**Stockholm School of Economics**

Master's Thesis in Finance

# Drivers of Swedish Swap Spreads

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**ABSTRACT**

According to a survey carried out by Bank of international settlements (BIS) and published by the Swedish Riksbank, the average turnover in Swedish interest rate swaps totaled almost SEK 20 billion per day in 2004. The International Swaps and derivatives association (ISDA) reported that the notional outstanding amount of privately negotiated (over the counter) derivatives at the end of 2004 was over $164 trillion around the world compared to the $31 trillion aggregated principal of all the worlds' bond markets taken together.

In this paper, we investigate the drivers of SEK interest rate swap spreads for 5 and 10 year maturities during the period of 1999-2006. We apply an error-correction methodology based on the concept of cointegration. We find that SEK swap spreads are cointegrated with the Swedish borrowing need and the credit spreads on Swedish mortgage bonds. However, only the credit spread is significant in the long term model, suggesting that the risk in the Swedish banking sector is a key swap spread determinant on a long-term horizon.

We then estimate a short term error-correction model that integrates the long-term relationship together with six short term determinants: the slope of the treasury yield curve, implied volatility of CAP contracts, the difference between on-the-run and off-the-run yields, the Swedish borrowing need, Euro swap spread and the credit spread.

Our result shows that the slope of the yield curve, the volatility, the off/on the run spread, the Euro swap spread and the credit spread are important determinants of SEK swap spreads in the short run.

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# 1 Introduction

Since the creation of the first interest rate swap[1] contracts in the beginning of the 1980's the swap market has grown into a large and mature financial market. According to a survey carried out by Bank of international settlements (BIS) and published by the Swedish Riksbank, the average turnover in Swedish interest rate swaps totaled almost SEK 20 billion per day in 2004.[2] The International Swaps and derivatives association (ISDA) reported that the notional outstanding amount of privately negotiated (over the counter) derivatives at the end of 2004 was over $164 trillion around the world compared to the $31 trillion aggregated notional of global government bond markets.[3]

Swaps have become a popular instrument since it helps both borrowers and speculators to accept or to avoid interest rate risk. In a simple swap contract, two counterparties exchange cash flows of floating and fixed interest rate payments. In that way the underlying fixed debt can be transformed to floating debt or the reverse (Hull 2003).

The swap spread is defined as the difference between the fixed rate on the swap contract and the yield on a treasury bond with the same maturity, and it is an important variable in pricing the contracts (Fabozzi 2003).

After the large increase in swap spread volatility in the end of the 1990's, both the industry and researchers have been paying closer attention to the determinants of swap spreads.[4] The studies of swap spreads, performed by analysts and the academic community have more or less focused on two factors embedded in swap spreads, credit- and liquidity risk.[5]
The available research on swap spreads in e.g. the US market is fairly large. However, the results from previous research have not been conclusive[6] and different variables have been found to affect swap spreads in different domestic markets (Cortes 2003). We have therefore chosen to focus on the factors driving SEK swap spreads.

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[1] The use of the word swap will from here on refer to interest rate swaps, more specifically fixed for floating interest rate swaps traded in the Swedish swap market. This is to clarify since there are many different types of swaps such as currency swaps, basis swaps etc.
[2] The Swedish Financial market (2005).
[3] Molinas et al (2002) and Kobor et al (2005).
[4] See Fantuzzi et al (2002) and Kobor et al (2005).
[5] See Grinblatt (1995) ,Duffie et al (1997) and Kobor et al (2005).
[6] See Kobor et al (2005) and Duffie et al(1997)

In our study we want to investigate the fundamental forces driving SEK swap spreads. To be able to do this we need to describe the theory behind the contracts and the swap market and its conventions. We wish to explain the movements in SEK swap spreads over the past 7 years focusing on variables that have a sound economic interpretation.

We have organized our paper in the following way. First we review the theory behind swap contracts and swap spreads and the conventions in the Swedish Swap market. Then we review available previous empirical studies on swap spreads. We move forward by describing our hypotheses regarding possible determinants of SEK swap spreads. Then we present our methodology and finally discuss our study's empirical results.

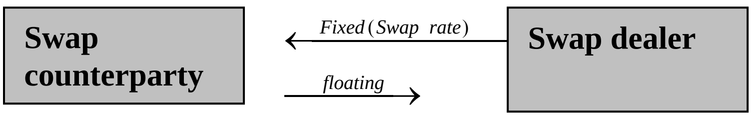
# 2 Theory

In this section we will describe the fundamentals of the plain vanilla[7] fixed for floating swap contracts traded in the Swedish swap market. We will describe how these contracts are valued and describe the Swedish swap market, its conventions and its participants. Moreover, an overview of previous research on swap spread determinants will be provided.

## 2.1 Description of plain vanilla interest rate swaps

The most commonly used interest rate swap is called a generic or plain vanilla swap. In the plain vanilla swap two parties agree to exchange payments that are calculated on the basis of a specified coupon rate and a notional principal amount (Hull 2003). Plain vanilla swaps are structured as an exchange of floating-rate interest obligations for fixed-rate interest obligations. The typical situation for a fixed-for floating interest rate swap is described in Figure (1) below. The counterparties in the swap are known as the payer of the fixed rate and the receiver of the fixed rate (Hull 2003). Swaps can be structured for different maturities but the trading activity is largest up to ten years in global swap markets. (Ducovny 1998).

*Figure 1 Fixed-for floating interest rate swap*




[7] A term that refers to a relatively simple derivative financial instrument, usually a swap or other derivative that is issued with standard features.

## 2.2 Institutional Features and Market Conventions in the Swedish Swap Market

The most common structure of the swap contracts traded in the Swedish swap market are swaps where at the end of every quarter a three-month Stockholm interbank offering rate (STIBOR, with the STIBOR rate determined at the beginning of the quarter) is exchanged against a fixed rate (the swap rate) .[8] STIBOR is the rate of interest offered by banks on deposits from other banks in the Swedish money market[9]. One-month STIBOR is the rate offered on one-month deposits and three-month STIBOR is the rate offered on three month deposits. The levels of STIBOR rates are determined in the interbank[10] market (Hull 2003).
The most common and liquid maturities in the Swedish swap market are 5- and 10-year contracts.[11]

The liquidity in the swap market is provided by market makers[12](Hull 2003). Market makers should always be willing to quote prices were they either want to receive or pay in the swap contract. The bid rate they quote is equal to the fixed rate in a contract where they want to pay fixed and receive floating; the offer rate is then the reverse, the fixed rate where they want to receive fixed and pay floating (Hull 2003). Table (1) below shows typical quotes for plain vanilla SEK swaps. In this example the bid-offer spread is 3 basis points.

*Table 1 Bid/Offer quotes for Swap rates quoted by Swedish Market makers.*

| *Maturity (years)* | *Bid (%)* | *Offer (%)* |
|---|---|---|
| 5 | 3,40 | 3,43 |
| 10 | 3,66 | 3,69 |

Most swaps agreements are between a swap market maker and a swap user who is not a dealer. Market makers play an important role both as liquidity providers but also in holding

[8] See Kobor et al (2005) for a comparison to the US market.
[9] The money market is the financial market for short-term borrowing and lending, typically up to thirteen months.
[10] The interbank market is not a formally organized exchange. It is an informal network of trading relationships among world participants, which include primarily central banks, major commercial banks, investment banks, s ecurities brokers and dealers.
[11] Thomas Olofsson, Head of funding, Debt management department, The Swedish National debt office.
[12] A trader who is willing to quote both bid and offer prices for an asset.

the interest rate risk that are embedded in the contracts. This risk is often hedged using the futures or repo[13] markets. [14]

## 2.3 Default risk in the Swedish swap market

When trading swaps in the Swedish market as well as in the global market deals are documented using the ISDA Master agreement. This is a swap legal documentation, which is updated regularly (the 2002 ISDA is currently in use).[15] The counterparty for which the swap value becomes positive has a credit exposure on the other counterparty equal to the value of the swap. The credit risk is minimized by different practices (Hull 2003). For example, participants in the swap market have minimum rating requirements for the clients they deal with and swaps are marked-to-market on a regular basis (monthly or even daily between swap dealers). The counterparty with a negative value must set aside collateral that is proportional to the value of the swap.[16] These requirements are then also often tightened if the counterparty's credit rating is downgraded. Swedish Swap dealers exchange collateral daily on the basis of their netted global positions with the clearing system Swapclear (Svensson 1998).

[13] A contract in which the seller of securities agrees to buy them back at a specified time and price.
[14] Kobor et al (2005).
[15] See Kobor et al (2005).
[16] See Kobor et al (2005) and 2002 Master agreement protocol published by ISDA.

## 2.4 Swap rate calculations

When a swap contact is initiated, the counterparties are agreeing to exchange future interest rate payments and no upfront payments are made. This means that the swap contracts must have the value of zero, which implies that the present value of the cash flows for the payments to be made by the two counterparties should be equal. This principle is used when calculating the swap rate (Sundaresan 2002).

The swap rate is the fixed rate paid on the same dates as the floating payments with a present value being equal to that of the floating payments.[17] Since the swap contracts in our study are tied to 3-month STIBOR, the swap rate locked in at date $t$ will be a weighted average of STIBOR rates.

If we define our discount functions quoted at date $t$ for various future dates $j$ as $b(t, j), (j = 1, \ldots\ldots 4)$.

Then according to Sundaresan (2002) the swap rate, $x$ that is payable at each date $s_i$ should be equal to:

$$\begin{aligned} & x\left[b(t,s_1)+b(t,s_2)+b(t,s_3)+b(t,s_4)\right]= \\ & r_t(s_1)b(t,s_1)+r_t(s_2)b(t,s_2)+r_t(s_3)b(t,s_3)+r_t(s_4)b(t,s_4) \end{aligned} \tag{1}$$

The left-hand side of equation (1) above calculates the present value of paying the swap rate $x$ at the dates $s_1, s_2, s_3$ and $s_4$. The right hand side of equation (1) calculates the present value of paying the floating STIBOR interest rates, $r_i$ determined at date $t$ but paid at dates $s_1, s_2, s_3$ and $s_4$.

Once one have calculated the discount factors $b(t,s_1), b(t,s_2), b(t,s_3)$ and $b(t,s_4)$ one can solve for the swap rate $x$. [18]

The swap rate $x$ is therefore defined as:

$$x=\frac{r_t(s_1)b(t,s_1)+r_t(s_2)b(t,s_2)+r_t(s_3)b(t,s_3)+r_t(s_4)b(t,s_4)}{\left[b(t,s_1)+b(t,s_2)+b(t,s_3)+b(t,s_4)\right]} \tag{2}$$

[17] Sundaresan (2002).
[18] Sundaresan (2002).

## 2.5 Swap spreads as driven by the shape of the yield curve

The relation between swap spreads and the shape of the yield curve is explained based on both option theory and demand of interest rate swaps.

Sorensen and Bollier (1994) argue that the credit risk between two counterparties in a swap contract is asymmetric. They therefore apply option pricing theory to explain the relationship between swap spreads and the shape of the yield curve. They argue that the pricing of the possible default risk in a swap contract depends on the shape of the yield curve since it affects the option value that is embedded in the cost of replacing the swap.

When there is an upward sloping yield curve the choice, or option, to receive fixed in the swap is worth less than the choice to pay the fixed rate. The pay fixed option is more valuable than the receive fixed since future rates are higher than current rates. According to Sorensen and Bollier (1994) the expected losses from this situation are not symmetric. This is due to the larger default risk exposure for the party paying the fixed swap rate and the lower default risk exposure for the party receiving the fixed swap rate. This possible default risk results in that the fixed rate payer may miss out on the future interest rate payments which also would be larger than the ones received today, as a result of a steeper yield curve. The fixed rate payer will therefore be compensated for this asymmetric default risk by paying a lower swap rate causing swap spreads to decrease.

When the yield curve is downward sloping the receive fixed party's option will have a larger value than the pay fixed party's option. The fixed rate receiver will be compensated for this potential default risk by demanding a higher swap rate in the contract, causing the swap spreads to increase. This theory can be summarized as, a higher (lower) option value for the fixed rate payer is shown as a lower (higher) swap rate, i.e. the swap spread is connected to the slope by using option theory.

Additional explanations why there should be a negative relationship between swap spreads and the slope of the term structure of interest rates are provided in previous research.

Cortes (2003) and Fransolet et al (2001) argue that corporate debt issuers and different national funding agencies have a big impact on swap spreads. These market participants often use swaps in connection with debt issues where they focus on total funding costs of their liabilities. When the yield curve is upward sloping and steep it is relatively more expensive to issue long dated fixed rate bonds and the institutions use the swap contracts to swap the fixed rate debt to shorter liabilities. This is done by receiving fixed rate in the swap and paying floating rates in the short end of the curve. When the institutions' demand for receiving fixed in the swap increases, the dealers can pay a lower swap rate. This is due to the fact that swap rates are in fact the prices that the market participants are willing to pay to receive fixed rates, and the extra demand to receive fixed will cause swap rates to decrease and swap spreads to become tighter. The opposite is then true when the yield curve flattens and there is an extra demand for paying fixed in the swap causing swap rates to increase, leading to larger swap spreads.

Several studies have found strong statistical significant relationships between the shape of the yield curve and the swap spreads.

Fang & Muljono (2001) examines the determinants of interest rate swap spreads on the Australian Swap market. Their sample period covers daily data from 1996 to 1999. The study found that the movements of the Australian swap spreads are negatively related to the slope of the term structure.

Similar results were found by Eom et al (2000) who investigate the pricing of Japanese yen interest rate swaps during the period 1990-96. The authors obtain measures of the spreads of the swap rates over comparable Japanese government bonds for different maturities and analyze the relationship between the swap spreads and different explanatory variables. They conclude that the swap spread is negatively related to the slope of the term structure and they see this as evidence that the value of the credit optionality is included in the swap spread.

## 2.6 The liquidity component in Swap spreads

When using treasury securities as a hedging vehicle, dealers are vulnerable to phenomenon's like flight to quality[19]. These flights to liquidity events often effects both financing rates and prices of treasury bonds. Treasury bonds categorized as on-the-run securities[20] often become more expensive, because of their liquidity advantage, compared with the less liquid off-the-run treasury securities.[21]

This effect can be captured by the spread between off-the-run and on-the-run treasury bonds, a proxy for liquidity that has been put forward in earlier research (Sundaresan (2002), Grinblatt (1995) and Kobor et al (2005)).

The financing rate or repo rate often becomes lower for the more liquid on-the-run bonds causing the on-the-run bonds to trade special[22] in the repo market leading to a lower borrowing cost and a greater demand for these bonds (Sundaresan 2002).

Dealers who receive the fixed rate in a swap often hedge their position by shorting treasury bonds. This is illustrated in Figure (2) below. If there is a liquidity event in the market dealers who hedge by shorting the treasury bonds will be penalised by the cost of buying back a popular bond to cover the short position. As a consequence the dealers will demand a higher swap rate to compensate for the higher cost (Sundaresan 2002).

*Figure 2 Swap hedge (dealer receive fixed)*


When dealers pay the fixed rate they can hedge their position by buying treasury bonds.

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[19] Phenomenon in which investors sell low credit quality debt and invest the proceeds in highly liquid and safe securities, such as treasury bonds.

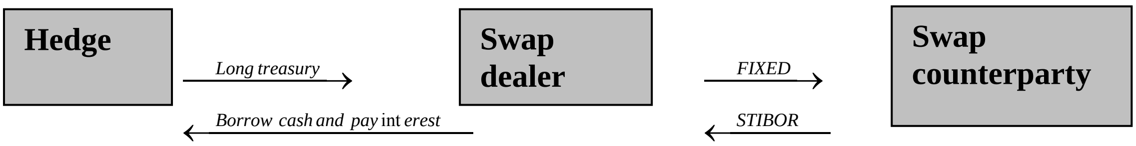
[20] On-the-run government bonds are those that are the most recently issued by the government, that is, they are highly liquid due to the frequent trading activity. Off-the-run government bonds are assets less frequently traded, i.e. more illiquid, that were issued prior to the on-the-run bonds.

[21] See e.g. Sundaresan (2002).

[22] Securities that are more demanded during periods may trade at rates that are much lower than the general repo rate. Such rates are called special repo rates.

This is illustrated in figure (3) below. If a flight to quality event occurs, the cost of the hedge will decline since they can take advantage of the lower borrowing cost, since their bonds will trade as special. Dealers are then willing to pay a higher swap rate. The swap spread should therefore increase when the off-the-run/on-the-run spread widens (Sundaresan 2002).

*Figure 3 Swap hedge (dealer pay fixed)*




Previous research have found that liquidity have a statistical significant relationship with swap spreads and that and that swap spreads should increase when the yield spreads between off-the-run and on-the-run treasuries increases.

Grinblatt (1995) develops a model where he argues that swap spreads are a result of the liquidity loss you get by receiving fixed in a swap compared to buying a treasury bond. This liquidity advantage of treasury bonds is called a convenience yield by Grinblatt and is the single most important factor driving swap spreads.
The convenience yield alone explains around 40 % in Grinblatt's model and is specified as a stochastic factor determining swap spreads.

Lekkos and Milas (2001) found a positive relation between liquidity factors and US swap spreads though the strongest relation was found between short term swaps and their liquidity proxy.

Huang et al (2002) investigates whether liquidity help predict and contribute to the fluctuations in the spreads between US dollar swaps and treasuries, both with 10 yr maturity. To asses the relative importance of their factors, vector autoregression (VAR) method is used. Their results conclude that the swap spreads is manly driven by market liquidity.

Feldhütter et al (2005) analyze a six-factor model for treasury bonds, corporate bonds and swap rates using U.S data covering the period from 1996 to 2003. The authors decompose swap spreads into three components: A convenience yield from holding treasuries, a credit risk element from the underlying LIBOR rate, and a factor specific to the swap market.

## 2.7 Swap spreads as driven by market volatility

An increased volatility leads to a more uncertain environment and can influence the general economic environment affecting credit spreads (Kobor et al 2005).
As markets become more volatile the demand to hedge the interest rate exposure by derivatives will increase as well, thus increasing the demand for swaps. The rising demand for "fixing" the interest rate by swaps will in turn push swap rates to be higher and hence causing the spreads to increase (Fantuzzi et al 2002).

In previous research strong relationships between different volatility proxies and swap spreads are found.[23]
Eom et al (2000) use the curvature[24] factor as a proxy for interest rate volatility. They found that the yen swap spreads are positively related to the curvature factor.

Minton (1997) estimates common empirical determinants of U.S. interest rate swap rates. The model which use a bond pricing framework and allow for default, show that swap rates are positively related to short-term interest rate volatility. Minton concludes that the value of the default option in a swap contract depends on short-term interest rate volatility, the positive coefficients are interpreted as evidence of the option to default, and, therefore counterparty default risk is present in the swap contract.

[23] See Kobor et al (2005) and Cortes (2003) who use implied equity volatility while Eom et al (2000) use interest rate volatility and Ma et al (2005) use implied volatility from bond options.
[24] Proxy for volatility defined as: (10 year government bond yield+3month t-bill yield) / 2 –1 year government bond yield.

## 2.8 Swap spreads as driven by credit spreads

While swaps can be considered to be default–risk-free instruments (See e.g. Grinblatt 1995), one can assume that swap spreads are affected by the changing perception of credit risk over the long term, particularly the credit risk in the financial sector, e.g. for the banks that quote the LIBOR rates.[25] As pointed out by Kobor et al (2005) the credit risk contained in LIBOR rates is also present in the swap rates simply because the floating leg of the swap is fixed to the LIBOR rate. If there is an increase in risk in the financial sector, LIBOR rates should increase which should push swap spreads higher (Sundaresan 2002).

Several studies have identified a strong significant relationship between different proxies for credit spreads and swap spreads.

Brown et al (2002) find that credit spreads are an important factor in explaining swap spreads and that the relationship between the variables is positive. The authors define the credit spread proxy as the difference between the yield on bonds issued by Australian banks and the yield on Australian government bonds.

Lekkos et al (2001) study weekly data from the period of 1991 to 1999 using a vector autoregression model. Their results show that corporate bond spreads have a significant effect on the determination of swap spreads in both the USD and GBP swap markets.

[25] See Cortes (2003).

## 2.9 Swap spreads as driven by treasury supply

Several studies (Kurpiel 2003 and Kobor et al 2005) have found that the treasury supply may be a driver of the swap spread.[26] Since swap spreads measure the relative price between government bonds and swaps, an increase (decrease) in supply of treasuries should imply a lower (higher) swap spread. Swap spreads should thus be influenced by the dynamics of fiscal deficit and government debt.

## 2.10 Linkages between swap spreads in different markets

Given the increased globalization of trade and finance, one would expect that international capital markets are more or less fully integrated. Positive relationships between Sterling and Euro swap spreads and between Sterling and Dollar swap rates have been found in previous studies by Chatterjee (2005) and Cortes (2003).

## 2.11 Models for long-term drivers of swap spreads

Several researchers have found, using error correction technique, that swap spreads are related to different variables in the long run.

Kobor et al (2005) finds that US swap spreads have a long term relationship with the treasury supply and AA spreads,[27] as proxy for credit risk in the financial industry. Kobor et al (2005) use error correction technique to estimate a model for US swap spreads for the period 1994 to 2004. The error correction model that is used is formulated around the presence of cointegration. They find that the treasury supply and the credit spread are cointegrated with the US swap spreads and conclude that this is a sign that those two variables are long term drivers of US swap spreads. The authors then estimate an error-correction model that integrates this long-term relationship with the influence of determinants that are important drivers in the short term.

Kurpiel (2003) performs a similar study as Kobor et al (2005) on the German swap market and finds a long term relationship between German Swap spreads and the size of the public deficit.[28]

[26] See e.g. Kobor et al (2005).
[27] By finding that the variables are cointegrated.
[28] See Kurpiel (2003) and Kobor et al (2005).

# 3 Hypotheses

In this part we will present the hypotheses and variables that we believe affect the swap spreads in the Swedish market. The hypotheses and variables are selected based on the theory presented and the previous research reviewed. We will present the hypotheses one by one and then summarize them all together with their expected signs in a table in the end.

## 3.1 Hypothesis 1: The swap spread will decrease with an increased slope of the term structure.

Several studies reviewed above have found a strong negative relation between swap spreads and the slope of the term structure. The theory behind this hypothesis can be explained based on both option theory and demand effects on interest rate swaps. We believe Sorensen and Bollier (1994) option theory and Cortes (2003) and Fransolet et al (2001) theory about increased demand for interest rate swaps both explain why a tightening of swap spreads can be expected as the yield curve gets steeper. We therefore expect that the Swedish swap spreads will tighten when the Swedish yield curve steepens, i.e. a negative relation between the two variables.

### 3.2 Hypothesis 2: The swap spread should be increasing in the liquidity factor as reflected by the prevailing spread between the yield of off / on-the-run treasury benchmark securities.

We want to test whether the liquidity factor is an important factor determining swap spreads in the Swedish swap market. Previous studies reviewed in this paper have found that liquidity factors have been important in other markets determining swap spreads.[29]

We define our liquidity proxy as the spread between off-the-run and on-the-run Swedish government bonds. We believe that this proxy will capture the convenience yield presented by Grinblatt (1995). In line with previous research, we believe that the spread between off-the-run and on-the-run Swedish government bonds should have a positive relationship with the Swedish swap spread.

[29] See Sundaresan (2002), Grinblatt (1995) and Kobor et al (2005).

## 3.3 Hypothesis 3: The swap spread will increase with an increased volatility

We believe an increased volatility in the market will increase swap spreads. Higher volatility can influence the general economic environment affecting credit spreads which then can influence swap spreads.

An increased volatility can also affect swap spreads, as markets become more volatile the demand to hedge the interest rate exposure by derivatives will increase as well. The rising demand for "fixing" the interest rate by using swaps will in turn push swap rates to be higher and hence causing the spreads to increase (Fantuzzi et al 2002). Through both forces we believe an increased volatility will increase Swedish swap spreads.

In previous research different proxies for volatility are used. Eom et al (2000) use the curvature factor as a proxy for interest rate volatility. We believe that this proxy might be problematic. A flat yield curve has no curvature, but this does not mean that the interest rate market expects zero volatility. We would therefore like to use a volatility proxy that incorporates expectations of future volatility.

Kobor et al (2005) and Cortes (2003) use implied volatility from Equity indices as a proxy for volatility. This might be a crude measure of volatility for the interest rate markets. We have chosen to use implied volatility derived from Interest rate CAP[30] contracts as a proxy for volatility. Interest rate volatility reflects a more uncertain economic environment, which in turn affects credit spreads. Similar proxies for volatility have been used in studies on USD swap spreads where researchers have used the implied volatility from bond options.[31] This is not an alternative for us since we do not have actively traded options on bonds in the Swedish market. We instead believe that the Cap volatility will capture the same effects.

Hence, our hypothesis is that the swap spread will increase when the implied volatility of the cap contract increases.

[30] An option that provides a payoff when a specified interest rate is above a certain level. The interest rate is a floating rate that is reset periodically (Hull 2003).

[31] Ma et al (2005).

## 3.4 Hypothesis 4: The swap spread will increase with an increase in the credit spread

Previous research have found that different specifications of credit spreads have been an important factor explaining swap spreads in different swap markets.[32]

Following the results found by Sundaresan (2002) and Kobor et al (2005) we believe that the swap spreads should change if the view on credit risk changes in the market. Furthermore, we believe that this factor could be captured by a proxy for the credit quality of the Swedish financial sector.

Since STIBOR is the rate used in the floating leg of the SEK swap, the overall or systemic risk of the Swedish banks should influence swap spreads. As the average credit quality of the banks quoting STIBOR falls, we may expect STIBOR to go up as investors demand a higher compensation for assuming increased credit risk. It then follows that the swap rate must increase when the average credit quality of the banks quoting STIBOR decreases.

As a proxy for the credit quality of the Swedish financial sector, the spread between five year Swedish mortgage bonds and Swedish government bonds with the same maturity could be used. Mortgage bonds are used because the Swedish corporate bond market is illiquid. If instead other corporate bonds would be used, that could lead to more noise in the data.[33] Hence, we will use data from the Swedish mortgage bond market which is more liquid.

We believe that Swedish swap spread should increase if the credit risk increases in the Swedish financial market.

[32] Lekkos et al (2001) and Brown et al (2002).

[33] See e.g. statistics published by the Swedish Riksbank on www.riksbank.se.

## 3.5 Hypothesis 5: The swap spread will decrease when the Swedish government borrowing need increases

Previous studies have found that different proxy variables connected to the supply of treasury bonds have a long term relation to swap spreads.[34] We therefore want to test if this relationship also exists in the Swedish swap market.

The problem we are facing is defining which measure of government bond supply to use. One could look at the size of the treasury market or the size of the government debt market in relation to the GDP. More generally, the problem is that it is difficult to incorporate expectations of future treasury supply or supply shocks (like buybacks announcements) in the data. The proxy we have chosen is the monthly borrowing need that is published every month by the national debt office. Our hypothesis is that there should be a negative relationship between the swap spread and the Swedish government's borrowing need.

[34] See Kurpiel (2003) and Kobor et al (2005).

## 3.6 Hypothesis 6: The swap spread will increase when the Euro swap spread increases

Previous studies have found positive relationships between Sterling and Euro swap spreads and between Sterling and Dollar swap rates.[35]

We therefore want to test the hypothesis that also the Swedish swap market is linked to international swap markets. More specifically we believe that SEK and Euro swap spreads should be highly related. The reason for looking at the Euro market is that interest rates in the Euro area are closely followed by Swedish market participants. Hence, we believe there is a positive relationship between Swedish swap spreads and EURO swap spreads.

## 3.7 Summary of hypotheses

A summary of our hypotheses, i.e. potential drivers of the SEK swap spreads and their expected signs can be found in Table (2) below.

*Table 2 Expected signs of explanatory variables*

| ***Expected signs of explanatory variables*** | |
|---|---|
| **Explanatory variable** | **Expected sign** |
| $\Delta Slope$ | Negative |
| $\Delta Off\ /On-the-run\,spread$ | Positive |
| $\Delta 1yr\ CAP\ volatility$ | Positive |
| $\Delta Credit\ spread$ | Positive |
| $\Delta Borrowing\ need$ | Negative |
| $\Delta Euro\ swapspread$ | Positive |

[35] See Chatterjee (2005) and Cortes (2003).

# 4 Data description

Our study is based on Swedish monthly data covering the period from January 1999 to February 2006, a total of 85 observations. The swap data for our study consist of monthly midmarket swap rates for maturities of five and ten years. The reason for choosing these maturities is because these contracts represent the most liquid and actively-traded maturities on the Swedish swap market. These rates are based on end of- trading-day quotes available in Stockholm to ensure comparability of the data. The data for swap rates are provided by the Royal Bank of Scotland. As an independent check on the data, we also compare the rates with quotes obtained from DataStream; the two sources of data are generally very consistent.

The Treasury data consists of 5 and 10 year constant maturity Treasury (CMT) yields derived from the Swedish Government Bond yield curve. The constant maturity series are constructed by taking the yield of the point on a constructed yield curve which represents a synthetic bond with exactly the length of time to redemption in years, in our case 5 and 10 years. The yield curve is constructed by calculating a best fit curve based on the yields of the Swedish government bonds on that particular date. The CMT data is provided by DataStream. More details about how they are calculated are given in Appendix (A).

We have defined the swap spread as the difference between the market swap rate and the CMT yield of the same maturity as the swap. By doing this we get an accurate estimate of the level of swap spreads currently traded in the market. The problem we correct for by using CMT yields is that swap rates are always quoted on a fixed maturity basis while yields derived from treasury benchmark bonds have a variable maturity. To illustrate, Swedish benchmark bonds are only of ten years maturity whenever the Swedish Debt office issues a new ten year bond while the 10 year Swap rate is quoted with a ten year maturity each day. By taking this market convention into account we make sure we compare two yields with the same maturity. This is a well used concept in the literature (Eom et al 2000).

The slope of the yield curve is defined as the difference between Swedish Government benchmark bond (SGB) with maturity of 10 yr and 2 yr SGB, which are obtained from DataStream. In previous studies similar proxies for the slope of the yield curve have been used. Kobor et al (2005) use the spread between the 20 year and the 10 year yield on treasury bonds and Huang et al (2002) use the 10 and 2 year Treasury Yields to measure the slope of the yield curve.

As a proxy for volatility in the interest rate market we use the implied volatility[36] from 1 yr CAP contracts. The CAP volatilities are spot mid-volatilities and are provided by DataStream. As mentioned above, a variety of different variables for volatility have been used in previous studies.

As a proxy for liquidity we use the off/on the run spread. This proxy is calculated as the yield spread between the 1037 and the 1038 Swedish Government bonds. The reason for choosing these two bonds is that they were both traded as on/off the run during our sample period with 1037 being the most liquid one. The spread is derived from historical bond prices, obtained from DataStream. For details on how the yields were derived see Appendix (B). To ensure quality, we compare our computed yields with yields of the 1037 and 1038 bonds provided by the Swedish Riksbank (Bank of Sweden).

The credit spread is obtained from the Swedish Riksbank and is calculated as the difference between the five year Swedish mortgage bond yield and the five year Swedish government bond yield.

The 5 and 10 yr Euro swap spread is calculated as the difference between the 5 and 10 yr Euro Libor swap rates and 5 and 10 yr German Government bond yields. The data is obtained from DataStream.

Finally, the Swedish monthly borrowing need measured in SEK billion and is obtained from the Swedish National Debt Office and the Swedish Statistical Bureau (SCB).

[36] Volatility implied by equating the market price of the cap to the price implied by the model price and solving for the volatility.

The definitions of our explanatory variables and the sources of the data are summarized in Table (3) below.

*Table 3 Sources of monthly data for variables included in the model*

| ***Sources of monthly data for variables included in the model*** | | |
|---|---|---|
| **Variable** | **Definition** | **Source** |
| $10yr\ SEK\ swap\ spread$ | 10 yr SEK swap rate-10 yr CMT SGB yield | Royal Bank of Scotland, & DataStream |
| $5yr\ SEK\ swap\ spread$ | 5 yr SEK swap rate-5 yr CMT SGB yield | Royal Bank of Scotland & DataStream |
| $Slope$ | 10 yr SGB yield-2 yr SGB yield | DataStream |
| $Off/On-the-run\ spread$ | SGB 1038 yield - SGB 1037 yield | DataStream & The Riksbank (Bank of Sweden) |
| $1yr\ CAP\ volatility$ | Implied Volatility of 1 yr SEK Cap contract | DataStream |
| $Credit\ spread$ | 5 yr SMB-5 yr SGB yield | The Riksbank (Bank of Sweden) |
| $Borrowing\ need$ | The Swedish Borrowing need expressed in SEK billion | The Swedish National Debt Office and The Swedish Statistical Bureau (SCB) |
| $10yr\ Euro\ swap\ spread$ | 10 yr EURO LIBOR swap rate-10 yr GGB yield | DataStream |
| $5yr\ Euro\ swap\ spread$ | 5 yr EURO LIBOR swap rate-5 yr GGB yield | DataStream |

Note: SGB, Swedish Government Bond; GGB, German Government Bond; CMT, Constant maturity; SMB, Swedish Mortgage Bond

# 5 Descriptive statistics

Graph (1) below is a plot of the monthly observations of SEK swap rates for February 1999 to March 2006. As the graph shows, SEK swap rates in general declined during the sample period. Typically swap rates increase with maturity which is similar to the treasury term structure. Thus for example the 10 yr curve lies above the 5 yr swap curve during the whole period. In other words, the swap term structure was upward sloping during the sample period.

*Graph 1 SEK 5 and 10 yr Swap rates*

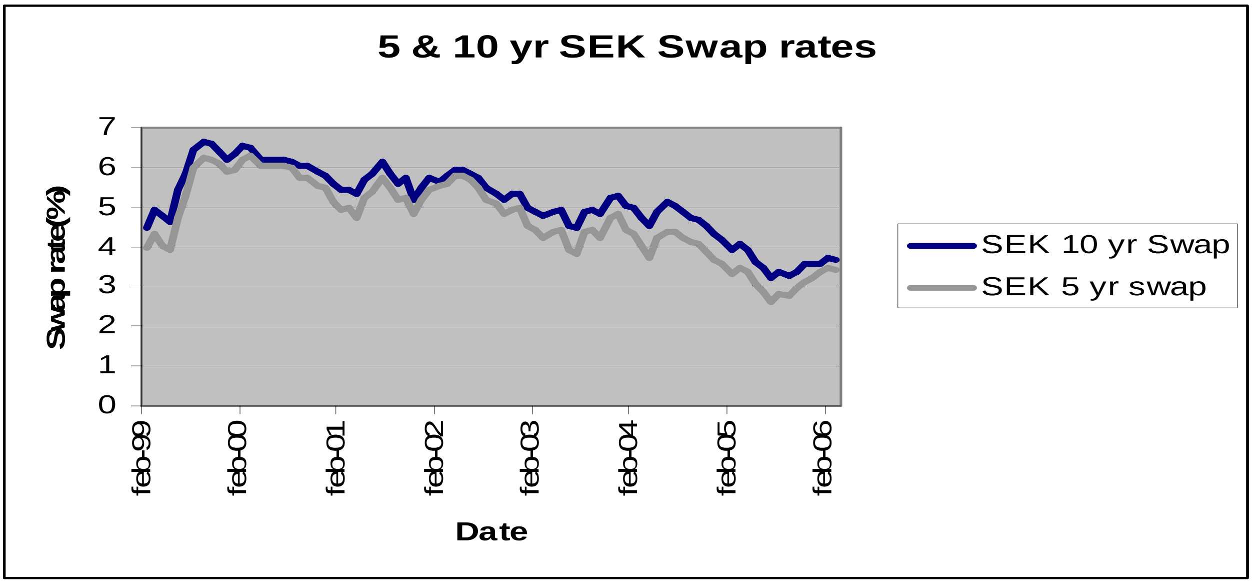



Table (4) presents summary statistics for the 5 and 10 yr swap rates in both levels and first differences.

*Table 4 Descriptive statistics of SEK swap rates*

| Maturity | Mean | Standard deviation |
|---|---|---|
| | *Level* | |
| 5 yr | 4.69 | 0.995 |
| 10 yr | 5.14 | 0.900 |
| | *First Differences* | |
| 5 yr | -0.002649 | 0.088 |
| 10 yr | -0.00257 | 0.109 |

Graph (2) below plots the five-year and ten-year swap spreads over the sample period. As shown, the swap spreads moved together during most of our sample period. It is also interesting to see that spreads have tightened during the sample period. Since 2003 the spreads have been traded below 40 bps. It is also worth noting that the spreads seem to have been more volatile during the beginning of our sample period. This could be due to the aftermaths of the Russian default and the 9/11 attacks.

*Graph 2 SEK 5 and 10 yr Swap spreads*

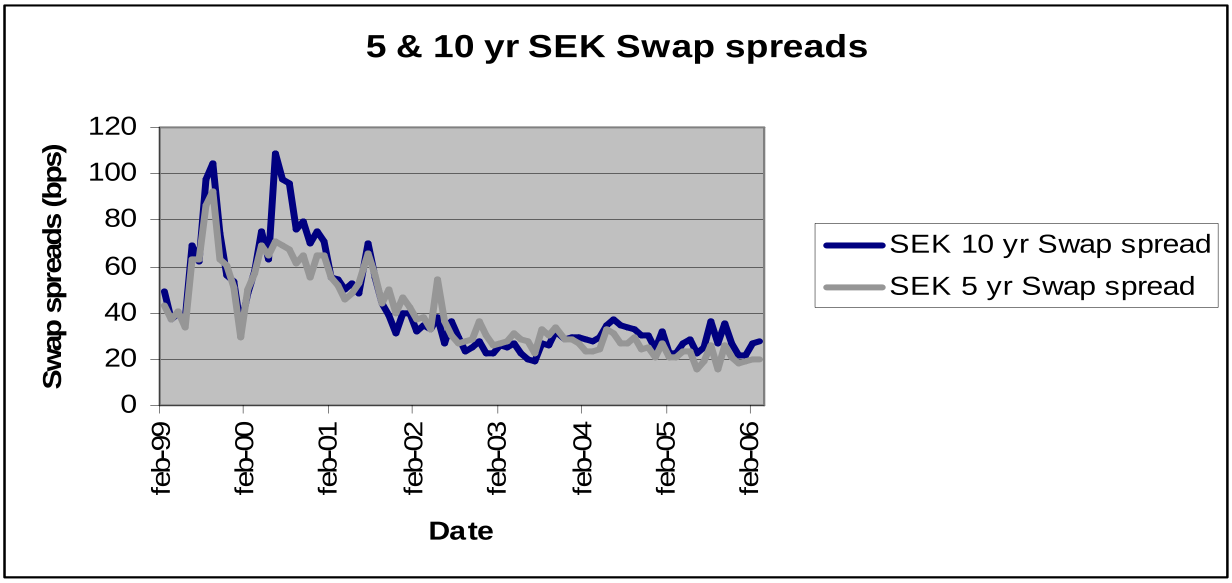



Table (5) provides means and standard deviations for the monthly swap spreads and the other variables used in the regressions. The average spreads of the SEK interest rate swaps show an upward sloping term structure. The standard deviations of monthly swap spreads are around the order of 17.6 to 21.5 basis points. The largest standard deviation is found in the 10 yr Swap spread. The mean of the credit spread lies fairly close to that of the swap spreads, especially close to the ten year maturity. The mean of the borrowing need has been negative over the time period indicating that the Swedish public finances have been stable.

As could be seen graphically, the Δ10 yr and Δ5 yr SEK swap spreads have negative means i.e. there is a downward sloping trend in the swap spreads during the period. The means of the ΔSlope and the ΔOff/on the run spread are low and positive. The mean of the ΔVolatility is low and negative, indicating a slight downward trend. The mean of the ΔCredit spread is negative suggesting a downward sloping development of the credit spread. The mean of the ΔBorrowing need variable is positive suggesting that, on average, the negative borrowing need of the period is decreasing. Both means of the ΔEuro swap spread maturities are negative just like the means of the ΔSwedish swap spread maturities.

*Table 5 Descriptive statistics of SEK swap spreads and the explanatory variables*

| **Maturity** | **Mean** | **Standard deviation** |
|---|---|---|
| | *Level* | |
| $5yr\ SEK\ swap\ spread$ | 0.39 | 0.176 |
| $10yr\ SEK\ swap\ spread$ | 0.42 | 0.215 |
| $Credit\ spread$ | 0.436 | 0.230 |
| $Borrowing\ need$ | -6.85 | 17.4 |
| | *First Differences* | |
| $\Delta 5yr\ SEK\ swap\ spread$ | -0.0026 | 0.088 |
| $\Delta 10yr\ SEK\ swap\ spread$ | -0.003 | 0.1098 |
| $\Delta Slope$ | 0.000492 | 0.152 |
| $\Delta Off\ /\ On-the-run\ spread$ | 0.000824 | 0.0918 |
| $\Delta 1yr\ CAP\ volatility$ | -0.0614 | 2.45 |
| $\Delta Credit\ spread$ | -0.00422 | 0.0863 |
| $\Delta Borrowing\ need$ | 0.221 | 21.2 |
| $\Delta 10yr\ Euro\ swap\ spread$ | -0.00265 | 0.0523 |
| $\Delta 5yr\ Euro\ swap\ spread$ | -0.000588 | 0.0866 |

# 6 Methodology

## 6.1 Test for stationarity

By looking at Graph (2) above one might suspect that the 5 and 10 yr swap spreads are not stationary. Most empirical studies consider swap spreads as a nonstationary process.[37] This nonstationarity could be confirmed after performing an augmented Dickey Fuller test. Details regarding the augmented Dickey Fuller test and nonstationarity can be found in Appendix (C).

Our results showed that we couldn't reject the null hypothesis of nonstationary time series. Because of this the time series were transformed to first differences. New augmented Dickey Fuller tests were performed on the first differences and the hypothesis of nonstationarity could then be rejected for all our variables at a 1 % confidence level. It can therefore be concluded that all variables are stationary in first differences.

## 6.2 Test for causality

To test the assumption that our dependent variables are endogenous and that our independent variables are exogenous we perform Granger causality tests (See Appendix (D) for further details). By using the Granger causality test we want to investigate whether the dependent variables also influence the independent variables. If this is the case we have to specify our model in a way to take this reverse causality into account. One alternative would then be to use a VAR model (See e.g. Lekkos et al 2001 and Huang 2002).

The results show that our dependent variables do not granger-cause any of our external explanatory variables.[38] The causality and reverse causality tests were performed with one lag. By finding no reverse causality for the external variables in the model we can conclude that our models do not suffer from any potential external endogenity bias.

[37] Kobor et al (2005).

[38] However, there are indications of reverse causality for the error correction term. This will not make us re estimate the model since the error correction term is the lag of the error term from the regression in levels and not an external variable. Furthermore the Granger causality test is specified to test the causality on the first lag which might be part of the explanation for the reverse causality for this variable. This, since the first lag of the error term from the regression in levels is what is used as the ECT variable in the short term model with error correction mechanism.

## 6.3 Test for Cointegration

There are reasons to believe that there could exist variables that have long term relationships with swap spreads in the Swedish swap market. Kobor et al (2005) find that US swap spreads have a long term relationship with the treasury supply and AA spreads (proxy for credit risk in the financial industry). Kurpiel (2003) finds a long term relationship between German Swap spreads and the size of the public deficit.[39]

We want to test for long run relationships by applying the cointegration methodology. (See Appendix (E) for further details).

The variables found to have long run relations and to be cointegrated with the swap spreads in previous studies are tested for cointegration in our study. Proxies similar to borrowing need and credit spread have been used as determinants of swap spreads in long run regressions in previous studies. [40] Therefore these two variables are tested for cointegration in our study.

The first step in the procedure is to identify a potential cointegration relationship among the selected variables. The tests for cointegration (between the swap spread, the borrowing need and the credit spread) show that cointegration relationships exist between the variables, for both the five and the ten year maturities. I.e. the residuals from estimating these regressions in levels are stationary. The results from the cointegration tests can be seen in Appendix (E).

The long term relations are specified as:

$$10yr\ SEK\ swap\ spread = \beta_0 + \beta_1 Credit\ \ Spread + \beta_2 Borrowing\ need + \varepsilon_t \qquad (3)$$

And

$$5yr\ SEK\ swap\ spread = \alpha_0 + \alpha_1 Credit\ Spread + \alpha_2 Borrowing\ need + e_t \qquad (4)$$

[39] See Kurpiel (2003) and Kobor et al (2005).
[40] See Kurpiel (2003) and Kobor et al (2005).

## 6.4 Short term model with error correction mechanism

Since we have identified that the 5 and 10 yr Swap spreads, the credit spread and the borrowing need are cointegrated, we decide to use the technique called error correction mechanism (ECM).[41]
After we estimated the long term regression between the 5 and 10 yr Swap spreads, the credit spread and the borrowing need in levels, we continue by estimating a second regression for each maturity which explains the short run movements around the long run trend. The second regression contains the lags of the residuals of the long term relation as one of the explanatory variables together with the other explanatory variables in first differences.

The error correction term is defined as the estimation error of formula (3) and (4) denoted as $ECT_t$ calculated in formula (5) and (6) below.

$$ECT_t = 10yr\ SEK\ SwapSpread_t - (\hat{\ddot{\chi}} + \hat{\beta}_1\ Credit\ Spread + \hat{\beta}_2\ Borrowing\ need) \quad (5)$$

$$ECT_t = 5yr\ SEK\ SwapSpread_t - (\hat{\ddot{\kappa}} + \hat{\alpha}_1\ Credit\ Spread + \hat{\alpha}_2\ Borrowing\ need) \quad (6)$$

Following the ECM technique $ECT_{t-1}$ is used as one of the explanatory variables in the short term equation addition to the first differences of the previous variables: [42]

$$\Delta 10yr\ SEK\ swap\ spread = \lambda_0 + \lambda_1 ECT_{t-1} + \lambda_2 \Delta 10yr\ Euro\ swap\ spread + \lambda_3 \Delta Slope + \lambda_4 \Delta Credit\ Spread + \lambda_5 \Delta Off\ /\ On + \lambda_6 \Delta 1yr\ Cap\ Vol + \lambda_7 \Delta Borrowing\ need \quad (7)$$

$$\Delta 5yr\ SEK\ swap\ spread = \delta_0 + \delta_1 ECT_{t-1} + \delta_2 \Delta 5yr\ Euro\ swap\ spread + \delta_3 \Delta Slope + \delta_4 \Delta Credit\ Spread + \delta_5 \Delta Off\ /\ On + \delta_6 \Delta 1yr\ Cap\ Vol + \delta_7 \Delta Borrowing\ need \quad (8)$$

[41] See Gujarati (2003).
[42] See e.g. Kobor et al (2005) for another example of the ECT specification.

# 7 Results

## 7.1 Long term model

The relationship between the credit spread and the 10 and 5 year SEK swap spread levels is positive and highly statistically significant. The relationship seems to be stronger for the five year swap spread both in terms of statistical significance and size of coefficient which is in line with the finding by Kobor et al (2005), who found the AA credit spread to be a long term determinant of the US swap spread. Furthermore, Cortes (2003) points out that the risk in the banking sector should determine the levels of swap spreads in a long-run equilibrium. Although the credit spread is in many studies used as a proxy for credit risk it can also be assumed to be determined by liquidity factors.[43] As can be seen in the theory section above it is difficult to clearly distinguish the liquidity factors and credit risk factors in the swap spread since some variables can be assumed to be affected by both factors. However, as discussed, we find support for the hypothesis that the credit spread has an impact on SEK swap spreads and this can be assumed to be an indication that the credit spread variable is linked to the risk in the banking sector. Especially as the proxy variable used is the difference in yields between Swedish Mortgage Bonds and Swedish Treasury Bonds.

The borrowing need is negative but not significant in either of the two regressions. This finding is in contrast to previous research where different public deficit factors have been important long term determinants of swap spreads.[44] In finding relevant proxies for the public deficit we choose to use the Swedish actual monthly borrowing need. This variable is easily measurable and accurate. There might, however, be other estimations of public deficit that are more highly related with the SEK swap spread, this could be e.g. expectations of the future borrowing need or changes in expectations of the future borrowing need. These factors would, however, be more difficult to measure in an accurate and unbiased manner.

[43] See Grinblatt (1995).
[44] See Kobor et al (2005) and Kurpiel (2003).

*Table 6 Long term model, Determinants of SEK Swap spreads*

| | $10yr$ *SEK swap spread* | $5yr$ *SEK swap spread* |
|---|---|---|
| *Credit spread* | 0.756419<br>(11.88)*** | 0.67415<br>(16.24)*** |
| *Borrowing need* | -0.000857<br>(-1.02) | -0.0003417<br>(-0.62) |
| *Constant* | 0.0835<br>(2.77) *** | 0.09542<br>(4.86) *** |
| *Adjusted* $R^2$ | 0.6667 | 0.7841 |

*Variables significant at 10 % are marked with *; at 5 % with **; at 1 % with ***.*

## 7.2 Short term model with error correction mechanism

We notice that the slope of the term structure is an important factor in the ten year swap spread regression. The coefficient for the slope has the correct sign according to theory and is statistically significant on 1 % level for the 10 yr SEK swap spread. However, for the five year SEK swap spread the relationship is different: the slope coefficient is not statistically significant. Our findings of stronger relationship between the ten year SEK swap spread and the slope of the yield curve, than between the five year SEK swap spread and the slope of the yield curve, is in line with the results of Kobor et al (2005) and Eom et al (2000). However, the findings of Fang and Muljono (2001) show a stronger relationship for the five year swap spread and the slope, than for the ten year swap spread. The proxy variable for the slope of the yield curve is based on the 10 and 2 year Swedish Treasury Yields. It could be argued that our results may somehow be affected by the choice of proxy variable for slope. However, in the paper by Huang et al (2002) on USD 10 year swap spreads, the 10 and 2 year Treasury Yields were used to measure the slope of the yield curve. In the paper by Kobor et al (2005) the spread between the 20 year and the 10 year Treasury yields was used to measure the slope. The reason for choosing the two year and the ten year Swedish government bonds are because they are both liquid, giving less room for noise in the data. Hence, we would not consider our results biased by the choice of proxy variable despite the more significant impact shown by slope on the 10 yr SEK swap spread than on the 5 yr spread.

Our proxy for liquidity, the $\Delta Off / On - the - run\, spread$ is an important factor in explaining the variations for both the 5 yr SEK Swap spread and the 10 yr SEK Swap spread. The coefficients are positive, as predicted by theory and highly statistically significant. The $\Delta Off / On - the - run\, spread$ is slightly more significant in the five year swap spread regression than in the ten year swap spread regression. Lekkos and Milas (2001) found a stronger relation between the shorter maturity swaps and the liquidity factor in the US market. They argued that this was due to the abundance of short term instruments, resulting in a lower liquidity of the shorter maturity swaps. This might explain our results, indicating a lower liquidity of the five year swaps than the ten year swaps given that the liquidity of the ten and five year government bonds are equal. Strong relationship between liquidity factors and shorter maturity swaps has also been found in other previous studies.[45]

[45] See Kobor et al (2005).

Our results also show that the volatility in the interest rate market seems to affect the SEK swap spread. The proxy for volatility is statistically significant and has the correct sign according to theory for the ten year SEK swap spread. The coefficient in the five year regression shows the correct sign but is not statistically significant. Hence, volatility seems to be a more important factor for the longer, ten year, maturity swap spread. This result is in line with the findings of Eom et al (2000) but Fang and Muljono (2001) have found a stronger relationship for the five year swap spread.
The credit spread show a high statistical significance and positive sign for both maturities. The coefficients are of approximately equal size and the significance is in approximately equal terms. Hence, the credit spread does seem to be an important determinant for both maturities. Previous studies from other domestic swap markets have shown similar results.[46]

The borrowing need variable has the right sign but it is not statistically significant for any of the two swap spread maturities. That indicates that our findings do not support the hypothesis of borrowing need being an important determinant of the SEK swap spreads. The study by Kobor et al (2005) showed strong support of the hypothesis. As argued above, there are several ways of measuring this factor, in Kobor et al (2005) a treasury supply index has been used and in Cortes (2003) future budget balance expectations has been used.

The Euro Swap spread is positive in both regressions but is only statistically significant for the 10 yr SEK swap spread. One could interpret this as that the European Swap market is a more important factor for longer maturity swaps than it is for the medium ones. The results in the ten year regression is in line with the results obtained by Chatterjee 2005, where a significant positive relationship was found between the Sterling and Euro swap spreads and Cortes (2003) where a significant positive relationship was found between the Sterling and Dollar swap spreads.[47] Our results confirm the relationship between swap spreads in International financial markets, at least for the longer swap maturity. The finding of stronger relationship between the ten year maturities than between the five year maturities on swap spreads in different markets is also in line with the findings of Chatterjee (2005) and Eom et al (2000).

[46] See Kobor et al (2005).
[47] See Eom et al (2000) as an additional source.

When looking at the results from the short term model with error correction mechanism we see that the error correction terms in both models are negative and statistically significant. This could be seen as an indication of that the SEK swap spread reverts to its long-run level, which is in line with previous studies e.g. Kobor et al (2005) and our expectations.

Regarding our models' goodness of fit, we obtained an adjusted $R^2$, for the two maturities, between 0.48-0.56 which is in line with goodness of fit obtained by previous research on swap spreads in other markets.[48]

*Table 7 Short-term model, Determinants of SEK Swap spreads- Error correction model*

| | $\Delta 10yr$ *SEK swap spread* | $\Delta 5yr$ *SEK swap spread* |
|---|---|---|
| $\Delta 10yr$ *Euro swap spread* | 0.3973<br>(2.48)*** | |
| $\Delta 5yr$ *Euro swap spread* | | -0.0004691<br>(-0.01) |
| $\Delta$*Slope* | -0.2332<br>(-4.04)*** | -0.04152<br>(-0.82) |
| $\Delta$*Credit spread* | 0.5264<br>(5.48)*** | 0.5261<br>(6.20)*** |
| $\Delta Off/On-the-run\ spread$ | 0.1889<br>(2.16)** | 0.2586<br>(3.32)*** |
| $\Delta 1yr$ *CAP volatility* | 0.007601<br>(2.18)** | 0.003559<br>(1.16) |
| $\Delta$*Borrowing need* | -0.0006672<br>(-1.73) | -0.0002988<br>(-0.87) |
| $Error\ correction\ term_{t-1}$ | -0.2201<br>(-3.32)*** | -0.4169<br>(-4.68)*** |
| *Constant* | 0.0008709<br>(0.11) | -0.0004093<br>(-0.06) |
| *Adjusted* $R^2$ | 0.5643 | 0.4807 |

*Variables significant at 10 % are marked with *; at 5 % with **; at 1 % with ***.*

[48] See Cortes (2003) for a study on US Swap spreads and Eom et al (2000) for a study on Yen Swap spreads.

# 8 Conclusion

The purpose of the thesis is to examine the determinants of SEK swap spreads and to estimate an econometrical model for the 5 and 10 yr SEK swap spreads by using monthly data from 1999-2006. After having identified six possible determinants of Swedish swap spreads we ran regressions on proxy variables of these on SEK swap spreads of 10 and 5 year maturity.

The long term model includes the variables credit spread and borrowing need. The credit spread is positive and highly statistically significant for both the ten and the five year maturity. Since the credit spread is defined as the yield spread between mortgage bonds and government bonds, the spread should serve as a good proxy of the risk in the Swedish banking sector. The regression results are in line with previous research for other domestic markets; see e.g. Kobor et al (2005). It is argued by Cortes (2003) that the swap spread levels should in a long-run equilibrium be determined by the risk in the banking sector, a result confirmed by our results. However, as mentioned above, some researchers[49] argue that swap spreads are to a large extent determined by liquidity factors, and the credit spread could be interpreted as a proxy for liquidity. However, we find the context of the credit risk effect seem more applicable due to the nature of the credit spread variable. As a proxy for public deficit or treasury supply in the market, the actual monthly Swedish government borrowing need has been used. This variable is not statistically significant in either of the two regressions. In previous research[50] the public deficit/government debt factor has been an important determinant of levels of long run swap spreads. In these studies other proxy variables, e.g. variables based on expectations of future public deficit or treasury supply have been used. This indicates that the factor may be relevant on the Swedish swap market if a proxy variable including future expectations government debt is used.

The short run model with error correction mechanism includes all the six proxy variables for the hypotheses in first differences, and the lag of the residuals from the long term model. The slope of the yield curve is negative and highly significant in the ten year regression. For the five year maturity the slope is negative but not statistically significant. Hence, our results confirm the theory for the longer maturity swaps. The liquidity proxy off/on the run spread is positive and statistically significant for both maturities. The result is in line with theory and

[49] See e.g. Griblatt (1995).
[50] Kobor et al (2005) and Kurpiel (2003).

indicates that liquidity factors have an impact on the SEK swap spreads and the effect seems to be slightly stronger on the five year swap spread. The volatility is positive and statistically significant in the ten year regression, it is positive but not statistically significant in the five year regression. The results indicate that volatility is a more important factor on the ten year swap spread in the Swedish market. The borrowing need is not statistically significant in either of the short run regressions. This might be due to the choice of proxy variable, as discussed above. The Euro Swap spread is positive in both regressions but is only statistically significant for the 10 yr SEK swap spread. These results confirm that at least 10 year SEK swap spreads have a strong relationship with the Euro swap market. The error correction term is negative and statistically significant in both regressions. This indicates that the Swedish swap spreads revert towards a long term level. This finding is in line with previous studies.

To conclude, the credit spread is as expected an important determinant of SEK swap spreads both in the short and in the long run. The slope of the yield curve and the volatility factor has, according to our results, stronger relation to the longer maturity swap spread. A possible explanation to this could be the higher amount of credit risk incorporated in longer maturity contracts. This conclusion must, however, be questioned due to the research showing little importance of credit risk in swap contracts (See Grinblatt 1995). Additionally, as mentioned above, sophisticated measures to strongly reduce credit exposure on swap contracts between counterparties is today common practice. The liquidity factor, off/on the run spread, is significant in both regressions giving support to the theory of liquidity being an important determinant of SEK swap spreads.

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# 10 Appendix

## 10.1 Appendix A

### Least squares polynomial method of best fit calculations[51]

The constant maturity series are constructed by taking the yield of the point on the stored yield curve which represents a synthetic bond with exactly the length of time to redemption in years as indicated by the Constant maturity data type. The curve is a calculated best fit curve based on the yields of the Swedish government bonds on that particular date. Bonds which are perpetual or redeem outside the limits of the yield curve calculation for the market are not included, nor are bonds which do not have liquid price histories. Below follows details regarding the calculations of the constant maturity yields.

The formula describe the mathematical derivation of a polynomial equation (of up to the 5th power) as best fit to a series of data-points expressed as co-ordinates $(X, Y)$

The equation of the curve is in the form:

$$y = a + bx + cx^2 + dx^3 + ex^4 + fx^5 \qquad (9)$$

The notation used in the following pages is:

$Y_i =$ Observed value of $Y$

$\sum Y_i =$ Sum of observed values of $Y$

$\bar{Y} =$ Mean value of $Y$

$y_i = (Y_i - \bar{Y})$ =difference between observed and mean values of Y

To fit a polynomial curve to the points, the standard method of least squares curve fitting is used. This minimizes the differences between the observed values of $y$ and $x$ and the curve.

[51] Source: Datastream.

Using this method, the values that determine the shape of the yield curve ( $a, b, c, d, e$ and $f$ ) Are found by solving the following linear simultaneous equations:

$$\begin{aligned}
\sum_{i=1}^{n} Y_i &= na + b\sum_{i=1}^{n} X_i + c\sum_{i=1}^{n} x_i^2 + d\sum_{i=1}^{n} x_i^3 + e\sum_{i=1}^{n} x_i^4 + f\sum_{i=1}^{n} x_i^5 \\
\sum_{i=1}^{n} Y_i X_i &= a\sum_{i=1}^{n} X_i + b\sum_{i=1}^{n} x_i^2 + c\sum_{i=1}^{n} x_i^3 + d\sum_{i=1}^{n} x_i^4 + e\sum_{i=1}^{n} x_i^5 + f\sum_{i=1}^{n} x_i^6 \\
\sum_{i=1}^{n} Y_i X_i^3 &= a\sum_{i=1}^{n} X_i^3 + b\sum_{i=1}^{n} x_i^4 + c\sum_{i=1}^{n} x_i^5 + d\sum_{i=1}^{n} x_i^6 + e\sum_{i=1}^{n} x_i^7 + f\sum_{i=1}^{n} x_i^8 \\
\sum_{i=1}^{n} Y_i X_i^4 &= a\sum_{i=1}^{n} X_i^4 + b\sum_{i=1}^{n} x_i^5 + c\sum_{i=1}^{n} x_i^6 + d\sum_{i=1}^{n} x_i^7 + e\sum_{i=1}^{n} x_i^8 + f\sum_{i=1}^{n} x_i^9 \\
\sum_{i=1}^{n} Y_i X_i^5 &= a\sum_{i=1}^{n} X_i^5 + b\sum_{i=1}^{n} x_i^6 + c\sum_{i=1}^{n} x_i^7 + d\sum_{i=1}^{n} x_i^8 + e\sum_{i=1}^{n} x_i^9 + f\sum_{i=1}^{n} x_i^{10}
\end{aligned} \quad (10)$$

Where $Y_i =$ observation of redemption yield of the bonds used.

$X_i =$ Observation of life of corresponding bonds used.

$n =$ Number of bonds used to derive the curve.

These equations are then solved using matrix reduction techniques to provide values for $a, b, c, d, e$ and $f$ .

The situation above describes the derivation of the equation of a curve in the 5th power of $X$

Finally we calculate the squared multiple correlation coefficient ( $R^2$ ) by applying the following:

1. For each value of $Y_i$ observed, we record: $\sum (Y_i - \bar{Y})^2$
2. We then take each value of $x$ observed and substitute it into the curve-fitting polynomial we previously derived, to obtain a fitted value for $Y, Y_f$
3. We then have:

$$R^2 = \frac{\sum (Y_f - \bar{Y})^2}{\sum (Y_i - \bar{Y})^2} \quad (11)$$

A better fit is achieved as ( $R^2$ ) approaches 1.

## 10.2 Appendix B

### Off/On-the-run calculations

The yield-to-maturity of the SGB 1037 and 1038 is derived given the two bonds prices, settlement dates, maturity date, issue date, coupon and quoted price. The yields are calculated in accordance with the formula below using a standard spreadsheet package such as Excel.

Data of the bonds

| 1038 | 1037 |
| --- | --- |
| **Svenska 1996 6,5% 25/10/06** | **Svenska 1996 8% 15/08/07** |
| **Sweden (Kingdom of)** | **Borrorwer; Sweden (Kingdom of)** |
| **Coupon 6,5%** | **Coupon 8%** |
| **Issue date Oct 25 1996** | **Issue date Feb 21 1996** |
| **Redemptio date Oct 25 2006** | **Redemption date Aug 15 2007** |

Consider a treasury bond with that matures at date $T$. We assume that the settlement date is $t < T$ and that there are $N$ coupon dates remaining. Let $z$ be the number of days between the settlement date and the next coupon date, and $x$ be the number of days between the last coupon date and the next coupon date.[52] Then given the price $P_t$, the relation between $P_t$ and $y$ is

$$P_t = \left( \frac{100}{\left(1+\frac{y}{2}\right)^{N-1+\frac{z}{x}}} \right) + \sum_{j=0}^{j=N-1} \frac{\frac{c}{2}}{\left(1+\frac{y}{2}\right)^{j+\frac{z}{x}}} \qquad (12)$$

[52] Sundaresan (2002).

## 10.3 Appendix C

### Stationarity[53]

In order to make a statistical inference from a single realization of a random process, stationarity of the process is often assumed. Intuitively, a process $X_t$, is stationary if its statistical properties do not change over time. More precisely, the probability distribution of the process should be time-invariant.

We tested for stationary using the augmented Dickey-Fuller test for a unit root:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \alpha_i \sum_{i=1}^{m} \Delta Y_{t-i} + \varepsilon_t \qquad (13)$$

Were the null hypothesis is:

$$H_0 : \delta = 0 \qquad (14)$$

$Y_t$ is nonstationary under the null hypothesis. If we can reject $H_0$ we conclude that the time series are stationary.

*Table 8: Results of augmented Dickey Fuller test*

*Critical values:* -3.532 (1%) -2.903 (5%) -2.586 (10%)[54]

| | *Test statistic* | |
|---|---|---|
| Variable | Level | First Difference |
| $10yr\ SEK\ swap\ spread$ | -2,.350 (Not reject) | -11,120 (Reject at 1%) |
| $5yr\ SEK\ swap\ spread$ | -2.209 (Not reject) | -11,286 (Reject at 1%) |
| $Slope$ | -1.956 (Not reject) | -10.750 (Reject at 1%) |
| $Off\ /\ On-the-run\ spread$ | -5.508 (Reject at 1%) | -11.931 (Reject at 1%) |
| $1yr\ CAP\ volatility$ | -3.139 (Reject at 5%) | -10.077 (Reject at 1%) |
| $Credit\ spread$ | -1.543( Not reject) | -8.359 (Reject at 1%) |
| $Borrowing\ need$ | -6.195 (Reject at 1%) | -13.415 (Reject at 1%) |
| $10yr\ Euro\ swap\ spread$ | -1,423 (Not reject) | -11,417 (Reject at 1%) |
| $5yr\ Euro\ swap\ spread$ | -3.926 (Reject at 1%) | -12.286 (Reject at 1%) |

[53] See Gujarati (2003).
[54] Reported critical values from statistics program Stata.

## 10.4 Appendix D

### Granger causality test[55]

The Granger causality test enables one to test whether one variable causes another variable. Consider the example where we have variables x and y. Variable x is said to granger cause y if the prediction of y obtained by regressing y on its own lags can be improved by adding the lagged variables of x to the regression model.[56]

The test involves estimating the following regressions. The number of lags chosen for the Granger causality test in this paper is one. The reasoning behind this choice is that since monthly data is used in the regressions we expect the effects of any possible reverse causality to be available already in the first lag. Regressions (14) and (15) illustrate the Granger causality test for a regression with two variables (one dependent variable (y) and one explanatory variable (x)).[57]

$$x_t = \sum_{i=1}^{n} a_i y_{t-i} + \sum_{j=1}^{n} \beta_j x_{t-j} + u_{1t} \qquad (14)$$

$$y_t = \sum_{i=1}^{n} \lambda_i y_{t-i} + \sum_{j=1}^{n} \delta_j x_{t-j} + u_{2t} \qquad (15)$$

To test the causality from y to x, a test on the joint significance of $a_1$ to,.... $a_n$ is performed.

This is done completed with an $F - test$ with the null hypothesis of $a_1$ to,.... $a_n = 0$.

Since y is the dependent variable in the (original) regression, this would be considered to be a test for reverse causality. To instead test for Granger causality from x to y, a test of joint significance of $\delta_1,....,\delta_n$ is performed.

The test statistic of the Granger causality F-test can be written as:[58]

$$F = \frac{(RSS_R - RSS_{UR})/m}{RSS_{UR}/(n-k)} \qquad (17)$$

[55] See Gujarati (2003).
[56] See Kobor et al (2005) for another example of the Granger causality test.
[57] Gujarati (2003).
[58] Gujarati (2003).

If the null hypothesis is not rejected, no clear evidence of causality is found. However, if the null hypothesis is rejected, there are indications of causality. Our tests have been performed in both directions, too see whether there is evidence of causality, reverse causality, both or none. As mentioned the tests are performed for all variables on the first lag. As mentioned in Gujarati (2003) the results can vary when the number of lags tested change. We believe a test for the first lag is appropriate. There are no indications of reverse causality for any of the external variables. However, there are indications of reverse causality for the error correction term. We do not consider this as a major problem of the model since the error correction term is the lag of the error term from the regression in levels and not an external variable. Furthermore the Granger causality test is specified to test the causality on the first lag which might be part of the explanation for the reverse causality of this variable, since it the first lag of the error term from the regression in levels that is used as the ECT variable in the short term model with error correction mechanism.

*Table 9: Results of Granger causality test ($F_{1,73}$) Critical values 7.05 (1%) 3.95 (5%) 2.76 (10%)*[59]

| *10 Year SEK swap spread* | *Test statistic* | |
|---|---|---|
| Variable | Causality | Reverse causality |
| *Slope* | 0.402 (Not reject) | 0.00064 (Not reject) |
| *Off / On – the – run spread* | 0.0895 (Not reject) | 1.30 (Not reject) |
| 1*yr CAP volatility* | 0.00027 (Not reject) | 0.000031 (Not reject) |
| *Credit spread* | 4.16 (Reject at 5%) | 0.691 (Not reject) |
| *Borrowing need* | 0.0167 (Not reject) | 0.533 (Not reject) |
| 10*yr Euro swap spread* | 0.547 (Not reject) | 0.465 (Not reject) |
| Re*siduals* | 5.57 (Reject at 5%) | 13.1 (Reject at 1%) |
| *5 Year Swap spread* | *Test statistic* | |
| Variable | Causality | Reverse causality |
| *Slope* | 0.506 (Not reject) | 1.09 (Not reject) |
| *Off / On – the – run spread* | 0.577 (Not reject) | 0.0395 (Not reject) |
| 1*yr CAP volatility* | 0.166 (Not reject) | 0.647 (Not reject) |
| *Credit spread* | 3.88 (Reject at 10%) | 0.341 (Not reject) |
| *Borrowing need* | 0.0183 (Not reject) | 0.0179 (Not reject) |
| 5*yr Euro swap spread* | 1.20 (Not reject) | 0.0005 (Not reject) |
| Re*siduals* | 8.09 (Reject at 1 %) | 15.4 (Reject at 1%) |

[59] See critical values in e.g. Gujarati (2003).

## 10.5 Appendix E

### Cointegration[60]

A regression of a nonstationary time series on another nonstationary time series may produce a spurious regression. Consider two nonstationary time series X and Y. Suppose then that we regress X on Y as follows:[61]

$$X_t = \beta_1 + \beta_2 Y_t + u_t \tag{18}$$

This could be written as:

$$u_t = X_t - \beta_1 - \beta_2 Y_t \tag{19}$$

If we now test $u_t$ for stationarity we may find that it is stationary even though X and Y individually are nonstationary. The reason for this possibility is that the linear combination of X and Y cancels out the stochastic trend in the two series. In this case we say that the two variables X and Y are cointegrated. Variables will be cointegrated if they have a long term, or equilibrium relationship between them.

### Testing for Cointegration

**Engle-Granger tests**

To test for cointegration using the Engle-Granger test we estimate the regressions (20) and (21), save the residuals and perform the augmented Engle Granger test which is a modification of the augmented Dickey Fuller test. After estimating (20) and (21) a unit root test is performed on the saved residuals. If the computed value is lower than the 1 percent critical value the conclusion will be that the residuals are stationary.

The following regressions are estimated:

$$10yr\ SEK\ swap\ spread = \beta_0 + \beta_1 Credit\ Spread + \beta_2 Borrowing\ need + \varepsilon_t \tag{20}$$

$$5yr\ SEK\ swap\ spread = \alpha_0 + \alpha_1 Credit\ Spread + \alpha_2 Borrowing\ need + e_t \tag{21}$$

[60] See Gujarati (2003).
[61] Gujarati (2003).

We perform the augmented Dickey Fuller test on the residuals from the two regressions. The null hypothesis is that the time series are nonstationary.

The results of the tests can be found in Table (10) below. Since the computed value is smaller than the critical value we reject the null hypothesis. Hence, the residuals are stationary and the variables are cointegrated.

*Table 10 Results from Cointegration test*
*Critical values -3.53 (1%) -2.90 (5%) -2.59 (10%).*[62]

| Swap Spread | $\tau_{observed}$ | Decision |
|---|---|---|
| 10 yr SEK swap spread | -3.604 | Reject $H_0$ at 1% |
| 5 yr SEK swap spread | -4.868 | Reject $H_0$ at 1% |

[62] Reported critical values from statistics program Stata.