Safe haven currencies

An empirical study of the Swedish krona

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Abstract: This thesis investigates whether the Swedish currency provides safe haven characteristics and how the currency's behavior has been affected by the financial crisis. These questions are determined by investigating how risk factors defining safe haven currencies affect the Swedish krona and if these coefficients have experienced a structural break during the recent financial crisis. The results are contradictive but it is concluded that the appreciation of the SEK in recent time is not a result of safe haven characteristics, but rather a result of a strong development in the Swedish economy along with troubles in the Eurozone. This for example since investors wanting to be exposed to Europe have been forced to allocate their resources in economies with strong fiscal balances. That the SEK would function as a safe haven in the long run is not supported by our findings.

Keywords: Safe haven currencies, Swedish krona, flight to quality, structural breaks

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1. Introduction

The recent financial crisis has been described as the worst economic crisis of all time. Few investments have been left unaffected which has led to the mapping of a new financial landscape. New types of investments have become important while others have lost their significance. In the previous two years, the Swedish Krona (SEK) has appreciated strongly against the Euro (EUR) and the US Dollar (USD). This has not gone unnoticed by magazines and professionals as some have suggested that the SEK might be the new safe haven[1] in the midst of the Eurozone sovereign debt crisis. In February 2010 Financial Times ran an article: *"Swedish krona – set to become haven"*

> *"The Swedish krona is likely to materially benefit from increasing purchases of the country's assets as investors liquidate Eurozone assets in favor of safer harbors. Sovereign risk is here to stay and asset allocators looking for 'safe' destinations, especially in Europe, do not have that many options,"* (Geoffrey Yu, strategist at UBS).

At the time Norway was expected to show strong surpluses, signifying low lending needs. Other countries expected to stay healthy fiscally was Denmark and Switzerland. Denmark however was pegged to the Euro and as a result they could also gain stimulus from a weakening currency. As for the Swiss franc, investors were reluctant to enter positions with the uncertainty of whether central banks would intervene for a weakening of the currency. That left Sweden, expected to be the healthiest key European economy with a budget deficit. It was anticipated that demand for Swedish bonds would be high even internationally and that the SEK would show relative safe haven characteristics during the Eurozone sovereign debt era (Financial Times 2010).

The previous research conducted in the area of safe havens has been concentrated to traditional safe haven currencies such as the Japanese Yen (JPY) or the Swiss Franc (CHF). Characteristics regarding the SEK is however not as investigated. During recent years, features of safe haven countries and their currencies as well as what parameters reflect risk appetite in the world has been examined (Ranaldo & Söderlind 2010, Habib & Stracca 2011, Caballero & Krishnamurthy 2008). Consequently, this thesis aims to contribute to the knowledge of the SEK as well as to provide a more detailed understanding for the reasons behind the appreciated Swedish exchange rate. Our purpose is to provide a better understanding of the characteristics of the Swedish krona, especially after the recent financial crisis. Our research question is formulated as followed:

[1] Concept of "safe haven" will be thoroughly explained in chapter 3

Does the Swedish currency provide safe haven characteristics and has its behavior regarding these characteristics been affected by the financial crisis?

We address these questions by:

Investigating how risk factors defining safe haven currencies affect the Swedish krona and if these coefficients have experienced a structural break during the recent financial crisis.

The analysis is divided into three parts. First we determine if there has been a structural break in the SEK's behavior (using USD, EUR, JPY, CHF and the TCW index) with respect to different risk parameters explaining global market conditions. In our factor model specification we include different parameters that are important when measuring safe haven characteristics. These parameters account for changes in volatility and changes in world risk appetite. Previous research shows that accepted parameters are stock indices, bonds, volatility and liquidity risk premia. Further, the method used throughout our analysis for detecting structural changes has been developed through a large series of statistical publications as the research within behavioral changes in data is extensive and subject to many streams of literature. We apply a methodology that provides means for testing whether structural changes in the risk parameters discussed above have taken place (QLR) and determine the timing of the possible change (least squares estimation). In the second part we conduct before-and-after regressions depending on the potential break date detected in part one. Regression parameters on either side of the break date are estimated in order to conclude how the parameters affect the SEK after the break and if we can see a trend towards safe haven characteristics. The third part looks at fundamental country elements characterizing safe haven countries and their currencies. These elements are identified by Habib & Stracca (2011) as country risk and vulnerability, size of the domestic market and liquidity of the currency as well as financial openness and globalization. We compare Sweden's fundamental elements to those of six other relevant countries to determine whether Sweden can function as a safe haven.

The analysis provides contradictive results regarding the safe haven parameters of our empirical model. Several coefficients are statistically significant and point in the direction of safe haven features whereas others tell the opposite story or fail to be significant. We have identified breaks in the four currency crosses examined during the recent financial crisis. However, no break has been detected in the weighted SEK index. We can therefore determine that there has been a change in the coefficients of the safe haven parameters in our factor model. As such, the SEK has changed its behavior. However, when looking at the before-and-after regressions as well as the country elements we conclude that the appreciation of the SEK in recent time is not a result of safe haven characteristics, but rather a result of a strong development in the Swedish economy along with troubles in the Eurozone. This for example since investors wanting to be exposed to Europe has been forced to allocate their resources in economies with strong fiscal balances. That the SEK could function as a safe haven in the long run is not supported by our findings.

1.1 Delimitations

The field of currencies is a global and extensive subject. We have therefore restricted our thesis in several aspects. First, we have limited the analysis to look at only four currency exchange crosses (SEK/USD, SEK/EUR, SEK/JPY, and SEK/CHF) as well as a weighted SEK index (TCW). The crosses are chosen based on two factors: the volume of trades or the fact that the counter currency is regarded to be a safe haven according to previous research. Second, the timeframe analyzed is limited to the period between the 1st of January 2000 and the 30th of April 2011. A timeframe extended further back would have resulted in an era where the Euro was not an established currency, which would have complicated the analysis. Third, the data used is daily data and not high frequency, which can lead to failures in detecting the short term fluctuations. Another aspect regarding the data is the existence of other factors affecting safe haven characteristics than those used in our model. However, we have chosen to restrict the regression model to include only safe haven determining factors as further factors would have required larger amounts of resources than those available for this thesis. Fourth, although the method used in our statistical analysis is an established and accepted method capturing the features we require, there might also exist more suitable models beyond our statistical skills. We finalize our analysis with an examination of Swedish economic fundamentals where the data analyzed is constricted to a portion of the relevant conclusions drawn by Habib & Stracca (2011).

1.2 Disposition

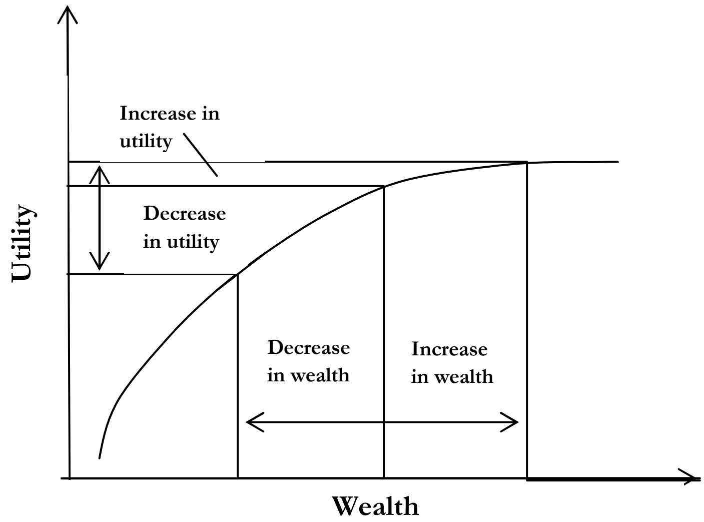
Chapter 2 presents the theoretical framework used in the thesis. This is followed by the literature review in chapter 3, presenting an overview of relevant literature connected to the concepts of safe haven currencies as well as to our method. The data is described and motivated in chapter 4 and thereafter the methodology is presented in chapter 5, organized in a sequential order. Further, the results, the analysis and conclusions are presented in chapter 6, 7 and 8 respectively.

2. Theoretical framework

2.1 Risk aversion

To understand the concept safe haven assets one can begin with the concept of risk aversion which goes back as far as 1738 with Daniel Bernoulli's paper "Exposition of a New Theory on the Measurement of Risk". In the paper, Bernoulli suggested that the value of an item should be determined by the utility it yields to its owner, not by its price. He argued that the price is equal to everyone, regardless of how rich or poor the individual might be. Utility on the other hand might differ across individuals since they have different preferences and wealth. He stated that "there is no doubt that a gain of one thousand ducats is more significant to a pauper than to a rich man though both gain the same amount" (Bernoulli 1954). This citation is an introduction to the concept of diminishing marginal utility. If the marginal utility as a function of wealth is diminishing, we can understand that an individual that is endowed with 100 units of wealth and looses 50 units experiences a loss of utility that is greater than the gain of utility the same individual would experience if winning 50 units. Daniel Bernoulli derives this result in his paper (1954) and can easily be understood by Figure 1.

Figure 1: Changes in utility vs. changes in wealth



An individual with a diminishing utility function as presented in Figures 1 would not participate in a game where the probability of doubling his wealth is the same as the probability of losing half his wealth. This is because winning yields less utility than the disutility losing yields. Because of this finding he states that an individual prefers a certain outcome over an uncertain if the expected payoff is the same. The individual is, as most people, *risk averse.* In contrast there are also risk seeking and risk neutral investors.

From the findings of Daniel Bernoulli outlined above we understand that a risk averse person always demands higher expected payoff for taking on greater risks in investments. This can be modeled as in Mark Kritzman's article (1992):

$$U = E(r) - \lambda * \sigma^2$$

Where E(r) is the expected return of the investment, λ is a coefficient for the individual's risk aversion, σ^2 is the standard deviation of investment returns and U is the utility an investment with the specific combination of expected return and risk will yield depending on the individual λ. A risk averse person has a positive value of λ, which leads the utility function to be decreasing in risk. The model also shows what was previously stated, the risk averse investor will demand higher expected return for every increase in standard deviation in order to maintain the same level of utility. If the risk of an investment suddenly increases, a risk averse investor will demand higher expected return. If that is not possible with the investment he or she is currently endowed with, the investor will transfer capital away from the current investment to an investment with higher expected payoff or lower risk.

2.2 Knightian uncertainty

Risk is something that is measurable and makes it possible for investors to assign probabilities to different outcomes, leading them to make calculated decisions aware of the return possibilities. Uncertainty on the other hand is not calculable; the investor cannot measure any risks, since he doesn't know how probable an outcome is compared to another. Knight (1921) puts words to the difference between risk and uncertainty:

> *"A situation is said to involve risk if the randomness facing an economic agent presents itself in the form of exogenously specified or scientifically calculable objective probabilities, as with gambles based on a roulette wheel or a pair of dice. A situation is said to involve uncertainty if the randomness presents itself in the form of alternative possible events, as with bets on a horse race, or decisions involving whether or not to buy earthquake insurance."*

As Knight points out, the difference between risk and uncertainty is that the former is measurable and the latter is not. When facing higher risks investors can still make calculated bets on the performance of an investment in order to capture the higher risk premium. When faced with Knightian uncertainty investors do not know anything about the risk premium related to a particular investment.

2.3 Flight to quality and safe haven assets

Flight to quality is said to occur when investors transfer their capital away from risk or uncertainty and into markets, instruments or countries that is believed to experience a smaller amount of risk. Hence, these investments are of higher "quality" i.e. the risk of bad performance is lower. This is especially important to risk averse investors in times of turmoil when volatility of markets is higher than usual and they might face Knightian uncertainty. Caballero & Krishnamurthy (2008) find that several flight to quality episodes, for example the decline in stock markets in October 1987 or the time after 9/11, showed common investor behaviors, resulting in conservatism and flight from risky activities. They state that the named flight to quality episodes and the behavior in them was not due to an increase in "ordinary" risk but due to Knightian uncertainty. They also relate Knightian uncertainty and liquidity squeezes to flight to quality episodes. They show that when an investor faces Knightian uncertainty and liquidity is limited he is worried that he will be put in a situation where liquidity in a time of need is denied. The investor therefore tries to avoid risk and turns to safe investments.

One result of capital flight and the flight to quality phenomenon is that some investments function as "safe havens"; sanctuaries of low risk that investors turn to when in need of stable investments. Baur & Lucey (2010) provide a definition for safe haven assets. The authors stress that the safe haven status is conditional on the reference asset of the potential safe haven. The definition is then based on a safe haven asset being an asset that is not positively correlated with its reference asset or portfolio in times of market turmoil. The authors also stress that a safe haven only needs to have non-positive correlation with its reference asset in the specific periods when the market is in turmoil.

This relates to the definition of a safe haven provided by Ranaldo & Söderlind (2010) They define a safe haven asset as an asset that provides hedging benefits on average or in times of stress (as Baur & Lucey). Gold is an example of an asset that provides hedging benefits on average since it is traditionally said to be uncorrelated to other assets. Assets that provide hedging benefits in times of stress can be defined as in Baur & Lucey (2010).

Since various assets can function as safe havens depending on market situation and timing, safe havens can also include currencies. Traditionally, safe haven status has been accredited primarily to the Japanese Yen, the US Dollar and the Swiss Franc (Ranaldo, Soderlind 2010, Doroodian, Caporale 2000, Campbell, Serfaty-De Medeiros & Viceira 2010). The fluctuation of an exchange rate primarily depends on increasing demand for the "safe" currency and decreasing demand for the corresponding "risky" currency. This will cause the appreciation of the safe country's currency relative to the uncertain currency.

2.4 The concept of structural change

Applied time series analysis is often based on the assumption of stationarity, e.g. the constancy of coefficients and parameters such as mean, variance or trends. Structural breaks are by definition, sudden events or time periods which change the structure of models under consideration (the assumption of stationarity is challenged) (Hansen 2001). Their occurrence is generally taken as a given when detected but are not viewed as part of the original model specification. In modern economics and finance, a structural break evolves during an unexpected shift in economic time series, as during the recent worldwide financial crisis. A structural break is considered to have taken place when at least one of the assumed stationary parameters has changed during the sample period. Consider a simple dynamic model (the first order auto regression):

$$Y_t = \beta_0 + \beta_1 y_{t-1} + \varepsilon_t, \quad E(\varepsilon_t^2) = \sigma^2 \tag{1}$$

If any of the above variables $(\beta_0, \beta_1, \sigma^2)$ experiences a statistically significant change during the sample period, one can confirm the existence of a structural break. A change in the parameter β_1 during the sample period would reflect changes in the serial correlation in Y_t. The intercept is a control for the mean of Y_t and is of interest as it represents the overall level of the dependent variable. Changes in σ^2 imply changes in the volatility of Y_t.

If structural breaks are not taken into account it can lead to enormous forecasting errors, policy recommendations can be misleading and implications about economic interactions can be overlooked or misunderstood (Hansen 2001). A wide range of important work in the theories regarding detection and testing for structural breaks have advanced for more than half a century[2]. The most prominent advances have been made within the following topics; computational features of constructing estimates and their limit distributions, testing for structural changes at unknown timing, techniques in determining the number of present changes and the timing of

[2] One example of a parallel development is the concept of Random walks (unit roots). Nelson and Plosser (1982) challenged the assumption of linear trends, suggesting that trends can be characterized by random walks e.g. trends will be shifted by random shocks and stay at a new level until the next shock disturbs the trend. Perron (1989) later showed how to test the random walk hypothesis against the trend break model. As of now, one main distinction between a random walk and a trend break model is largely colored by the frequency of shocks. In the random walk models these shocks occur more frequently whereas for the trend break model, shocks generally occur maybe once or twice (Hansen 1997). As mentioned, our analysis is going to focus on the detection of one structural break or evolution since we are interested in the effect of the recent financial crisis. This leads us to disregarding the random walk models.

these as well as tests to distinguish between a random walk (unit roots) and changes in time trends (Perron 1989).

3. Literature Review

3.3 Safe haven currencies

As of today, the research most closely connected to our purpose is that of Ranaldo & Söderlind (2010). They study a set of currencies (GBP, USD, EUR, YEN, and CHF) during the period 1993-2008 to determine if the currencies have safe haven properties. Their main purpose is to investigate if the appreciation of certain currencies can be statistically explained by increases in different risk measures as a safe haven would appreciate on increased risk and uncertainty. They use a factor model in order to find linear and/or non-linear relationships between the currencies and different risk factors. The risk factors are stock and bond market indices, an equity and FX market volatility proxy and a proxy for global liquidity.

The authors find evidence of Japanese Yen and Swiss Franc being safe haven currencies during the measurement period. The conclusion is based on the observation that the Japanese Yen and the Swiss Franc appreciated against the US Dollar when the US equity market fell and when bond prices and FX volatility increased.

Connected to this is Doroodian & Caporale (2000) application of a GARCH-M framework to four currencies against the US Dollar to show that the USD worked as a safe haven as it appreciated on FX uncertainty.

Another study related to our topic is the one by Campbell et. al (2010). They investigate what is the optimal composition of a portfolio in order to hedge currency risk. They find that the Swiss franc is negatively related to world and domestic equity market performance, which would indicate that the Swiss franc possesses safe haven properties.

Moreover, Farhi & Gabaix (2008) relate country risk to risk premia and suggest that risky countries have high risk premia due to a depreciated exchange rate and high interest rates. When general risk aversion is lowered because of bull markets or lower volatility, capital flows in and their currencies appreciates, lowering their risk premium. This would in turn mean that low risk countries experience depreciation in their currencies during times of decreased risk aversion which further strengthens the argument that safe haven currencies are negatively related to equity market performance and foreign exchange volatility.

An important study to this paper is the one provided by Habib & Stracca (2011) who investigate the characteristics that create a safe haven currency and find that there are three major explanations which we call the three country elements:

3.3.1 Country risk and vulnerability

First, the authors state that a currency can become a safe haven if the country issuing the currency is perceived as safe and of low risk. They mention several factors that are important to measure country risk. Among these factors are the ratio of public debt to GDP, the current account balances to GDP and the net foreign asset position to GDP.

3.3.2 Size and liquidity of financial markets

Second, the liquidity of the currency is an important parameter as well as the domestic market size. More liquid markets attract investors on the fact that market liquidity tends to dry up in stressful times. Also, larger markets can attract investors since the supply of instruments denoted in that currency is greater. The authors use the bid-ask spread in the FX market in order to measure liquidity in the market of interest. As size proxies the authors use stock market capitalization to the country's and world GDP.

3.3.3 Financial openness

Third, Habib & Stracca also show that a safe haven market should be less integrated to the financial globalization and not highly related to general world distress. They use the ratio of external financial assets and liabilities to GDP as well as foreign loans to GDP as factors to measure the financial openness in a market.

3.4 Carry trades and the forward premium puzzle

Related to the safe haven currency literature is the literature regarding carry trades. A carry trade consists of selling (borrowing) funds in a country where the interest rate is low and buying (investing) in a country where the interest rate is higher in order to make a profit on the interest rate differential (Brunnermeier, Nagel & Pedersen 2008). However, the uncovered interest rate parity (UIP) implies that any possible profits in interest differentials are cancelled out by relative depreciation in the investment currency (Brunnermeier, Nagel & Pedersen 2008). In theory, carry trades should therefore not be profitable, although the empirics tell a different story. As presented by Fama (1984) the investment currency appreciated in his study. This is of course a violation of the UIP since the high interest currency appreciated on average. The finding describes what is referred to as the forward premium puzzle, which could make a carry trade profitable. Brunnermeier, Nagel & Pedersen (2008) find similar evidence in their article.

The forward premium puzzle combined with the findings of Farhi & Gabaix (2008) provides some insight to safe haven currencies. As mentioned before, Farhi & Gabaix (2008) propose that high risk countries experience depreciated exchange rates and high interest rates. As the risk premium of high risk countries is lowered their currency appreciates, leading to the conclusion that high interest countries have currencies that appreciate in times of lowered volatility. This is in line with the forward premium puzzle discussed by Fama (1984). The connection to safe haven currencies is that in times of greater market volatility investors may want to turn to safer markets and thus move away from high risk countries with high interest rates. This will lead to the unwinding of carry trade positions (Brunnermeier, Nagel & Pedersen 2008). The unwinding could therefore in itself provide an explanation to the safe haven currency phenomenon. In contrast, Habib & Stracca (2011) emphasize that it is not the interest rate spread as proposed in the carry trade literature that is the most important predictor of a safe haven but the net foreign asset position that can be seen as an indicator of country risk. This is because carry trades do not target all currencies and not always the same ones.

3.5 Trend breaks in the literature

The classical test for detecting structural change is usually accredited to Chow (1960), although having the limitation of only being of use when the break point is known. This is because the break date has to be chosen based on some event during the sample period or based on some characteristic in the data. This can lead to the true break date being missed or the break date being endogenous due to correlation with the data. When the break point(s) is unknown, as in most economic applications, there exist two main streams of literature. The first considers tests that use the F-type test statistics (Quandt 1960, Andrews, Ploberger 1994, Andrews 1993, Hansen 1997), while the second uses generalized fluctuation tests, e.g. CUSUM type tests (Ploberger, Krämer 1992). These streams focus mainly on determining the existence of structural breaks and are not as precise when predicting their exact locations (Ntantamis 2010)[3]. The first stream of literature is more applicable for our problem area since we have relatively limited amount of time to conduct our research.

[3] A Cusum chart is a control chart in order to give signals when a process is out of balance. In a Cusum chart the sum of the deviations from a standard value is recorded. A Cusum chart is only an upper control limit. When the accumulated value of the deviations from the default value has reached the upper control limit of a Cusum chart you receive a warning that the process is out of balance. It can also be manipulated in order to detect negative changes as well. The Cusum chart was introduced by Page in the 1950s. Tests for structural change can also be based on a similar procedure using moving sums (Mosums) (Ploberger, Krämer 1992). However, we choose not to apply these methods further in our investigation.

4. Data

Since safe haven assets have the feature of performing relatively well in times of market turmoil our aim is to construct a model that captures the performance of the SEK relative to increases in global risk. In order to do this we have included several risk parameters and proxies in the model to find out how the SEK fluctuates due to changes in these parameters. We run regressions of several bilateral exchange rates, all of them including the SEK. These exchange rates are SEK/USD, SEK/EUR, SEK/JPY, and SEK/CHF. We are also interested in how the SEK has performed compared to a basket of different currencies in volatile times. Therefore we have included the TCW index, constructed by the Swedish central bank (Riksbanken), to our data. The TCW index is a geometric index with weights based on average aggregate flows of processed goods from 21 countries[4].

4.1 Factor model[5]

When the previous research above is taken into account, our factor model is defined:

$$R_t^e = \beta_0 + \beta_1 EquityIndex_t + \beta_2 Bond_t + \beta'_3 Risk_t + \beta_4 EquityIndex_{t-1} + \beta_5 Bond_{t-1} + \beta'_6 Risk_{t-1} + \beta_7 R_{t-1}^e + \epsilon_t \quad (2)$$

where R_t^e is the carry trade between the SEK and the counter currency (the appreciation of the SEK compared to another currency, plus the difference in interest rates of the two countries). As an example, the R_t^e for SEK/USD is the appreciation of the SEK relative to the USD plus the interest rate differential between Sweden and the US. We have used the base rate for each country as well as for the Eurozone. $EquityIndex_t$ varies depending on which currency pair we are looking at since we want to capture downturns in the "home" equity market (with Sweden being the foreign). For SEK/USD we use the log return on futures for the S&P500, for SEK/EUR and SEK/CHF we use the log return on futures for the S&PEuro350 and for SEK/JPY we have used the log return on Nikkei225. The variable used to account for bond demand is the return on the 10year US Treasury note futures. $Risk_t$ in our model represents a vector containing different risk measures as the CBOE's VIX, the TED spread and an index of FX volatility. The VIX is an index of equity market volatility derived from options, a good proxy

[4] http://www.riksbank.se/templates/stat.aspx?id=25022 , 2011-05-22

[5] The data is extracted from Thomson Reuters DataStream where daily data was available for the variables required.

for world volatility in equity markets. The TED spread is constructed by taking the difference between the three month USD LIBOR and the three month T-Bill rate. The FX volatility is a variable based on the realized volatilities of three chosen cross rates (USD/JPY, EUR/USD and GBP/USD). We have failed to find an index for overall FX volatility and therefore we have constructed the variable using a definition of FX realized volatility by The CME Group[6]. The FX volatility is calculated as a sum of the previous five days' realized volatility.

For the case when we include the TCW index in our model we have used a slightly different specification

$$TCW_t = \beta_0 + \beta_1 S\&P500_t + \beta_2 Bond_t + \beta'_3 Risk_t + \beta_4\, Reporate_t + \beta_5 S\&P500_{t-1} + \beta_6 Bond_{t-1} + \beta'_7 Risk_{t-1} + \beta_8 Reporate_{t-1} + \beta_9 TCW_{t-1} + \epsilon_t \quad (3)$$

TCW_t is the return on the TCW index. We have chosen to use the log return on S&P500 futures in this model as this can function as a proxy for world equity market performance. The Swedish Repo rate is also included as a factor.

4.2 Factor model motivation

The SEK/USD and the SEK/EUR are chosen since the US Dollar and the Euro are the two of the most heavily traded currencies. Therefore it is interesting to use the two currency pairs as reference assets to the SEK in order to investigate if the SEK has functioned as a safe haven since the recent financial crisis: a crisis that hit both the US market and the Eurozone with brute force. The SEK/JPY and SEK/CHF rates are also included in our investigation since the Yen and Swiss Franc are classic safe haven currencies as stated in the literature review. If the SEK has appreciated against the Yen and/or the Swiss Franc in times of greater market difficulties it would be a sign of investors turning to the SEK rather than these currencies when looking for a safe haven.

As pointed out above, the independent variables important to this analysis are variables that in one way or another can be used to measure changes in volatility, changes in global risk appetite and thus the safe haven characteristics of a currency. Ranaldo & Söderlind (2010) identify several variables that are important to use when determining if a currency possesses safe haven characteristics. As they treat the US as the home market in most of their models, they include the performance of the US equity market in their model. The interpretation is that falling US stock prices is a sign of an equity market downturn since the S&P500 is often used as a market proxy.

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[6] $Realized\ Volatility = 100 * \sqrt{\left(\frac{250}{N}\right) * \sum_{t=1}^{N} \left(ln \frac{P_t}{P_{t-1}}\right)^2}$, N=5, the number of days in the calculation period.

Investors might close their equity positions in times of stress, concerned about the falling stock prices and about what the uncertain future might hold they turn to safe haven assets. An increase in the return of an asset in times of falling equity markets would therefore be a safe haven feature.

Further, they include CBOE's VIX into their model accounting for equity volatility, which tends to increase during world turmoil. A safe haven currency would have a positive relation to the VIX. Several authors including Brunnermeier et al. (2008) have used the TED spread as a proxy for funding liquidity. An increase in the TED spread suggests greater illiquidity and can therefore function as a proxy for liquidity risk. We have chosen to include the TED spread in our model, since liquidity risk tends to increase during market turmoil. As we are looking for safe haven patterns in exchange rates, we have also included a measure of FX volatility to capture changes in FX risk. A safe haven currency would appreciate when FX volatility increases since it is regarded as "safe", even though the currency market as a whole experience greater risks. A drawback of using realized volatility is the fact that it is based on past measures. Past FX volatility may not be a good estimate of future or expected volatility due to the very dynamic FX market.

An increase in bond demand can in itself be regarded as an increase in the demand for safe havens because of their low overall risk. The implication of this is that a safe haven currency would be positively correlated to changes in bond demand, as bonds can in themselves be regarded as safe havens. Even though the default risk increased during the recent financial crisis for US government bonds the return on 10year Treasury note futures is still a good world market proxy for increasing bond demand.

When we regress the TCW index on the different risk parameters we also want to control for carry trades. However, it is difficult to construct a weighted interest rate basket since the weights of the TCW index is complex and constantly changing. Because of this, we include the Swedish Repo rate as an independent variable in order to capture capital flows to Sweden depending on carry trade and the Swedish interest rate.

We include lagged variables because we want to account for surprises in the variables as well as more expected developments in the parameters. Furthermore, previous research tells us that exchange rates experience a substantial amount of autocorrelation (Ranaldo & Söderlind 2010).

4.3 Data for Country Element analysis.

Habib and Stracca (2011) divide the elements into three categories: country risk and vulnerability, size and liquidity, financial openness. In order to analyze these elements we have chosen proxies influenced by the data used in their article. The proxies used to analyze the first element are government debt to GDP[7] and current account to GDP[8]. The tabulated years are 2009, 2010 and a forecast for 2011. A country strives for a lower debt-to-GDP ratio since this for example implies better abilities to repay its debt. In contrary a country with a higher current account to GDP limits its need for external financing since the balance of payments (exports minus imports) is positive. For the second element we use the currency distribution of global foreign exchange market turnover from the BIS Triennial Survey conducted by The Bank for International Settlements as a proxy for the liquidity measure. The data is collected during April in the years of 2001, 2004, 2007 and 2010. Habib & Stracca use the bid/ask spread as a liquidity measure, data which we were not able extract. However turnover is also a common variable when measuring liquidity. The higher the turnover the more liquid the currency will trade as this also can imply a narrower bid/ask spread. In order to evaluate the size of markets we analyze market capitalization of listed companies as of December 2010[9]. Instead of using financial assets and liabilities to GDP as well as foreign loans to GDP, a globalization index[10] is used when analyzing the third element. The total globalization index is a weighted index measuring economic, social and political dimensions of globalization. We have also included the economic globalization index separately as a complementary factor since this may better reflect globalization of the financial markets. This data is unfortunately only as recent as 2008 but can give us an idea of how the overall levels are distributed. The reason for the data range being so dispersed is due to availability issues.

5. Methodology

When constructing our method several aspects were taken into consideration. The research within behavioral changes in data is extensive and subject to many streams of literature. The methodology described below provides means for testing whether structural changes in the independent variables discussed have taken place (QLR) and the timing of the possible change (least squares estimation). It provides a method for determining which time periods to be tested

[7] OECD: Statistics Database 26th of May 2011
[8] IMF: World Economic Outlook 2011 Database 26th of May 2011
[9] Thomson Reuters DataStream
[10] KOF Swiss Economic Institute: Globalization Index

in our sample and whether multiple structural changes exist. Further, if we find a structural break, we will estimate the regression parameters from Equation 2 on either side of the break date to conclude how the parameters affect the SEK after the break and if we can see a trend towards safe haven characteristics. This method is identified by us as the most appropriate procedure to investigate our hypothesis and gain a broad knowledge about the features of the SEK.

5.1 Chow Test

Testing for a structural break at a specific date in the data regression is fairly simple. The most common approach is referred to as the Chow test (Chow 1960). Consider a model with one dependent variable Y_t and two independent variables X_t & Z_t. We let τ denote the hypothesis break date and let $d_t(\tau)$ be a dummy variable that equals one after the break date and equals zero before, $d_t(\tau) = 0$ if $t < \tau$ and $d_t(\tau) = 1$ if $t \geq \tau$. The regression will then take the below form including the break indicator:

$$Y_t = \beta_0 + \beta_1 x_t + \beta_2 z_t + \gamma_0 d_t(\tau) + \gamma_1[d_t(\tau) * x_t] + \gamma_2[d_t(\tau) * z_t] + u_t \qquad (4)$$

If there is no break in the data, the population regression function is the same for both periods which means that the terms including the binary break variable do not enter the regression equation. That is, under the null hypothesis, there is no break when $\gamma_0 = \gamma_1 = \gamma_2 = 0$. In contrast, the alternative hypothesis being that there is a break indicates that the regression equations are different before and after the break. This means that at least one of the γ-terms ≠ 0. This enables an F-test testing the hypothesis:

$$H_0\colon \gamma_0 = \gamma_1 = \gamma_2 = 0 \qquad H_1\colon H_0 \textit{ is not true}$$

This test is the one usually referred to as the Chow test and the regression can be modified in several ways (Stock, Watson 2007). The Chow test is considered to be a good estimate for linear regressions when the break date is known in advance (Hansen 2001).

5.2 Detecting structural change – QLR test

A development from Chows findings can be used where the break date for the analysis is unknown or known only within a range and has to be confirmed. To explain the procedure we assume that the break occurred sometime between two dates τ_0 and τ_1. Now we need a test that can handle testing all or several break dates within our time period of τ_0 to τ_1. The Chow test can be modified to test for the unknown break point by using the largest F-statistic over the range of dates ($\tau_0 \leq \tau \geq \tau_1$). This modified Chow test is referred to as the Quandt Likelihood Ratio (QLR) test, presented in (Quandt 1960).

Let F(τ) denote the F-statistic testing the hypothesis of a break in the regression coefficients at date τ. Since the QLR test statistic is the largest F-statistic over the range of date in the sample it results in the following maximization problem (Stock, Watson 2007):

$$QLR = \max\,[F(\tau_0), F(\tau_0 + 1), \ldots, F(\tau_1)] \qquad (5)$$

When running the QLR-test, one receives a sequence of F-statistics that can be compared with the appropriate critical values in order to determine if there exists a structural break in the data set. One positive aspect of the QLR-test is that it also rejects the null hypothesis with high probability in large samples when there are multiple discrete breaks or when the break comes in the form of a slow evolution of the regression function. This is probably a more accurate way of looking at the problem, since we see it unlikely that a structural break would be immediate as it is more reasonable to allow for a structural change within a time period. This would mean that the test can detect a period of instability instead of just detecting a single break, which is otherwise often assumed in the trend break models (Stock, Watson 2007).

5.2.1 Limitations

The limitations with this test are that for a large sample approximation to be good, τ_0 and τ_1 cannot be too close to the beginning or end of the sample. When searching for a break too close to the endpoints of the sample, we will get unrealistically high F-statistics due to lack of data in the smaller subsample. The QLR-statistic is therefore computed from within a range of the sample size. The standard choice is to use a range of 70% of the sample, $\tau_0 = 0.15T$ and $\tau_1 = 0.85T$ (Stock, Watson 2007). When using the highest F-statistic for determining the timing of the potential break the regression should be linear and have a homoscedastic form of the covariance matrix. From this it follows that the QLR concentrates on detecting the existence of a break rather than the timing of it. (Ntantamis 2010) We account for this later in our method.

5.2.2 Development of the appropriate critical values

For the case when the break date is known, the chi-squared distribution can be used to measure statistical significance. However, when the break dates are unknown the chi-squared distribution becomes inappropriate (Hansen 2001). Since the QLR-statistic is the largest of many F-statistics, its distribution of critical values will not be the same as for the F-statistic itself. Comparing the QLR-statistics to the F-statistics shows that the QLR-statistics are larger. This reflects the fact that the QLR-statistics looks at the largest of several F-statistics and therefore has several break dates and more opportunities to reject the null hypothesis. The critical values for the QLR-statistic must therefore be obtained from a different distribution which depends on the number of restrictions being tested. The number of restrictions being tested is the number of coefficients (including the intercept) that are being allowed to change under H_1. The critical values also depend on τ_0/T and τ_1/T, which expresses the endpoints of the subsample as a fraction of the total sample size (Stock, Watson 2007).

For several years the distribution described above remained a mystery and the Quandt statistic was hard to use in practical applications. The breakthrough was presented by Andrews (1993) who found the asymptotic distribution of a wide class of tests for structural change in econometric models. He also provided a table for critical values where the distribution is nonstandard and depends on two parameters; the number of restrictions and the range of the sample that is examined for the break date[11]. In 2003, a revised version of the table was presented in a corrigendum of the original article (Andrews 2003). A table of the revised distribution is provided in Table A.3 in the appendix.

5.3 Estimating the timing of structural change – least squares estimation

Detecting a structural change can be done using the QLR test described above where in some cases the most probable break date would be the one with the highest test statistic. This way of detecting the whereabouts of the break turns out to only be a good estimate in the case when the regression tested is linear and when the Chow test is constructed with the homoscedastic form of the covariance matrix. Therefore, in order to correct for the possibility of a heteroscedastic form of the covariance matrix, we have chosen to apply the same method used in Hansen (2001), where they use least squares estimation, a method developed by Jushan Bai (1994, 1997a, 1997b). Operationally the sample is split at every possible break date, the coefficients are calculated and the sum of squared errors is estimated for both sub samples. The break date will be represented by the date that minimizes the sum of squared errors or equivalently, minimizes the residual variance. This can be plotted on a graph where we have total sum of squared errors on the y-axis and break dates on the x-axis. According to theory, if the true parameters are constant, the calculated sum of squared errors will vary randomly across break dates. However if there is a structural break, the estimates will vary systematically where a well defined minimum will be located near the true break date (Hansen 2001).

5.4 Systematic method for estimating multiple structural changes

If evidence of a structural break is found one would consider testing for multiple structural breaks (i.e. local minimums in the least squares chart), since there might exist more than one break in the sample period. This method was discussed by Chong (1995) and Bai (1997a) and is

[11] A method for calculating p-values was also later provided by Hansen (1997) as he presented computationally convenient approximations p*(x) to the asymptotic p-value functions p(x) for the distributions described in the literature above.

sequential. After detecting evidence of a break they split the sample into two, at the estimated break date. The break test is then reapplied to the new subsamples. If the test detects structural breaks in the subsamples they estimate the timing of the breaks by least squares estimation. The sample is split again, but this time at the new estimated break date(s). This is repeated several times, where overlapping subsamples are used in order to confirm estimations and detect differences. The tests are repeated until a satisfactory analysis has taken place e.g. until each subsample fails to reject the hypothesis of a break. The same approach is used even though one might fail to detect a structural break in the first time period tested. This is especially important in long time series, where the sample might have to be split into shorter time periods in order to detect significant structural breaks. Although the initial test may not be significant, using local minima from least squares estimation as "possible" structural changes in order to determine the time period partition is an appropriate way of gaining accurate results. We have conducted such tests systematically in the order shown in Table A.1. Whether or not a structural break is identified, a test is still conducted in order to find a date which minimizes the sum of squared errors. This is according to Bai (1997b) the most effective way to determine the existence of structural breaks.

It is also important to note that different estimation periods might generate differences in significance and timing of break dates. Therefore, we have not always based our analysis on the break date with the highest F-statistic among significant break dates. Instead, we look for reoccurring potential break dates in our range of estimation periods. As an example, we have used break dates with lower F-statistics but with presence in three estimation periods instead of break dates with higher F-statistics, but presence in only one estimation period. We are aware of the fact that an evolution of the break (period of instability) is a more accurate assumption instead of a immediate structural break. However it is hard to determine the beginning and end of the evolution. Therefore we choose to use one specific date in our before-and-after regression analysis, determined by the least squares estimation.

5.5 Determining changes in safe haven characteristics

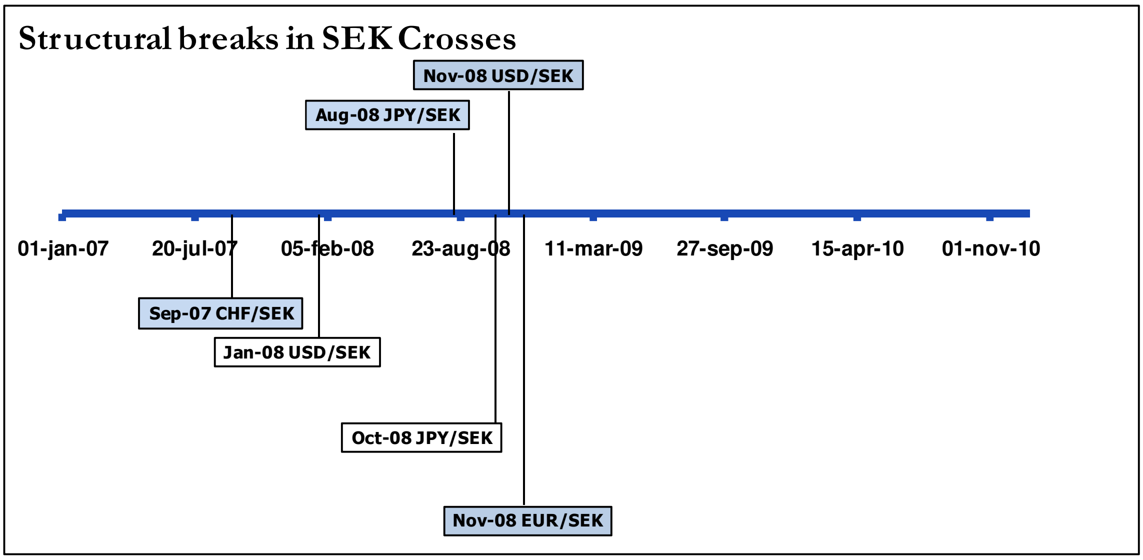
When determining the cause of the structural break, a dummy variable denoting the time after the break date is included in our model. We also interact all variables from Equation 2 with the dummy variable and estimate the extended model. If we find evidence of a structural break, significant coefficients for the dummy variable and/or the interaction variables represent the variables responsible for the break. To determine whether the structural change has been followed by safe haven characteristics in the SEK we conduct regressions robust to heteroscedasticity on either side of the break date. This provides regression outputs from both before and after a potential break date which will help to determine if the SEK has developed safe haven features after the break date. The time period used in the analysis for each currency pair depends on the break dates estimated in our QLR tests. As stated above, different estimation periods might generate differences in significance and timing of break dates. When a break date is significant in more than one time period we use the time period where the chosen break date has the strongest significance, for our regression analysis.

6. Results

6.1 Results from the QLR test

In table A.1 in the appendix, both the systematic method used and its result is illustrated. The table depicts all tests and their significance as well as the estimated break date using least squares estimation. The critical value used is taken from table A.3 (Andrews 2003) and equals 30.43 with 12 restrictions, a 70% sample test and a 5% significance level. For the TCW test the critical value is 33.56 as 14 restrictions are tested.

Figure 2.



Timetable showing the significant break dates for the four crosses analyzed. The shaded dates are the ones used in our before-and-after regression analysis.

As we can see in Figure 2, the SEK has in different crosses experienced several breaks within the timeframe of the financial crisis. However the TCW index has not experienced any significant breaks during the last 10 years. Table A.2 in the appendix displays the regression output for the TCW index over the whole sample period. We see that the TCW index has had a negative and statistically significant relationship to the fortunes of the S&P500. Furthermore, the positive coefficient for returns on 10year Treasury notes indicates a statistically significant relation to bond demand. This effect is however reversed after a day since the lagged coefficient is negative. The opposite case is true for the FX volatility coefficients index.

Focusing on the cross rates; SEK/CHF experienced a significant break during the early stages of the financial crisis in September 2007. SEK/JPY has experienced an evolution of breaks between August and October 2008. However, the ultimate date estimated for the regression in the before-and-after analysis occurs in August since this date has been indicated as a break date in three different tests, although only one of them was significant. This is seen in Table A.1 in the appendix. The SEK/USD has experienced two significant breaks, in January and in November 2008. The later date is detected in two tests as well as carrying the higher F-statistic and is therefore chosen when performing regressions. The Euro has experienced one single break, also in November 2008. The primary timeframe where breaks have occurred takes place just after the peak of the financial banking crisis of September/October 2008.

Table 1.

Yt	Break Date		Equity	10Y	VIX	TED	FXvol	Equity.L1	10Y.L1	VIX.L1	TED.L1	FXvol.L1	Yt.L1	α
SEKUSD	**04-nov-08**	β	0,034	0,089	0,010	1,778	-0,002	0,158	0,030	0,039	-2,756	-0,016	0,327	-1,601
		Interaction	**0,285**	-0,212	0,005	-3,182	0,064	-0,011	0,274	-0,083	5,728	-0,044	**-0,277**	**9,766**
SEKEUR	**(19-25) nov-08**	β	0,067	-0,052	0,015	0,422	0,028	-0,012	-0,053	-0,011	-0,623	-0,021	0,182	-0,415
		Interaction	**0,199**	-0,004	-0,026	0,906	-0,024	**-0,090**	**0,196**	-0,017	0,120	0,023	**0,149**	**4,760**
SEKJPY	**12-aug-08**	β	-0,001	-0,016	0,041	0,048	-0,019	-0,050	0,015	0,033	-0,190	-0,007	0,278	0,941
		Interaction	-0,074	0,081	-0,024	-1,413	-0,007	**-0,372**	**0,554**	-0,069	2,899	0,045	**-0,294**	**6,064**
SEKCHF	**11-sep-07**	β	0,125	0,021	0,021	-0,771	-0,004	-0,022	0,036	0,012	-0,735	0,004	0,530	-0,140
		Interaction	**0,150**	**-0,223**	-0,009	**2,140**	0,017	**-0,056**	0,005	-0,013	-0,607	0,000	**-0,170**	-0,033

The table displays the output from regression (5) where the interaction variables responsible for the break are characterized by a shaded background and bold numbers

$\Delta Equity_t = one\ percent \rightarrow \Delta SEK/X_t = y\ percentage\ points,$

$\Delta 10year_t = one\ percentage\ point \rightarrow \Delta SEK/X_t = y\ percentage\ point,$

$\Delta VIX_t = one\ unit \rightarrow \Delta SEK/X_t = y\ percentage\ point,$

$\Delta TED_t = 10\ bps \rightarrow \Delta SEK/X_t = y/10\ percentage\ points,$

$\Delta FXvol_t = one\ unit \rightarrow \Delta SEK/X_t = y\ percentage\ points$

The variables responsible for the change in SEK behavior is identified with a regression including a dummy variable (Equation 5) for the time period after the break as well as interacting all variables with the post break date dummy.

$$R_t^e = \beta_0 + \beta_1 Equity\ Index_t + \cdots + \beta_7 R_{t-1}^e + \gamma_0 d_\tau(\tau) + \gamma_1 [d_\tau(\tau) * EquityIndex_t] + \cdots + \gamma_7 [d_\tau(\tau) * R_{t-1}^e] + \epsilon_t \quad (5)$$

The dummy variables presenting significant coefficients are responsible for the break, since a significant interaction coefficient would mean that the variable of interest has experienced a significant change post the break date. It turns out that different variables are significant in different crosses. The Equity index impact has significantly changed in three of the crosses. For the SEK/JPY however, the impact of the Nikkei has not changed significantly. Other than that, we can see that the non-lagged variables have not had a significant change in any measure except with the SEK/CHF. However looking at the lagged variables we can see a change in the Equity index impact as well as two changes in the 10year bond impact. What can be concluded for all currency crosses is the fact that the autoregressive variable R_{t-1}^{e} has had a significant change. It has decreased in value and in three of the crosses, become negative. This implies reversion to the mean which is an indicator of overall stability of the process but not a safe haven characteristic and therefore not analyzed further. We can also detect a significant shift of the curve intercept to a higher level in three of the crosses.

6.2 Regression results from before-and-after regressions

Above we investigated which independent variables are responsible for the structural break in our factor model. In this part we present results from regressions run before and after the estimated break date for each currency pair. This helps us to determine whether a parameter has significant explanatory power of the fluctuations in the Swedish exchange rate after the structural break. Table 2 displays the output from the regressions.

Table 2.

	SEK/USD		SEK/EUR		SEK/JPY		SEK/CHF	
	Before	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
Equity	0,034	0,320	0,067	0,266	-0,001	-0,075	0,125	0,275
	(0,45)	(5,35)***	(4,84)***	(9,64)***	(-0,06)	(-1,56)	(10,77)***	(14,38)***
10year	0,089	-0,124	-0,052	-0,057	-0,016	0,065	0,021	-0,202
	(0,99)	(-1,28)	(-1,54)	(-0,91)	(-0,34)	(0,62)	(0,67)	(-3,89)***
VIX	0,010	0,015	0,015	-0,011	0,041	0,017	0,021	0,011
	(0,22)	(0,35)	(1,43)	(-0,59)	(2,17)**	(0,39)	(1,80)*	(0,91)
TED	1,778	-1,405	0,422	1,328	0,048	-1,364	-0,771	1,370
	(2,06)**	(-0,25)	(1,33)	(0,32)	(0,13)	(-0,78)	(-1,92)*	(2,10)**
FXvol	-0,002	0,061	0,028	0,004	-0,019	-0,027	-0,004	0,012
	(-0,10)	(2,09)**	(3,00)***	(0,35)	(-1,36)	(-0,71)	(-0,52)	(0,98)
Equity L.1	0,158	0,147	-0,012	-0,102	-0,050	-0,423	-0,022	-0,078
	(4,77)***	(3,30)***	(-0,91)	(-3,27)***	(-3,39)***	(-11,61)***	(-1,97)**	(-4,10)***
10year L.1	0,030	0,303	-0,053	0,143	0,015	0,569	0,036	0,041
	(0,27)	(2,80)***	(-1,30)	(2,30)**	(0,29)	(4,51)***	(1,16)	(0,76)
VIX L.1	0,039	-0,044	-0,011	-0,028	0,033	-0,036	0,012	-0,002
	(0,84)	(-1,03)	(-0,96)	(-1,35)	(1,81)*	(-0,85)	(1,01)	(-0,15)
TED L.1	-2,756	2,972	-0,623	-0,503	-0,190	2,709	-0,735	-1,341
	(-3,16)***	(0,55)	(-1,95)*	(-0,12)	(-0,53)	(1,53)	(-1,83)*	(-2,06)**
FXvol L.1	-0,016	-0,060	-0,021	0,001	-0,007	0,038	0,004	0,004
	(-0,64)	(-2,20)**	(-1,99)**	(0,10)	(-0,48)	(1,01)	(0,43)	(0,30)
Yt L.1	0,327	0,050	0,182	0,330	0,278	-0,016	0,530	0,360
	(8,74)***	(1,13)	(4,44)***	(7,80)***	(12,10)***	(-0,42)	(24,10)***	(11,76)***
Intercept	-1,601	8,165	-0,415	4,345	0,941	7,005	-0,140	-0,173
	(-9,84)***	(4,08)***	(-8,80)***	(4,11)***	(10,75)***	(12,43)***	(-1,88)*	(-1,88)*
N	881	649	895	634	2245	709	1495	949
R^2	0,864	0,328	0,510	0,401	0,436	0,618	0,802	0,393

Table 2 displays coefficients and t-values from the before-and-after regressions. *, ** and *** indicate statistical significance at the 1, 5 and 10 percent respectively.

$\Delta Equity_t = one\ percent \rightarrow \Delta SEK/X_t = y\ percentage\ points,$

$\Delta 10year_t = one\ percentage\ point \rightarrow \Delta SEK/X_t = y\ percentage\ point,$

$\Delta VIX_t = one\ unit \rightarrow \Delta SEK/X_t = y\ percentage\ point,$

$\Delta TED_t = 10\ bps \rightarrow \Delta SEK/X_t = y/10\ percentage\ points,$

$\Delta FXvol_t = one\ unit \rightarrow \Delta SEK/X_t = y\ percentage\ points$

For the SEK/USD there are some significant results. First, we can see that the return on the S&P500 has a significant impact on the SEK both before and after the structural break. Second, the coefficient for FX volatility is positively significant after the break date. However this effect seems to be reversed after a day since the negative lagged FX volatility coefficient is statistically significant. The relationship to bond demand is also statistically significant for SEK/USD. This effect is somewhat delayed since it is only the lagged coefficient on 10year note return that is statistically significant. We can also point out that that the TED spread no longer has any significant explanatory power after the break date. The overall explanatory power of the model is substantially lower after the break date; comparing the R^2 measures we see that it has decreased from 0,864 to 0,328.

The story is slightly different for the SEK/EUR. We see that the return on S&PEuro350 still has a statistically significant impact. However, after the break date this effect is partially reversed after a day. It is also interesting that the significant relationship to FX volatility has disappeared after the structural break for SEK/EUR. The same is true for the lagged TED spread coefficient. The lagged coefficient representing returns on 10year notes is statistically positive significant after the break date. The R^2 is roughly unchanged between 0,5 and 0,4.

A few comments can be made about the characteristics of the SEK/JPY parameters as well. To begin with, for returns on the Nikkei225 it is only the lagged coefficient that is statistically significant, both before and after the break date. Moreover, the relationship between the VIX and the SEK/JPY before the break date disappears after the structural break. As for the two previous currency pairs, the returns on 10year treasury notes have statistically significant explanatory power on the respective exchange rate after the break date. For these regressions the R^2 increased from 0,436 to 0,618.

There is a positive relationship between the SEK/CHF and intraday changes in the return of S&PEuro350. This effect is however partially reversed after a day both before and after the trend break. As opposed to the three cross rates previously mentioned, the return on 10year treasury notes has statistically significant negative influence on the SEK/CHF after the break date. Before the break, the TED spread coefficient was negative both for the lagged and non-lagged case. However, these coefficients were only significant at the 10 % level. After the break, both TED spread coefficients are significant at the 5 % level. The signs of the coefficients are opposite though, meaning that the positive effect of an intraday change is reversed after a day. We can also mention that the weakly significant VIX coefficient lost its significance after the break date and that the R^2 measure has decreased from 0,802 to 0,393.

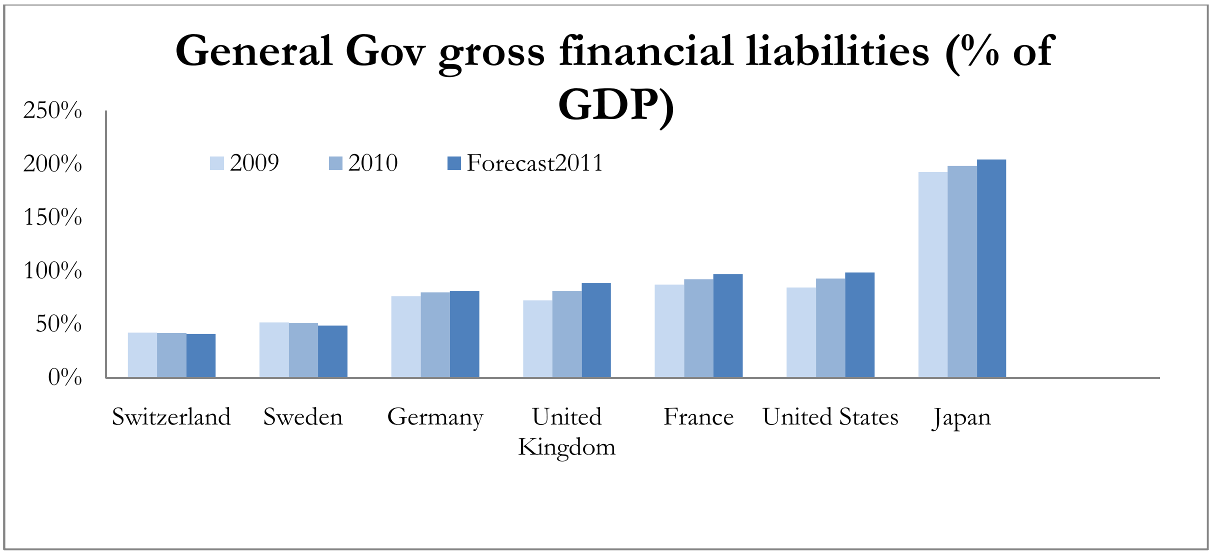
6.3 Robustness tests

The results presented above are robust to several changes. First, we replace the return on 10year treasuries with Merrill Lynch's Move Index; an index of implied volatility on Treasury options. The break dates estimated were robust to this change as well as all of the coefficients from the before and after regressions. The Move index itself was however not a significant parameter in the model. We also replaced the equity indices used in our model with the MSCI World index in order to capture world equity market performance rather than the performance of the "domestic" equity market and received similar results. The results from the TCW regression are also robust when excluding the Swedish repo rate.

6.4 Results from Country Element analysis

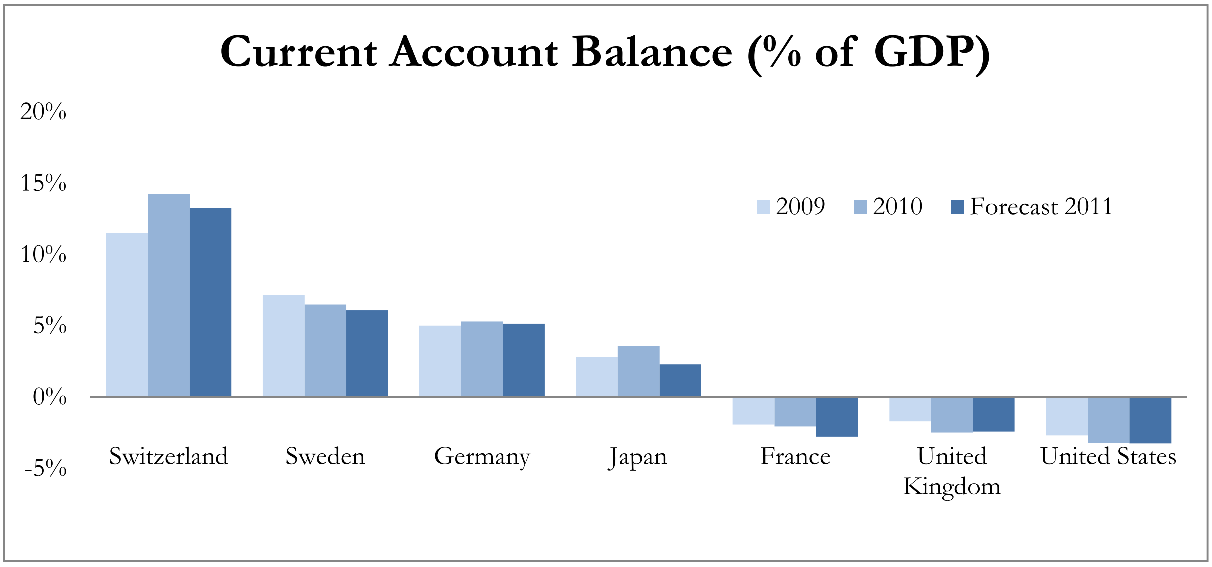
6.4.1 Country risk and vulnerability

Figure 3.



As we see in Figure 3 representing Government debt as percent of GDP Sweden ranks low in the chosen comparable countries, with a Debt to GDP ratio of approximately 50%.

Figure 4.



In Figure 4 we see a Current Account Balance as a percent of GDP. Sweden shows high values compared to the other countries although lower Switzerland

6.4.2 Size and liquidity

Table 3.

Currency distribution of global foreign exchange market turnover[1]

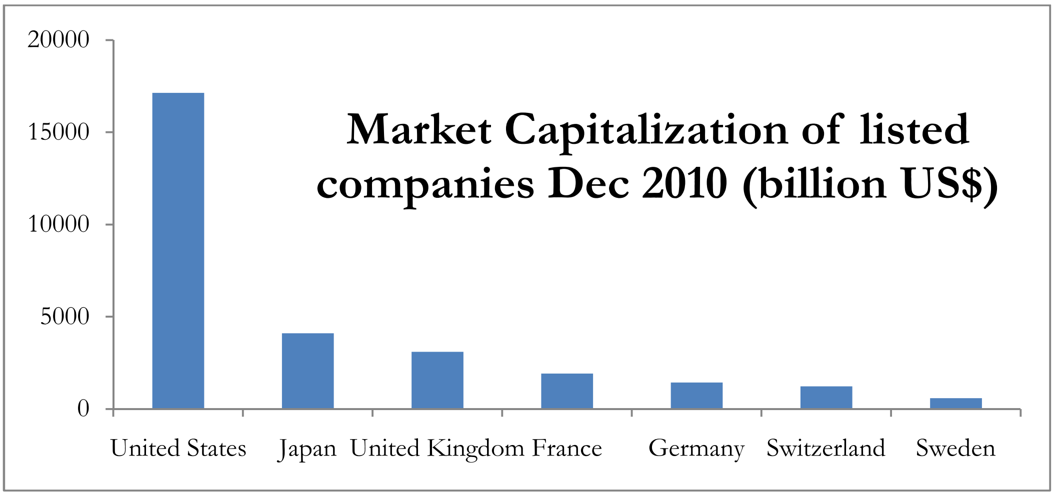
Percentage shares of average daily turnover in April

Currency	2001	2004	2007	2010
US dollar	89,9	88,0	85,6	84,9
Euro	37,9	37,4	37,0	39,1
Japanese yen	23,5	20,8	17,2	19,0
Pound sterling	13,0	16,5	14,9	12,9
Australian dollar	4,3	6,0	6,6	7,6
Swiss franc	6,0	6,0	6,8	6,4
Canadian dollar	4,5	4,2	4,3	5,3
Hong Kong dollar	2,2	1,8	2,7	2,4
Swedish krona	2,5	2,2	2,7	2,2
New Zealand dollar	0,6	1,1	1,9	1,6
Norwegian krone	1,5	1,4	2,1	1,3

[1] Because two currencies are involved in each transaction, the sum of the percentage shares of individual currencies in the world totals 200% instead of 100%.

Table 3 demonstrates that Sweden ranks relatively low compared to other safe havens counties in our proxy for the size and liquidity measure. The SEK generally seems to trade a third of the volume of the CHF.

Figure 5.



In Figure 5 Sweden ranks extremely low when we look at the Market Capitalization of listed companies on the domestic market as our market size proxy. Total market cap in Sweden as of Dec 2010 was roughly 581 billion US$, compared to Switzerland which has a market cap of 1230 billion US$.

6.4.3 Financial openness

The total globalization index is as described before a weight of economic, political and social globalization measures. Sweden ranks as the most globalized country in our sample of countries.

Figure 6.

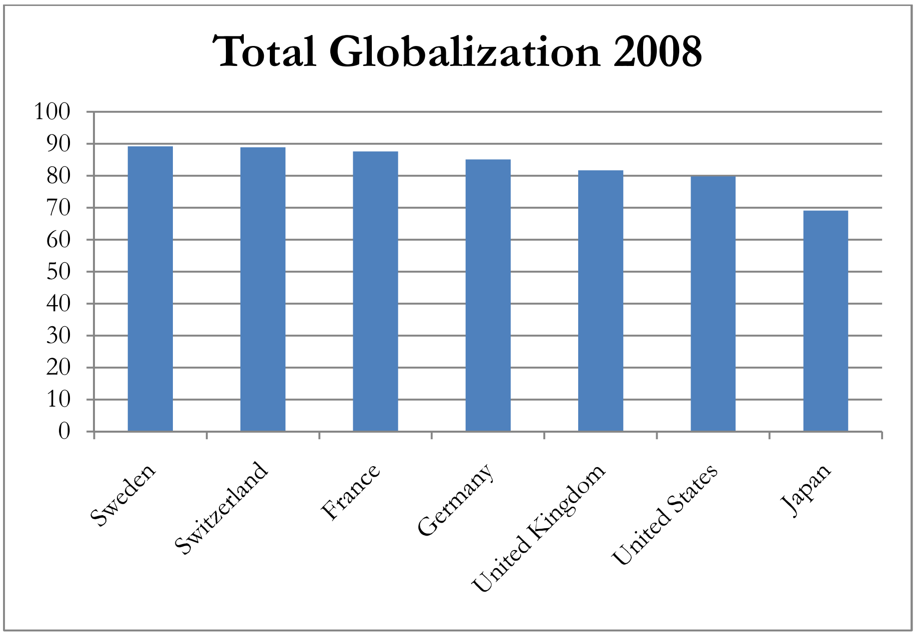
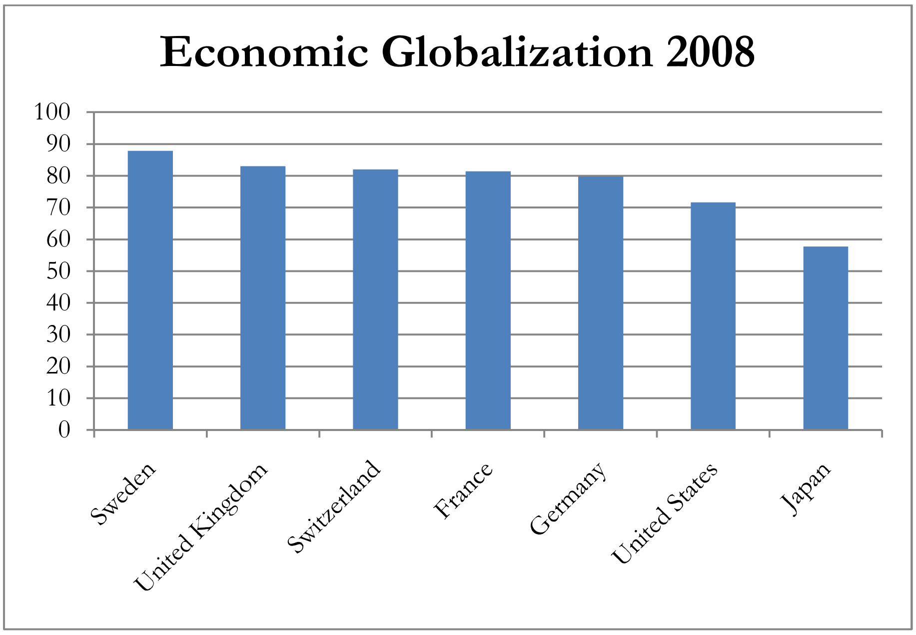


Figure 7.



7. Analysis

In this section, we review what implications a change in the various coefficients have had and attempt to explain why these coefficients have undergone changes. The interpretation and implications of our results are rather dispersed. Some coefficients point in the direction of safe haven characteristics and others tell a totally different story. This section is concluded with an analysis of the three country elements investigated.

To begin with, the TCW has not experienced any structural breaks during the sample period indicating no change in the features of the weighted index of the SEK. When conducting the heteroscedastic robust regression over the whole sample period we see safe haven features regarding equity market performance and bond demand. In terms of FX volatility however, the case is opposite. Thus, the results are contradictive. Furthermore, the R^2 measure is relatively low (value of 0.115) compared with the other regressions conducted in our study, which could be a result of the index being weighted over 21 different currencies and the relatively long time period estimated. Because of the above we choose not to focus our analysis to these results.

Turning to the SEK/USD case, the coefficient for FX volatility indicates a safe haven characteristic after the break date since it is positive and statistically significant. The lagged coefficient however is negative; the safe haven feature seems to be reversed after a day. The interpretation is that investors turn to the SEK when FX markets experience greater volatility, in fear of turmoil. The previous day however they normalize their positions when the change in volatility is no longer a surprise, but expected or already taken into consideration. Another sign of the SEK being a safe haven to the US Dollar after the break date is the positive relationship to bond demand, as noted by the positive coefficient for returns on 10year Treasury notes. When investors are more risk averse their demand for safety i.e. bonds increase. Since the excess return of the SEK over the USD is positively related to bond demand it implies that the SEK provides safety in stressful times as a safe haven should. In contrast to this, the SEK/USD has a positive relation to the performance of the equity market as denoted by the S&P500 coefficient. This is not a safe haven feature since a safe haven would provide safety and appreciate in equity market downturns. After the break date the excess return of the SEK/USD lost its significant relationship to the TED spread, thereby losing a safe haven feature.

Furthermore, the SEK/EUR is also positively related to equity market returns. Since this effect is only partially reversed after a day it does not imply safe haven features. It does however show safe haven features in one aspect, the relation to bond demand is positive. The same safe haven feature is present for the excess return of the SEK over the Japanese Yen. Moreover, the SEK/JPY shows another safe haven feature as it is negatively related to the fortunes of the Nikkei225 which implies that the SEK has provided hedging benefits to the JPY in equity market downturns. The SEK/EUR does not have a safe haven relation to the FX volatility after the break date, as it had before the break date. The SEK/JPY shows a similar development since it had a safe haven characteristic in the positive VIX coefficient before the break date, which was lost post the break date.

The interpretation of the results post break date for the SEK/CHF is contradictive because of the negative relation to bond demand and the simultaneously positive relation to illiquidity. Investors do not demand the SEK in favor of the CHF in times of stress and greater bond demand. On the other hand, investors seek the SEK when liquidity dries up (an effect that is reversed after a day) which is a safe haven feature. This is strange since the CHF is according to our liquidity analysis a more liquid currency. The relation between the SEK/CHF and equity market returns is the same as for the SEK/EUR case.

Generally speaking, the R^2 measure has decreased after the break date, although only slightly. This indicates that the factors explaining the cross rates in our factor model, has decreased in their explanatory power. To summarize the results from our before-and-after regressions as well as results from our break tests: the fact that the equity impact has increased positively is not surprising since equities along with the SEK has increased during the last years. This will ultimately result in a positive correlation overall. This means that safe haven characteristics have decreased. It should however be noted that the effect of the stock indices is small which in itself points to some safe haven features. The lagged equity parameter has depreciated further remaining negative for the currency crosses. This parameter is however not as large as the non-lagged equity parameter which then ultimately still points to the feature of overall positive correlation with equity indices. Two crosses have experienced an increased positive effect from the lagged bond index, which can be seen as a delayed safe haven effect, although this cannot be seen as a general feature of our sample. FX volatility generally has no significant impacts on SEK returns, neither has the VIX or the TED spread. This means that the chosen risk factors cannot explain the appreciated Swedish exchange rate. With this taken in mind, we cannot conclude whether the SEK experiences the safe haven characteristics considered in our model or not.

A prominent change is the dramatic increase of the intercept in three of the currency pairs. This implies, ceteris paribus, a positive shift in the overall return of owning the SEK after the crisis.

This in itself is not an increase of safe haven character but rather a significant rise in the valuation of the SEK. A strengthening trend does not make an asset a safe haven.

The analysis gives mixed results and overall we are unable to determine any safe haven features of the SEK. When analyzing our results from the country element analysis we can see that there are factors pointing in favour of and against the SEK being a safe haven. When looking at the factors chosen as a proxy for the first element (country risk and vulnerability) we see an evident inclination towards a low risk and invulnerable country. Whilst debt-to-GDP has risen in most countries we can see a realized and expected decline in Sweden as well as in Switzerland during recent times, which suggest that Sweden is a safe country. Along with Switzerland (a common safe haven), Sweden also has a greater current account balance to GDP compared to the other countries which also points towards safe haven features.

However, according to the following two elements analyzed, the SEK should not be seen as a safe haven currency in the long run. The second element describes size and liquidity where we can see that the SEK turnover in the FX market, as a proxy for liquidity, is very small compared to more common safe havens (Table 3). When global risk aversion is high, market liquidity tends to dry up and liquid markets usually attract more capital. To estimate the size of the market we have chosen to plot the market capitalization of listed companies, where we can see that the Swedish market is small in comparison. This is not a feature consistent with usual safe haven characteristic. The results from the third element (financial openness) also contradict safe haven features of the SEK. The globalization index shows a significantly larger globalization value than the other countries examined. A high rate of globalization makes a country more vulnerable to global turmoil. The fact that Sweden is such an export driven economy also confirms the high degree of globalization. Another aspect of the export driven nature of the economy is the fact that it is in the interest of the Swedish government to keep a low valuation of the SEK, especially during global crises. This view is also confirmed by recent complaints from the Swedish industry stating that a strong currency could cut profits[12]. The Swedish economy gained from a weak krona in the beginning of the recent financial crisis. In line with Sweden's high rate of globalization, we draw the conclusion that Sweden has come out strongly from the crisis mainly depending on the fact that our main export partners, Germany and the Nordic countries, have also experienced a decent recovery. If countries more closely connected to Sweden where to experience an economic disaster, the effect on the Swedish economy would be more prominent. Consequently, the SEK should not be seen as a safe haven in the long run.

[12] SVD (March 7 2011), "*Krokodiltårar för kronan*"

To conclude our findings we can say that there are elements that can explain why the SEK is seen by the media as a relative safe haven during for example the recent troubles in the Eurozone. However, in the long run the second and third element suggests that the Swedish economy is too small and too dependent on global market conditions in order to function as a safe haven.

8. Conclusion and discussion

The results and the analysis above show contradictive results regarding the safe haven parameters of our empirical model. Several coefficients are statistically significant and point in the direction of safe haven features whereas others tell the opposite story or are not significant at all. This points to the fact that there are a lot of factors explaining currency movement and that the exchange rate can be explained by several features not present in this model. Our analysis results in the fact that we are unable to conclude whether the SEK possesses safe haven characteristics post the financial crisis. When looking at the fundamentals of Sweden as a country in terms of risk, liquidity and globalization we can identify why the SEK may look like a relative safe haven in present times. Both the low debt-to-GDP ratio and the high current account to GDP ratio point to strong national finances and low country risk. There are however two big factors which must be taken into account when determining if the SEK can function as a safe haven in the long run. According to our analysis, Sweden is a small open economy dependent on the global environment. Even though Sweden has managed to recover at a remarkable pace from this crisis, the high rate of globalization does not guarantee the same outcome in the future. The size of the Swedish FX market may also be too small to provide the liquidity a full time safe haven must be able to provide.

Therefore, we conclude that the appreciation of the SEK in recent time is not a result of safe haven characteristics rather a result of strong a development in the Swedish economy along with troubles in the Eurozone. This for example since, investors wanting to be exposed to Europe has been forced to allocate their resources in economies with strong fiscal balances in order to limit their exposure to risky sovereign debt.

Further research on the Swedish Krona as well as safe haven features is encouraged. Including factors in the model that can explain exchange rates, other than global risk appetite parameters, is a constructive development of our thesis and could give more accurate results. Since some of the risk parameters included in our factor model have low significance, it is also interesting to include other risk variables in future research. A potential caveat with our analysis is that it is hard to account for carry trades when using the TCW index as dependent variable. Therefore we encourage future researchers to conduct a more thorough investigation of the SEK's behavior with respect to the weighted TCW index. In terms of behavioral finance future research could address the question of whether currencies are usually considered during flight to quality or if attention of risk averse investors is mainly focused to bonds. One could also divide the analysis into examining downturns and upturns in the market separately.

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http://www.cmegroup.com/trading/fx/realized-fx-volatilities/methodology.html

OECD
http://www.oecd.org/document/0,3746,en_2649_201185_46462759_1_1_1_1,00.html

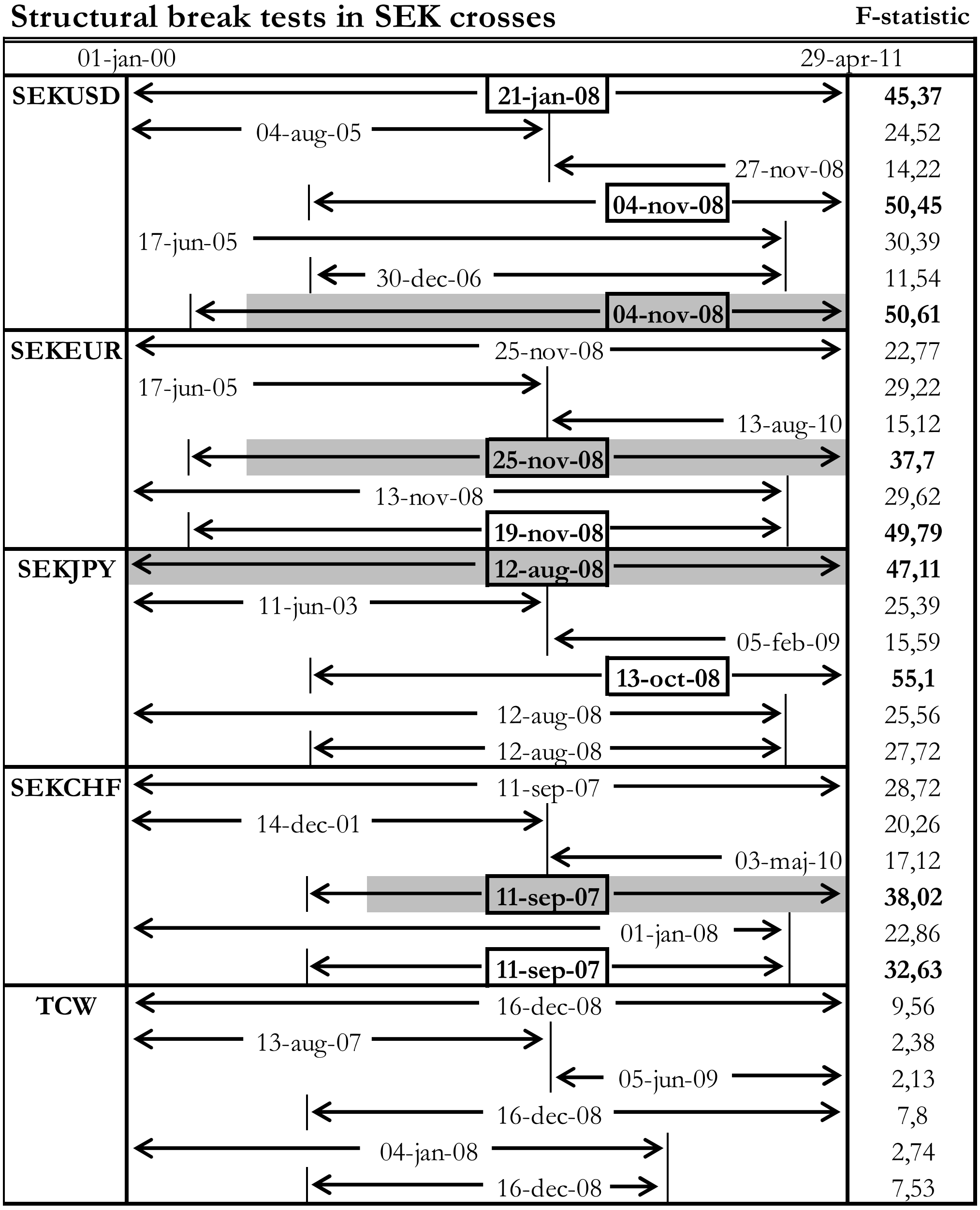
IMF
http://www.imf.org/external/data.htm

KOF Swiss economic institute
http://globalization.kof.ethz.ch/

Appendix

Table A.1

Structural break tests in SEK crosses



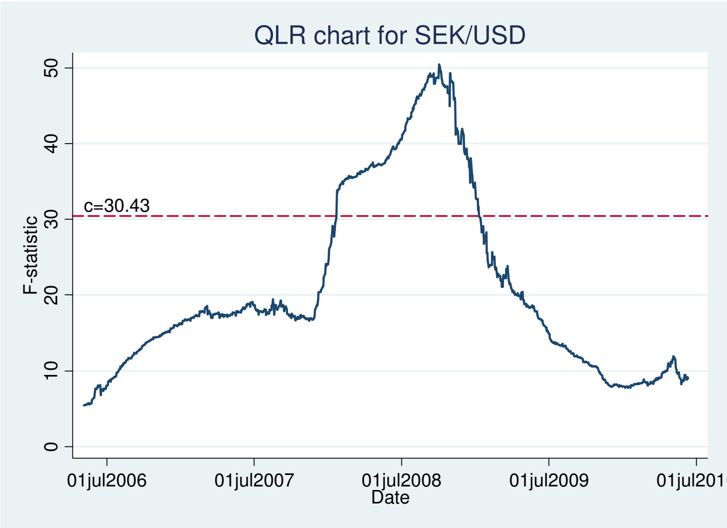
*The arrows show the time period tested for structural breaks using the QLR test. The date between these arrows is the date detected as a minimum using least square estimation. The dates in boxes represent minimums that are significant break dates. The darker shaded area indicates the period chosen to conduct the before-and-after regressions.

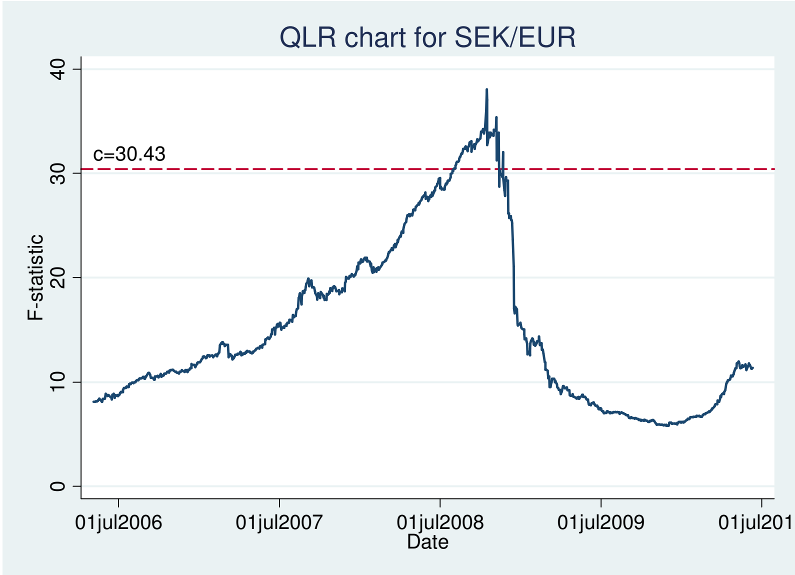
Table A.2

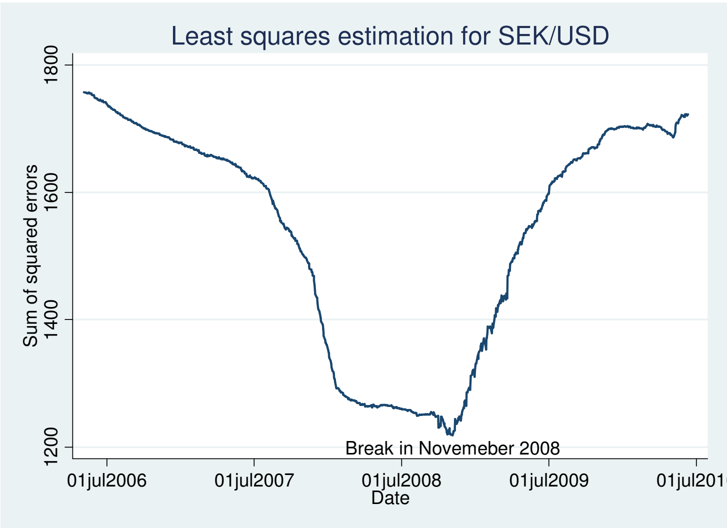
TCW Index output

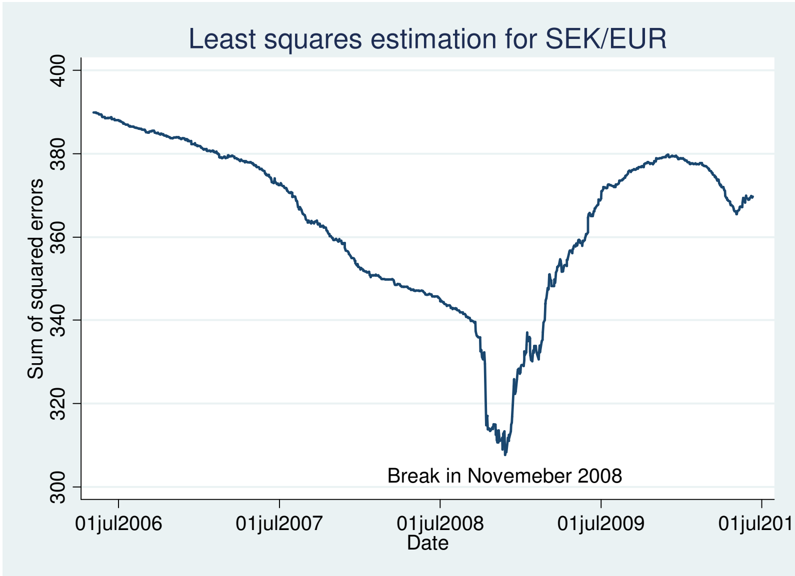
Equity	10year	VIX	TED	FXvol	Equity L.1	10year L.1	VIX L.1	TED L.1	FXvol L.1	Own lag	Intercept
-0,060	0,087	0,010	-0,240	-0,015	-0,082	-0,066	-0,010	0,245	0,017	-0,061	-0,024
-3,985	3,595	0,904	-1,851	-2,412	-8,082	-2,672	-0,847	1,891	2,629	-2,003	-0,634
***	***		*	**	***	***		*	***	**	
N	2954	**R2**	0,115								

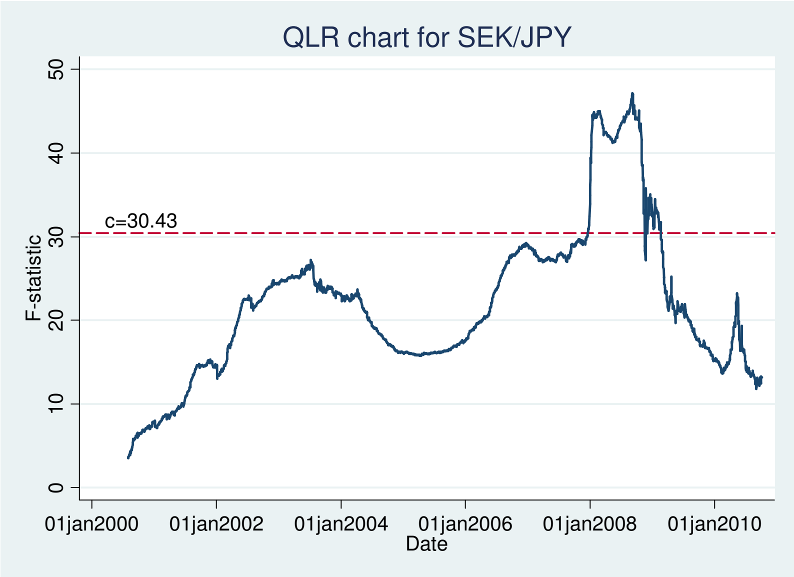
Graphs from the QLR test and Least Squares estimation










QLR chart for SEK/JPY
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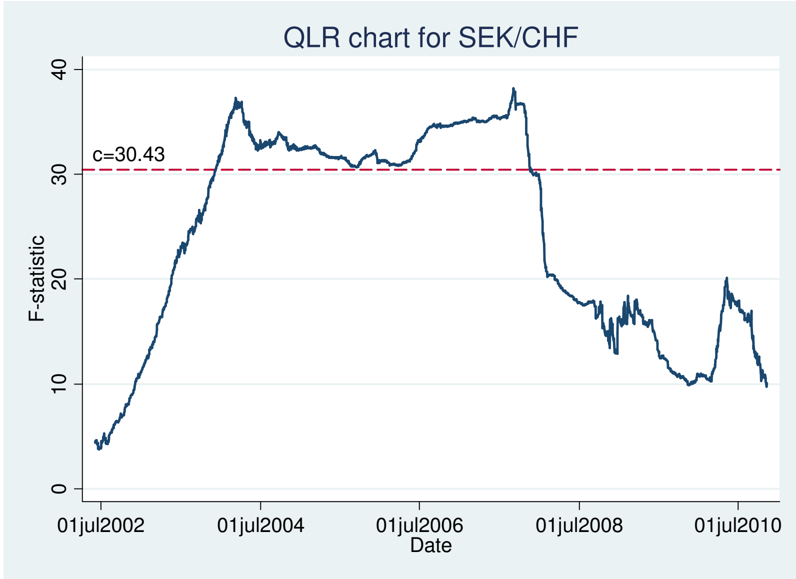
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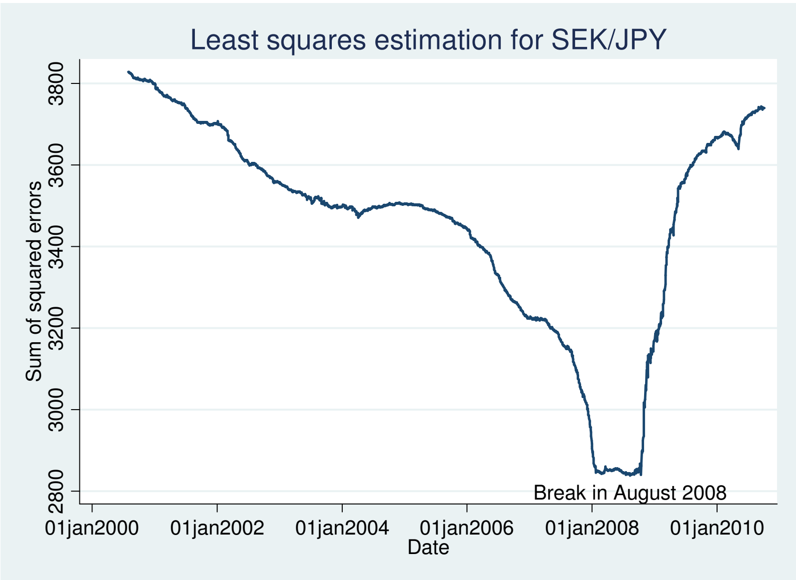
Least squares estimation for SEK/JPY
Sum of squared errors
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3200
3400
3600
3800
Break in August 2008
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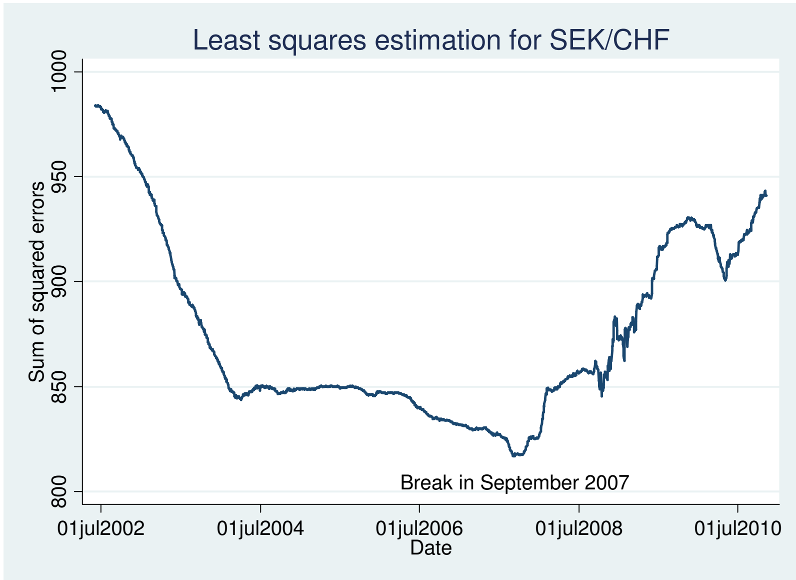
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Sum of squared errors
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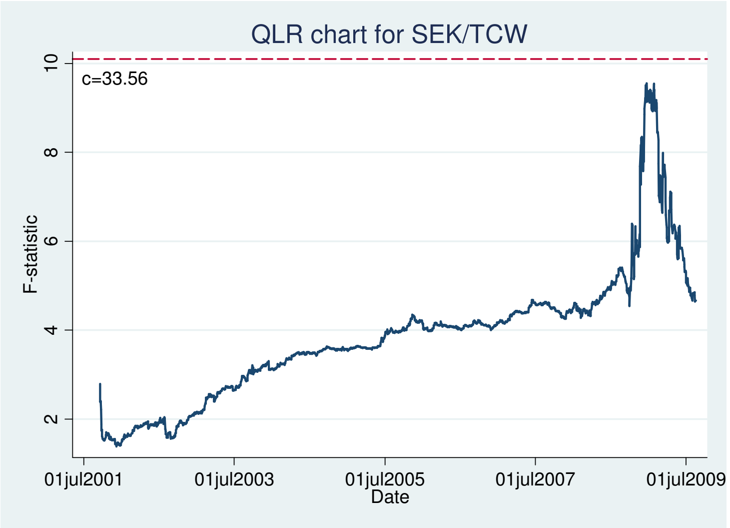
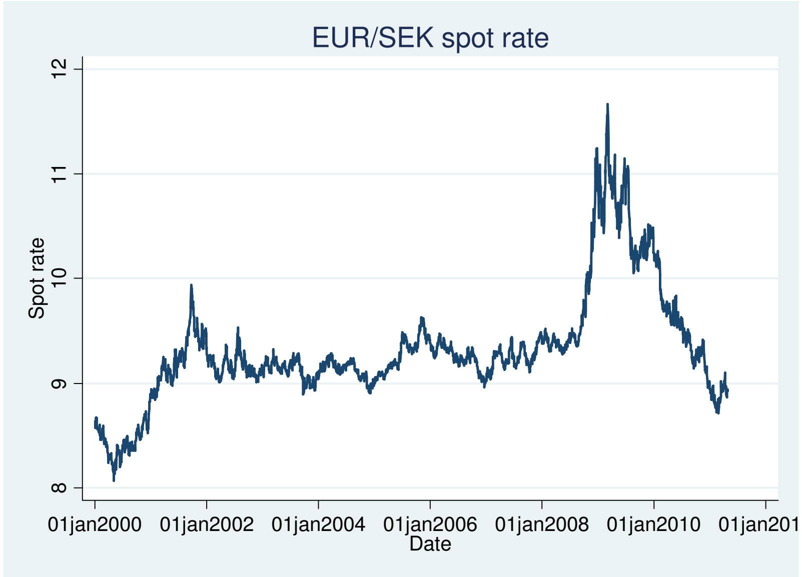
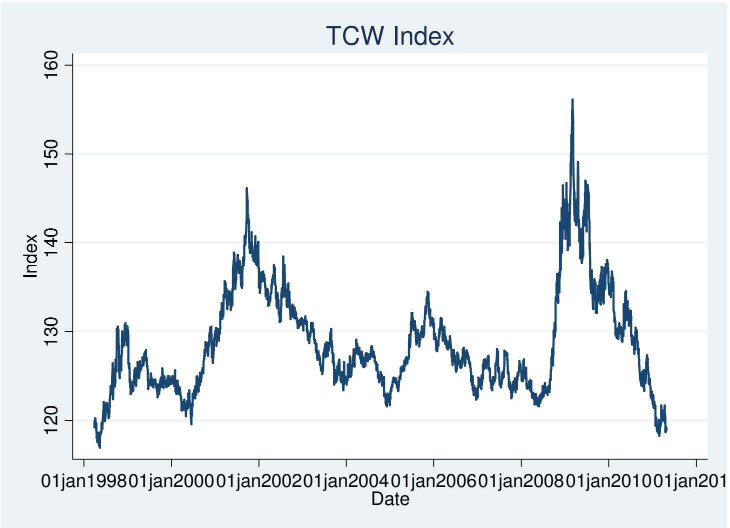
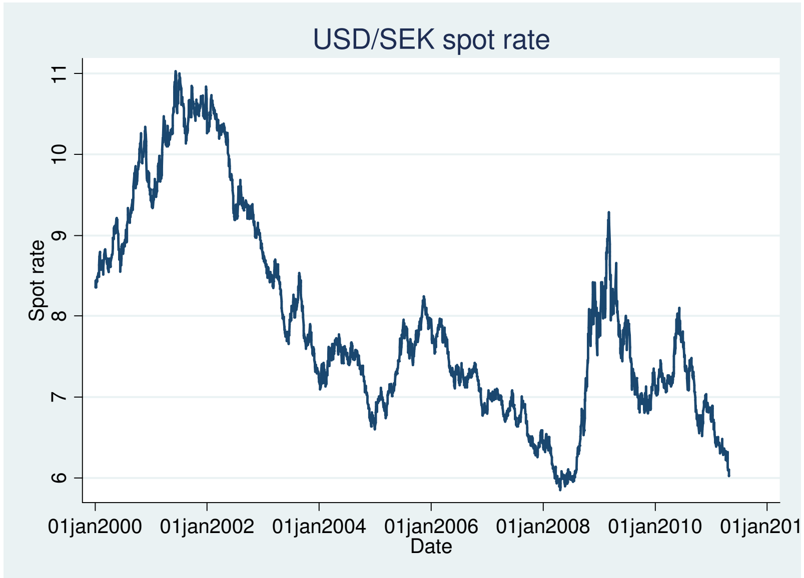
Date

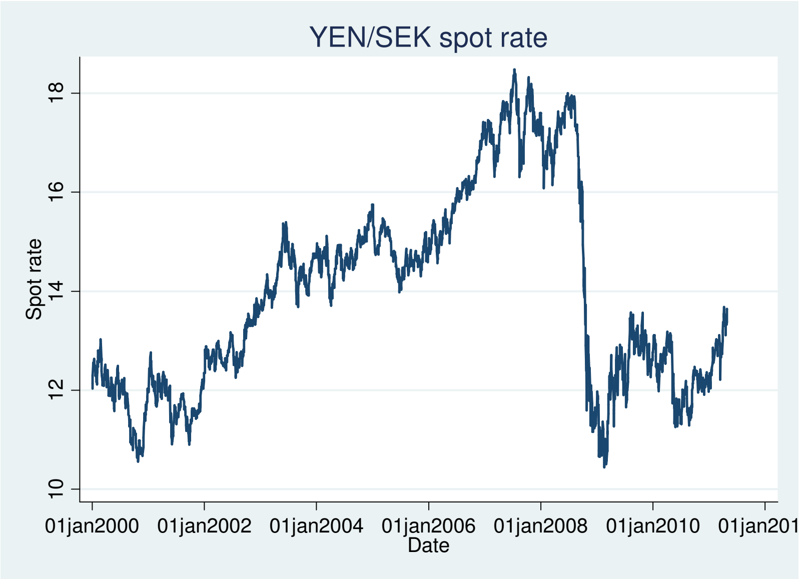




The plotted TCW index and the Exchange rates







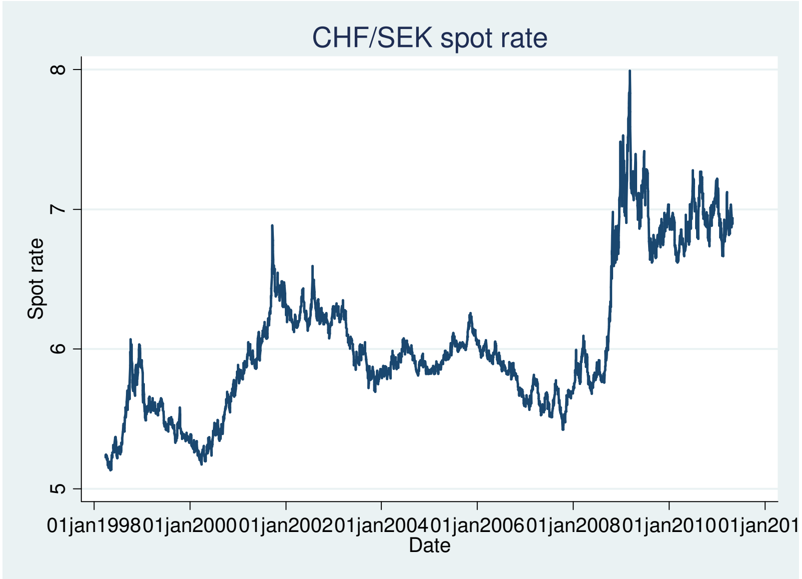


Table A.3 Andrews Table for F-statistics (2003)

		$p = 11$			$p = 12$			$p = 13$			$p = 14$			$p = 15$		
π_0	λ	10%	5%	1%	10%	5%	1%	10%	5%	1%	10%	5%	1%	10%	5%	1%
.50	1.00	17.24	19.62	24.55	18.52	20.96	25.92	19.76	22.29	27.36	20.98	23.55	29.07	22.24	24.89	30.47
.49	1.08	18.91	21.40	26.48	20.24	22.76	27.93	21.55	24.14	29.46	22.83	25.52	31.14	24.13	26.89	32.57
.48	1.17	19.61	22.13	27.23	20.99	23.54	28.72	22.31	24.94	30.26	23.60	26.32	31.92	24.94	27.71	33.35
.47	1.27	20.18	22.71	27.84	21.55	24.11	29.33	22.87	25.55	31.04	24.20	26.95	32.57	25.55	28.38	34.07
.45	1.49	21.02	23.58	28.76	22.38	24.98	30.39	23.77	26.47	32.07	25.14	27.84	33.57	26.50	29.28	35.12
.40	2.25	22.42	24.96	30.28	23.85	26.46	31.82	25.27	27.97	33.41	26.68	29.44	35.14	28.09	30.86	36.88
.35	3.45	23.43	26.00	31.24	24.90	27.52	32.87	26.38	29.00	34.43	27.78	30.57	36.31	29.22	32.00	37.87
.30	5.44	24.23	26.79	31.99	25.76	28.36	33.62	27.23	29.87	35.24	28.69	31.39	37.16	30.12	32.90	38.69
.25	9.00	24.97	27.52	32.71	26.48	29.06	34.33	27.98	30.64	35.96	29.50	32.15	37.80	30.93	33.68	39.30
.20	16.00	25.68	28.13	33.33	27.22	29.75	34.97	28.72	31.36	36.71	30.26	32.88	38.42	31.71	34.37	40.02
.15	32.11	26.38	28.81	33.96	27.90	30.43	35.67	29.45	32.04	37.29	30.98	33.56	38.96	32.47	35.10	40.68
.10	81.00	27.05	29.51	34.62	28.63	31.12	36.39	30.17	32.76	37.98	31.71	34.31	39.76	33.22	35.86	41.45
.05	361.00	27.92	30.33	35.36	29.55	31.95	37.12	31.11	33.63	38.78	32.66	35.16	40.65	34.15	36.77	42.34