value for ε_{t-1}^2 instead of the actual value itself. According to Nelson this allows for more intuitive interpretation of the magnitude and persistence of shocks. This is what enables the E-GARCH model to allow leverage effects (Enders, 2014).

5.1 Model specification

Moving to the specifications of the regressions. The general GARCH model that we will run incorporating the explanatory variables looks like the following:

$$\varepsilon_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i h_{t-i} + \sum_{i=1}^{G} X_i \tag{13}$$

Where X_i is the explanatory variables in our study such as monetary aggregate, VIX, etc. ε_t is the daily/monthly return of the volatility for EUR/SEK and USD/SEK. The specification of the models above begin with a gradual inclusion of the explanatory variables. In doing so, it allows us to check for any large changes in the p-value and the related coefficients.

Running the regression on the daily frequency, model(1) begins with regressing the exchange rate volatility on its ARCH and GARCH terms alone. Model(2) includes financial condition index, model(3) the volatility index, model(4) adds the news proxy, model(5) controls for the EUR/USD nominal exchange rate, model(6) adds the proxy for hedge-fund positioning in the Swedish krona. And finally, we investigate E-ARCH and E-GARCH effects on the volatility in the exchange rate in model(7).

Running the regression on monthly frequency, model(1) begin with regressing the exchange rate volatility on its ARCH and GARCH terms alone. Model(2) adds a proxy for market sentiment (financial stress index), model(3) adds the volatility for the Swedish monetary aggregate (M2), model(4) also adds the volatility of the monetary aggregate in the other either USA or European Union, and model(5) adds the monthly CPI number in Sweden. And finally, we investigate E-ARCH and E-GARCH effects on the volatility in the exchange rate in model(6).

6 Results

6.1 Empirical results

We begin analyzing the dynamic effect of exchange rate volatility by first estimating the GARCH effect for both currency pairs and for both frequencies and the results of which can be found by looking at table 4 to 7 (See Appendix). In checking for GARCH effects, the test for ARCH(1) and GARCH(1) errors was positive and significant for most model specifications and frequencies at the 0.01 significance level, which is in line with Thai Hung (2018) and Grydaki and Fountas (2010). (with the exception of model (4) and model (5) for the monthly frequency data for both EUR/SEK and USD/SEK).

In line with the findings of Thai Hung (2018), the coefficient for asymmetric affects on the volatility (EARCH, EGARCH) is also found to be positively statistically significant in all model specifications except for the monthly frequency USD/SEK volatility, indicating that negative shocks for the time series (appreciation of the Swedish krona in this case), have stronger impact than a depreciation of the Krona. This significant asymmetry may suggest that the market participants overall belief of the Swedish krona between 2000-2022 is that the Swedish krona should depreciate, (EUR/SEK increases), and whenever there is a negative price shock of EUR/SEK or USD/SEK, financial institutions who have allocated their money going short SEK must decrease their positions, and hence, increasing the exchange rate volatility because of increased trading volume.

Analyzing the explanatory variables in the daily frequency regressions, neither stock market volatility (VIX) or the news proxy were found to be significant on the 0.05 confidence level, which is the opposite of Frenkel (1982) and the following study of Stanèík's (2007). We found, however, that the return in EUR/USD was significant and negative for both the daily volatility in EUR/SEK and USD/SEK. The coefficient for the EUR/USD volatility is negative for both regressions, surprisingly indicating that when the return in EUR/USD increases, it has a negative effect on both the volatility in EUR/SEK and USD/SEK.

Regarding the longer frequency data where we regressed explanatory variables on the monthly exchange rate volatility for EUR/SEK and USD/SEK we find that the market sentiment index is statistically significant in 4 out of the 8 models it was included, where its' sign is negative and statistically significant for regression excluding the monetary aggregate. Indicating that higher sentiment (higher degree of confidence in financial markets), decreases long-run volatility.

In relation to the findings of Morana (2009), a change in the money stock impacts the monthly volatility in the USD/SEK case, where the volatility in the united states money supply was found to be statistically significant on the 0.001 confidence level. Looking at the EUR/SEK case, the eurozone monetary aggregate was only statistically significant for the 0.05 confidence level when the corresponding aggregate for Sweden was excluded. When both the Swedish, and Eurozone monetary aggregate is included in the same model the eurozone monetary aggregate is only significant at the 0.1 level.

The consumer price index did not show any level of significance in the EUR/SEK case offering some evidence against the earlier proposition by Hacche et al. (1983) who suggested relative prices might affect exchange rate volatility. Finally much like the financial condition index, the Swedish market sentiment index was found to significant at the 0.05 level and later at the 0.1 level when accounting for the Swedish monetary aggregate.

6.2 Theoretic discussion of the results

In regards to the regressions using monthly data we believe that the the reason for lower significance between and Sweden and the Eurozone is because of deeper economic integration between the two. By this we mean that the spillover of monetary policy diminishes if the Swedish Riksbank enacts the same policy decisions as the ECB. This might explain why the significance changes differently when accounting for US and EU monetary aggregates respectively. On the topic of economic integration we moreover, hypothesise that Swedish and European inflation rates might exhibit stronger co-movements implying that relative prices remain unchanged to a larger degree as compared to the Swedish and US case.

The implications of these result show that monetary policy might play an important role in determining the volatility of exchange rates. The monetary stock or money supply is one of the tools used by central banks in order to target inflation. Within the new Keynesian framework, Money supply is used to control interest rates which in turn are used to hamper or stimulate demand which impacts inflation. The first relationship can be seen in a Hicks-Hansen model(IS-LM) and the second can be studied in the canonical new keynseian model through the NK IS curve and NK Philipscurve. For example, a decrease in money supply implies higher interest rates which makes domestic investments more attractive to foreign capital and thus exchange rates appreciate (Romer, 2012). We argue that it is through this channel the investment channel, the monetary stock affects the volatility of the exchange rates. Fluctuations in monetary stock implies fluctuations in interest rates which in turn makes investments relatively more attractive or less attractive which causes fluctuations in the exchange rate. On the other hand our Macroeconomic news variable for monetary policy news remains insignificant. This can be the case since the news proxy captures unanticipated monetary events whereas the central banks usually signals their policy intentions in advance which makes financial markets slowly adjust to a new policy implementation. The idea that the monetary stock is important to the price stability of currencies is in line with Dornbusch (1976) and Morana (2009). Much like Morana (2009), most economic variables(both monetary and fiscal) show only weak significance in relation to the volatility of exchange rates. Although our results lends support to these findings it did not show any significance for inflation, contrary to Morana (2009).

Regarding Hedgefund-positioning, we find that it is positive but insignificant. The positive sign might indicate that the more long-positions FX hedgefunds have in the Swedish Krona during the period of 2000 to 2022, the greater impact it has on the foreign exchange volatility. In line with Kenourgios et al. (2015), the hedgefund positioning in the Swedish krona could exhibit some kind of herding behavior and whenever the Swedish krona depreciates the institutions collectively unwinds their long-position with a loss, and doing so might have a positive effect on the volatility because of increased trading volume.

Regarding the market sentiment index, which has a negative and significant relationship with exchange rate volatility in the long-run, indicating that a decreasing market sentiment over a certain period tends to make institutions reallocate their currency holdings towards "safe-heaven-currencies" such as the USD and EUR thereby increasing volatility in the long-run.

Controlling for EUR/USD return in the short run, it shows that it has a significant and negative relationship in all models it was included. This suggest that when EUR increases relative to USD, it will have a decreasing effect on the volatility for both EUR/SEK and USD/SEK. In line with the previous argument that the European and Swedish market are more integrated this results seems reasonable due to the fact that a stronger EUR/USD also stabilizes the demand for the Swedish Krona.

7 Summary

This study updates the previous literature of exchange rate volatility determinants and its dynamic effects, with an emphasis of the Swedish krona in regards to the Euro and US-dollar. We do this by reverting back to previous literature and theory and use daily and monthly frequency data from 2000 to 2022.

In this paper we have analyzed the dynamic behavior of exchange rate volatility for EUR/SEK and USD/SEK and its determinants. As possible determinants, we have incorporated theory, and previous research to find relevant variables that could impact the exchange rate volatility. These variables are Monetary Policy(Monetary Aggregates), Market uncertainty, Financial conditions, Economic news and inflation. The exchange rate volatility is modelled as a GARCH model where we regressed the set of variables described in section 3 on the volatility of EUR/SEK and USD/SEK. We emphasised the possibility of the asymmetric effects that shocks might have and also incorporated EGARCH model specification. Our study confirms that there is a strong asymmetric affect of exchange rate volatility, indicating that a positive price (SEK depreciates) shock impacts the volatility differently compared to a negative one (SEK appreciates) for both currency pairs.

Neither the stock-market volatility index or the constructed new proxy were found to be significant. This is not in line with Frenkel (1982) and Stanèík (2007). On the other hand the return in EUR/USD was found to be significant for both EUR/SEK and USD/SEK. Moreover the effect found is negative suggesting that increased returns in EUR/USD has negative relationship to the EUR/SEK and USD/SEK volatility.

In our longer frequency data the regressions find that the financial condition index is found to be significant in only 1out of the 10 models it was included. In regards to the EUR/SEK volatility it was found to be significant in all models whilst it lost its significance for the USD/SEK rate when the US monetary aggregate was accounted for. This is in line with Morana (2009) , who suggested that the volatility in the money stock affected the exchange rate dynamics. For the USD/SEK rate the monetary aggregates for the US was found to be significant at the 0.001 level. In the European case it was found to be significant at the 0.05 level. However including both the Swedish and EU monetary aggregates it was only found to be significant at the 0.1 level.

This study contributes to the literature by showing that in the case of Sweden, EUR/SEK and USD/SEK volatility exhibits GARCH and EGARCH effects on both daily and monthly data over the period 2000 to 2022. Moreover, we test the validity of variables proposed by previous literature as well as incorporating new variables that capture the effects market sentiment and technological development relating to hedgefund positioning in the foreign exchange markets.

For future research, one could expand this study by controlling for daily/monthly volumes of trading in the respective exchange rate as well as dividing the data set into different time periods characterized by different market conditions to investigate whether the results of this study change by doing so.

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Appendix

Regressions Results

Table 4: *EUR vis-a-vis SEK Daily Frequency Regressions.*

	(1) EUR/SEK volatility	(2) EUR/SEK volatility	(3) EUR/SEK volatility	(4) EUR/SEK volatility	(5) EUR/SEK volatility	(6) EUR/SEK volatility	(7) EUR/SEK volatility
EUR/SEK volatility							
FinanciaConditionIndex		-0.00000335	0.00000588	0.0000195	0.0000165	0.00000371	
		(0.0000252)	(0.0000309)	(0.0000327)	(0.0000329)	(0.0000367)	
VIX			0.00000552	0.00000414	0.00000299	0.00000391	
			(0.00000729)	(0.00000808)	(0.00000805)	(0.00000838)	
EURSEKNews				0.00000653	0.00000728	0.00000733	
				(0.00000794)	(0.00000786)	(0.00000835)	
EURUSD_return					-0.0497***	-0.0483***	
					(0.00822)	(0.00851)	
Hedgefund positioning in SEK						0.00000125	
						(0.00000167)	
Constants	-0.00000292	-0.00000341	-0.000119	-0.000106	-0.0000819	-0.000114	-0.119***
	(0.0000513)	(0.0000548)	(0.000149)	(0.000159)	(0.000158)	(0.000166)	(0.0187)
ARCH							
ARCH	0.124***	0.124***	0.126***	0.136***	0.138***	0.132**	
	(0.00883)	(0.00885)	(0.00897)	(0.00995)	(0.0102)	(0.0102)	
GARCH	1.049***	1.049***	1.031***	1.003***	1.004***	1.008***	
	(0.0559)	(0.0561)	(0.0556)	(0.0591)	(0.0597)	(0.0630)	
EARCH							0.049***
							(0.00797)
EGARCH							1.129***
							(0.0342)
Constants	-0.00000342***	-0.00000342***	-0.00000313***	-0.00000293**	-0.00000295**	-0.00000302**	0.781***
	(0.000000910)	(0.000000911)	(0.000000899)	(0.000000986)	(0.000000995)	(0.00000109)	(0.215)
N	5812	5812	5607	4389	4389	4218	5812

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: *USD vis-a-vis SEK Daily Frequency Regressions.*

	(1) USD/SEK Volatility	(2) USD/SEK Volatility	(3) USD/SEK Volatility	(4) USD/SEK Volatility	(5) USD/SEK Volatility	(6) USD/SEK Volatility	(7) USD/SEK Volatility
USD/SEK Volatility							
FinanciaConditionIndex		0.0000588	0.000102	0.0000610	0.0000316	0.000149**	
		(0.0000438)	(0.0000551)	(0.0000568)	(0.0000319)	(0.0000559)	
VIX			0.0000201	0.0000197	0.00000435	-0.00000491	
			(0.0000129)	(0.0000136)	(0.00000783)	(0.0000113)	
EURSEKNews				-0.00000218	0.00000862	0.00000944	
				(0.0000152)	(0.00000741)	(0.0000118)	
EURUSD_return					-1.043***	-1.008***	
					(0.00864)	(0.0136)	
Hedgefund positioning in SEK						0.000125	
						(0.000206)	
Constants	-0.0000426	-0.0000324	-0.000436	-0.000392	-0.0000751	0.0000729	-0.0000143
	(0.0000931)	(0.000101)	(0.000263)	(0.000271)	(0.000156)	(0.000210)	(0.0000922)
ARCH							
ARCH	0.150***	0.151***	0.155***	0.178***	0.162***	0.0342**	
	(0.0139)	(0.0139)	(0.0143)	(0.0170)	(0.0141)	(0.0128)	
GARCH	0.806***	0.803***	0.778***	0.765***	1.000***	1.776***	
	(0.0679)	(0.0670)	(0.0663)	(0.0664)	(0.0554)	(0.337)	
EARCH							0.0290**
							(0.0110)
EGARCH							0.997***
							(0.0497)
Constants	0.00000262	0.00000270	0.00000393	0.00000325	-0.00000366***	-0.0000111*	-0.0343
	(0.00000321)	(0.00000316)	(0.00000315)	(0.00000310)	(0.000000933)	(0.00000446)	(0.488)
N	5812	5812	5607	4389	4389	2205	5812

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6: *EUR vis-a-vis SEK Monthly Frequency Regressions.*

	(1) EUR/SEK Volatility	(2) EUR/SEK Volatility	(3) EUR/SEK Volatility	(4) EUR/SEK Volatility	(5) EUR/SEK Volatility	(6) EUR/SEK Volatility
EUR/SEK Volatility						
Market Sentiment Index		-0.0508**	-0.0566*	-0.0645	-0.0643	
		(0.0192)	(0.0237)	(0.0422)	(0.0398)	
Swedish Monetary Aggregates(M2)			0.0150	0.0297	0.0333	
			(0.0462)	(0.0690)	(0.0703)	
ECB Monetary Aggregate(M2)				-0.0072*	-0.0069	
				(0.0036)	(0.0036)	
Swedish CPI					0.0020	
					(0.0026)	
Constants	0.0000	-0.0002	-0.0004	0.0008	0.0005	0.0005
	(0.0007)	(0.0007)	(0.0009)	(0.0011)	(0.0012)	(0.0007)
ARCH						
ARCH	0.2034***	0.2277***	0.3669**	0.1731	0.1725	
	(0.0585)	(0.0639)	(0.1266)	(0.1993)	(0.2111)	
GARCH	0.6410***	0.5793***	0.3430	-0.5455	-0.5458	
	(0.1279)	(0.1494)	(0.2099)	(0.6070)	(0.6302)	
EARCH						0.1485**
						(0.0483)
EGARCH						0.9300***
						(0.0412)
Constants	0.0000	0.0000	0.0001*	0.0002*	0.0002*	-0.6231
	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0001)	(0.3651)
N	263	263	188	113	113	263

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7: *USD vis-a-vis SEK Monthly Frequency Regressions.*

	(1) USD/SEK volatility	(2) USD/SEK volatility	(3) USD/SEK volatility	(4) USD/SEK volatility	(5) USD/SEK volatility	(6) USD/SEK volatility
USD/SEK volatility						
Market Sentiment Index		-0.0866**	-0.0905***	0.0153	0.0147	
		(0.0266)	(0.0243)	(0.0162)	(0.0165)	
Swedish Monetary Aggregate (M2)			0.0555	0.0328	0.0301	
			(0.1033)	(0.0869)	(0.0867)	
FED Monetary Aggregate (M2)				0.5725***	0.5733***	
				(0.0305)	(0.0306)	
Swedish CPI					-0.0014	
					(0.0029)	
Constants	0.0000	0.0001	0.0002	-0.0037**	-0.0035*	0.0004
	(0.0014)	(0.0014)	(0.0019)	(0.0013)	(0.0014)	(0.0014)
ARCH						
ARCH	0.0490	0.0445	0.0606	0.3793*	0.3850*	
	(0.0320)	(0.0327)	(0.0445)	(0.1721)	(0.1761)	
GARCH	0.9156***	0.9286***	0.9092***	0.0483	0.0581	
	(0.0690)	(0.0662)	(0.0738)	(0.2107)	(0.2264)	
EARCH						0.0355
						(0.0368)
EGARCH						0.9613***
						(0.0559)
Constants	0.0000	0.0000	0.0000	0.0002*	0.0002*	-0.2915
	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0001)	(0.4193)
N	263	263	188	188	188	263

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Dicky Fuller Test Results

Table 8: Complete set of Dicky-Fuller tests

		Dicky-Fuller Critical Values			
Variable	Test statistic	1%	5%	10%	Approximate p-value
EUR/SEK News	-56.347***	-3.960	-3.410	-3.120	0.0000
USD/SEK News	-33.247***	-3.960	-3.410	-3.120	0.0000
FCI	-11.189***	-3.960	-3.410	-3.120	0.0000
Sentiment Index	-2.847	-3.989	-3.429	-3.130	0.1802
VIX	-5.735***	-3.960	-3.410	-3.120	0.0000
Hedgefund Positioning	-3.043	-3.960	-3.410	-3.120	0.1204
ECB Monetary Aggregate	-0.541	-3.989	-3.429	-3.130	0.9818
FED Monetary Aggregate	0.397	-3.989	-3.429	-3.130	0.9966
Riksbank Monetary Aggregate	1.308	-4.002	-3.45	-3.135	1.0000
EUR/SEK Rate	-3.595**	-3.960	-3.410	-3.120	0.0302
USD/SEK Rate	-2.115	-3.960	-3.410	-3.120	0.5375
EUR/USD Rate	-1.091	-3.960	-3.410	-3.120	0.9305
Consumer Price Index	-16.824***	-3.989	-3.429	-3.130	0.0000

* Z(t) <0.9, ** Z(t) <0.95, ***Z(t) <0.99