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An Empirical Analysis of Factors Driving the Swap Spread

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An Empirical Analysis of Factors Driving the Swap Spread

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En empirisk analyse af de bestemmende faktorer for swap spændet

Resumé (Danish summary):

I dette papir udfører vi en omfattende analyse af de bestemmende faktorer for det amerikanske swapspænd, hvori en bred vifte af teoretisk motiverede faktorer tages i betragtning. Vi undersøger, hvordan de forskellige mulige faktorers påvirkning af swapspændet ændres, når tidshorisonten ændres. Faktorernes følsomhed over for alle tænkelige modelspecifikationer har været undersøgt. Vi finder bl.a. at Treasury- og aktiemarkedsvolatiliteten såvel som aktiviteten på swapmarkedet blandt ejerne af amerikanske realkreditobligationer påvirker det amerikanske swapspænd kraftigt.

An empirical analysis of factors driving the swap spread

Abstract

In this paper, we perform a robust analysis of the determinants of US swap spreads using a wide range of theoretically motivated candidate factors. We conduct an analysis in the frequency domain to see how the impacts of the candidate factors on the swap spread differ between different horizons. The sensitivity of the parameters to all possible model specifications has been investigated. Among other things, we find that Treasury- and stock market volatility as well as the activity of the Mortgage Backed Security holders have strong impacts on the US swap spread.

1. Introduction

Banks, industrial firms, institutional investors and debt managers use swap contracts for reduction of borrowing costs, for managing interest rate risk, or to make profit from changes in interest rates. Swap rates serves as benchmark/reference rates when pricing other financial assets. Due to its importance for financial markets, the swap spread, i.e. the difference between the swap rate and the government bond yield, is one of the most closely monitored financial indicators.

Because of its significant market impact, a vast amount of research effort has been allocated to understand the factors behind swap spread movements. The swap spread is often decomposed into a credit risk component and a liquidity component. The relative importance of these two components has been the interest of a number of empirical studies. Sorensen and Bollier (1994) argue that the swap spreads are partially determined by counterparty default risk. Grinblatt (2001), however, argues that swaps are free from default risk. He therefore attributes the swap spread to the liquidity differences between Treasury securities and swap contracts. Nevertheless, even in the absence of the counterpart risk the swap spread still includes a component related to the credit risk of the banking sector. Duffie and Singleton (1997) conclude that both credit and liquidity risks have impact on the swap spread. More recently, Feldhütter and Lando (2007) find that the liquidity factor is the largest component of the swap spread, whereas Li (2007) finds that the credit risk component accounts for the largest share of the swap spread. It seems that there is yet no clear-cut answer regarding the relative contribution of the liquidity and credit risk factors.

This lack of consensus in the literature can to some extent be attributed to the difficulties in observing/measuring the credit- and/or liquidity components. To tackle this problem, researchers have taken different approaches. One strand has favored fairly structured models, which by nature are sensitive to the assumptions made about the underlying processes driving the spread. One major disadvantage with this approach is that it a priori excludes other potential determinants of the spread. The second strand has tried to model the swap spread using proxies for the liquidity and credit risk component. This approach is mostly data driven and because of its less restricted structure one can also include other potential factors in the models. However using this approach, one is faced with the problem that the potential variables for explaining the swap spread are often strongly correlated with each other and multicollinearity and/or omitted variable bias become crucial obstacles regarding both the accuracy of estimations and the interpretation of results. Another important issue is that the impact of the explanatory variables may vary over the time horizons under consideration.

The aim of this paper is to break new ground for understanding the relationship between the swap spread and its determinants by taking into consideration the interdependence between the candidate factors as well as the time frequency under which the factors affect the spread.

We perform a wavelet analysis to examine the frequency relationship between the swap spread and its potential drivers. Using the wavelet method we decompose the original series into three different scale/frequency components, which we entitle the short-tem, the medium-term and long-term component respectively. There are several motivations for employing this approach. Firstly, and perhaps most importantly, it enables us to isolate certain effects hidden in the raw data series. For example, by subtracting the short-term component we can filter out short-run noise, which may impede the estimation of the true relationship between the variables. In addition, by filtering out the long-term trends from underlying economic fundamentals we can mitigate the risk of estimating spurious co-movements between the variables of interest. Another advantage of the wavelet method is that it enables us to investigate the relationship between the variables at different time horizons. This is of special interest when a variable affects the swap spread through different channels.

This study is based on a wide range of theoretically motivated explanatory variables. By examining the interdependence between these variables, we are able to increase the knowledge about the mechanism underlying swap spread movements. By employing an extreme bound analysis we check the sensitivity of the parameters to all the possible model specifications. A seemingly unrelated regression is employed to estimate the effects of the factors on swap spreads with different maturities.

We find that the suggested variables can to a fair degree explain movements in the swap spread. The relationship between the spread and the explanatory variables are stronger at the medium-term horizon. The results suggest that the Mortgage Backed Security (*MBS*) holders' demand for swap rates strongly influences the US swap spread. Importantly, our analysis of the interdependence between the explanatory variables indicates that the underlying initiator of these activities is changes in the shape of the yield curve. We find that Treasury- and stock market volatility have significant effect on the swap spread, and we attribute this to both the credit- and liquidity component. The results also show that the curvature and the slope of the yield curve, as well as the spread between the short term repo rate and the T-bill rate, have a significant effect on the swap spread, but that these factors are sensitive to model specification.

The remainder of the paper is organized as follows: section 2 describes factors that may affect swap spread; section 3 describes data and construction of the variables; section 4 covers the empirical analysis and section 5 concludes the paper.

2. Factors affecting the swap spread

This chapter discusses the theoretical motivations behind our choices of the candidate variables. The variables include proxies for liquidity and credit risk components as well as other potential determinants of the swap spread.

2.1. Liquidity

Treasuries can be used as collateral in other financial agreements, thereby inducing a "convenience yield"[1] in the pricing of Treasuries.[2] Furthermore, Treasuries are taxed more favorable compared to other assets. In addition, using the latest issued bonds, the "on-the-run" Treasury bonds, as collateral in a repo contracts, often results in a lower, so called special, borrowing rate than the general collateral repo rate. Since the swap spread is calculated using the yield on an on-the-run Treasury bond, the spread will in part consist of this "special-minus-general" spread. Finally, Treasuries have very small bid-ask spreads, and are, due to the extreme intensity of their trading activities, often used by investors as a "safe-haven", in times of market turmoil.

We have two measurements related to the different parts of the liquidity component. Our first measure is the spread between the general collateral repo rate and the Treasure bill rate. This is a direct measure of the liquidity component. Unfortunately it is only observable for short-term contract but it can still be informative for the liquidity component of long-term contracts. Our second measure is the spread between a 10-year "off-the-run" Treasury bond and a 10-year "on-the-run" Treasury bond. This measure does not capture the entire liquidity component, but can potentially be the main driver of its movements. These variables are expected to have a positive relationship with the swap spread.

2.2. Default risk and the connection to the LIBOR / General Collateral spread

According to Li (2007), two types of default risk can be related to a swap contract. The first type of the default risk is due to the default probability of counterparties of the contract, i.e.

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[1] Convenience yield is a measure of the benefits obtained from holding an asset rather than a future position on the asset.

[2] When the supply of Treasury bond decreases, they become scarcer, and therefore the convenience yield associated with them increases.

the counterparty default risk. However, the swap market has developed methods, in form of the provision of collateral combined with frequent margin calls, to mitigate counterparty risk. Added to this is the fact that counterparty default risk is only important if the value of the swap is positive to the non-defaulting party and negative to the defaulting party and that the counterparties only exchange the net interest payment and not the notional amount of the swap. Therefore it is more or less the common practice today to disregard counterparty risk in modeling the swap spread.

The second type of the default risk is motivated by the fact the floating rate of the swap contract is the LIBOR rate. Since the LIBOR rate includes a default risk premium related to the average default probability of the bank system, the fixed rate of an interest rate swap will inherit this credit risk premium. For short-term contracts, this credit spread can be measured by the spread between the LIBOR rate and the repo/general-collateral rate, where the latter is generally accepted as the risk free rate.

He (2000) argues that the swap spread should be related to future expected LIBOR-to-repo spreads. To see this, consider the following strategy: receive fixed, say 10 year, swap rate (*S*) and pay, say, 6-month LIBOR. Sell a 10-year government par bond, with coupon rate *C*, and invest the money at the General Collateral rate (*GC*), i.e. a reverse repurchase agreement. If the notional amount of the swap agreement is *N*, then this strategy pays every 6-month: $[(S-C)-(LIB-GC)]N$. Following the same reasoning as when deriving the expectation theory of the term structure, the swap spread (*S*-*C*) should be equal to the expected future *LIB*-*GC* spread that will be realized during the maturity time of the swap contract. To the extent that the current *LIB*-*GC* spread also contains information about future *LIB*-*GC* spreads, its innovations could be correlated with movements in the swap spread.

2.3. Slope

There are several motivations for why the slope of the yield curve should be an important factor for the swap spread. According to Kobor et al (2005) a steep slope of the yield curve increases the incentive of the fixed rate bond issuers to switch from fixed to floating interest payment. This raises the demand for receiving fixed rate and reduces the demand for paying fixed-rate. Thus, a steep slope of the yield curve reduces the swap rate and lowers the spread. In addition, banks, who borrow money using shorter term contracts and lend out on longer horizons, may encounter a reduction of their margins due to a flattening of the yield curve. In such an environment they may find it attractive to hedge this risk by paying fixed swap rate, thereby pushing up the swap rate and increasing the swap spread. From these two viewpoints, the slope is a driver of the relative demand for swaps rates.

Cortes (2003) argues that the slope of the yield curve affects the swap spread because it reflects expectations of future economic conditions. For example, a negatively sloped yield curve (inverted yield curve) signals an economic slowdown, which might jeopardize the stability of the financial system. This induces an increase in the credit risk component of the swap spread. All in all, we expect the swap spread to be negatively related to the slope of the yield curve.

2.4. Level

There is no consensus in the literature regarding the effect of the level of the yield curve on the swap spread. On the one hand, Brown et al. (1994) argue that if there are temporal mismatches in the market makers' paid and received swap rates, the market makers' hedging costs rise as interest rates increase. This implies that the higher is the interest rate the lower will be the swap rate that the market makers accept to pay or receive. All in all this will result in a negative relationship between the level of the yield curve and the swap rate.[3] Lekkos and Milas (2001) include the variable *Level* in their empirical work and find that it contributes to variations in both the U.S. and the UK swap spreads, and that the relationship is negative. In addition, Subrahmanyam et al (2000) also find that the swap spread is negatively related to the level of interest rates, in the Japanese market. Furthermore, when the level of interest rates rises due to an increase in supply of bonds, i.e. when Treasuries become less scarce and the convenience yields falls, the swap spread is often believed to decrease. In this sense, a change in the variable *Level* is related to the liquidity component of the swap spread.

On the other hand, the variable *Level* can also be considered as a proxy for the general liquidity in an economy. A low level may therefore indicate a large "chase for yields" on swap rates, thereby putting downward pressure on the swap spread. This leads to a positive relationship between the swap spread and the variable *Level*. However, this effect of *Level* would plausibly be most dominant at lower frequencies; a steady decrease in *Level* may cause a slow increase in overall liquidity, and thereby affecting the swap spread negatively over longer horizons.

It also seems possible that the spread would be positively related to the level of interest rates due to a plain scaling effect; it does not seem reasonable that the market should demand the same spread when the general level is at say 1 pct. as when it is at say 10 pct.

As we will discuss below, the variable *Level* can also have an indirect (positive) effect via its impact on the duration of MBS portfolios.

To sum up, the effect of the level is hard to establish on purely theoretical grounds, and its effect may vary over time, over different frequencies and over different states of the economy.

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[3] Reflecting on this, it seems intuitive that the more liquid is the market, i.e. the easier it is for the market maker to match in and out flows, the less will be this potential effect.

2.5. Expected interest rate volatility

Since increasing interest rate volatility is often associated with economic uncertainty, and thereby increasing risk premiums, it should influence both the credit risk component and the liquidity component of the swap spreads. Swap rates may increase due to higher bank sector default risk at the same time that Treasury bond rates drop due to flight to quality/flight to liquidity. Therefore, this variable is expected to influence the swap spread positively.

2.6. Curve

The curvature of the yield curve has been used as a potential determinant of the swap spread by earlier empirical studies, such as Fang and Muljono (2003) and Subrahmanyam et al (2000). Theoretically, the curvature is related to the volatility of the interest rates (see for example, Litterman et al (1991) and Andersen and Lund (1997)), and the motivation given above for the expected interest rate volatility is therefore also applicable for this variable. Consequently, we also expect a positive relationship between the curvature of the yield curve and the swap spread.

2.7. Expected volatility of the stock market

The volatility of the stock market is a measure of stock market uncertainty. High uncertainty periods are often associated with 'flights-to-quality' portfolio reallocations, i.e. an increase in the demand for highly liquid assets.[4] This will in turn lower the Treasury bond yields and widen the swap spread. Furthermore, the stock volatility is often used as an explanatory factor in modeling default risk and in credit spread models (see for instance Churm and Panigirtzoglou (2006)). Hence an increase in stock market volatility may indicate an increase

[4] For instance Longstaff (2004) finds that there is a significant flight to liquidity component in government bonds, by comparing the price movements of treasuries with equally creditworthy, but less liquid, bonds in times of high market stress.

in the bank sector default risk, thereby influencing the credit risk component of the swap spread. Thus, this factor should be related to both the credit risk component and the liquidity component of the swap spread. However, the frequency in which it influences the liquidity component may be different from the frequency that it influences the credit risk component. The influence on the liquidity component is likely strongest at the higher frequencies, caused by short-lived tactical reallocations between the stock and Treasury bond markets. Credit risk on the other hand is, in general, a more slow-moving variable, (usually described with the term *credit cycle*), closely related to the overall business cycle.

To sum up, we expect a positive relationship between the stock market volatility and the swap spread.

2.8. Mortgage-backed securities duration

A decrease in the interest rates gives homeowners the opportunity to refinance their fixed-rate debt with lower interest rates. According to Cortes (2003), the early repayments of the MBS by the homeowners reduce the duration of the MBS. Assuming that the duration of the liabilities of the MBS holders remains unaffected, this increases their portfolio risk. To offset the reduction in the duration of MBS they can participate in a swap contract, receiving fixed and paying floating. The increase in the demand for the fixed rate will lower the swap rate and tighten the spread. This discussion also implies that the hedging activity of the MBS holders is highly correlated with the level of the yield curve. The MBS duration is expected to influence the swap spread positively.

3. Data and construction of the variables

We use weekly US data for the period from 1999-01-01 to 2007-08-13. There is a general perception that the swap market experienced a structural change around 1998, see for instance

Kobor et al (2005). We therefore start our sample in 1999 to circumvent potential estimation problems which may be induced by this structural change.

The swap spread (*SS*) is defined as the difference between the fixed yield on a swap contract (*SR*) and the on-the-run government bond yield (*GY*). We use three different maturities to define the spread, i.e. two-year, five-year and ten-year maturities.

We use the following variables as the potential determinants of the swap spread:

- *MBS*: we use the duration of the Lehman Brothers MBS index that is usually used as a benchmarking index and consists of fixed-rate securities with a minimum principal amount of $50 million. The securities within the index have an average life between 15 and 30 years.
- *ON-OFF*: this variable is measured as the spread between the yield on a 10-year off-the-run treasury bond and a 10-year on-the-run treasury bond.
- *Level*: The term structure variables, *Level*, *Slope* and *Curve*, are constructed by applying the standard principal component method on zero coupon yields of the on-the-run treasury bonds with maturities 3 months, 6 months, 1 to 10 years, 15 years, 20 years and 30 years. We use the first principal component as the proxy for the level of the yield curve.
- *Slope*: We use the second principal component of the zero coupon yields as the proxy for the slope of the yield curve.
- *Curve*: We use the third principal component of the zero coupon yields as the proxy for the curvature of the yield curve.
- *TR-VOL*: We use the Merrill Lynch yield curve weighted index of the normalized implied volatility on 1-month treasury options.

- *ST-VOL*: The stock volatility is measured by the implied volatility of the S&P 500 stock index (the VIX index).
- *LIB-GC*: The spread between the 3-month LIBOR rate and the 3-month General Collateral rate.
- *GC-TB*: The spread between the 3-month General Collateral rate and the 3-month Treasury bill rate.

All data has been collected from Bloomberg.

4. Empirical analysis

We initiate the analysis by a descriptive examination of the data at hand, and performing tests for stationarity. In section 4.2, we perform a regression analysis of the relationship between the swap spread and the candidate factors. Section 4.3 deals with a frequency analysis of this relationship using Wavelet. We perform an analysis of variances in section 4.4 to estimate the contribution of each factor in total variations in the swap spread. For the sake of space, we focus on the spread of the five-year maturity in most of the analysis. However, in section 4.5 we apply a seemingly unrelated regression for spreads of three different maturities, i.e. two, five and ten-year, to examine if the relationship between the potential factors and the swap spread varies across different maturities.

4.1. Preliminary data analysis

Exhibit 1 shows the developments of the 2, 5 and 10-year swap spreads, during the sample period. As can be seen, the 5-year swap spread peaked the around end of the year 2000 at around 105 basis points, after which it declined to an average level of about 30 basis points. In the end of the sample period, the turbulence in the international financial markets, caused by the crisis in the US subprime market, has widened the swap spreads.

Exhibit 2 displays the descriptive statistics of weekly changes in the swap spreads and their economic determinants. We can see that none of the variables are normally distributed. For most of the variables this is mainly due to the large kurtosis rather than the skewness.

The majority of the previous studies have found that the swap spread is non-stationary, and the majority of these examinations have therefore been conducted on the first-differenced series. We perform a test for stationarity by using the ADF tests and the KPSS (see Exhibit 3). The tests indicate that the different swap spread series are non-stationary. To mitigate the risk for spurious regression results, we use the first difference of each series in our regression analyses.

4.2. Regression analysis of five-year swap spread

We regress the 5-year swap spread on all the candidate variables. The regression model, including all the candidate variables is:

$$\begin{aligned}\Delta SS_5 &= \beta_0 + \beta_1(\Delta MBS) + \beta_2(\Delta ON - OFF) + \beta_3(\Delta Slope) + \beta_4(\Delta Level) + \beta_5(\Delta Curve) \\ &+ \beta_6(\Delta Tr.vol) + \beta_7(\Delta ST.vol) + \beta_8(\Delta LIB - GC) + \beta_9(\Delta GC - TB) + \varepsilon\end{aligned} \quad (1)$$

Looking at the result of the first regression, shown in Exhibit 4, we see that the factors can explain a reasonable portion of the variability in the changes in the five-year swap-spread; the adjusted R^2 of the model is 0.40.[5]

Furthermore we see that the *MBS* variable is a strong factor for the swap spread; a one unit increase in the *MBS* factor increases the 5-year swap spread with 15.3 basis points. In comparison, a one unit decrease in the slope increases the swap spread with 7.8 basis points. We also see that all the three volatility variables, the *TR-VOL, ST-VOL* and the *Curve* are significant. Furthermore, *LIB-GC* spread the *ON-OFF* spread and the *Level* variables are

[5] We find significant evidence of autocorrelation and heteroscedasticity and therefore adjust all standard errors using the Newey-West method.

insignificant. Finding the *LIB-GC* spread and the *On-Off* spread to be insignificant is in line with the results of Cortes (2003).[6] One possible explanation for this result is that innovations in these variables are in part caused by shocks that are unrelated to swap spreads, and that these shocks conceals the theoretically motivated connection. Thus, if these "noise" shocks were to be filtered out, the "expected" connection should be identifiable. We will return to this issue in section 4.5.

Looking at the correlation matrix, in Exhibit 5, we see a strong connection between the *MBS* factor on one side and the variables *Level* and *Slope* on the other side. In fact, regressing the *MBS* on *Level* and *Slope* reveals that these variables can explain 75 percent of the movements in the *MBS*.[7] This finding is important for understanding the relationship between the swap spread and these variables. The variable *Level* turns out to be insignificant in the regression of equation (1), see Exhibit 4, while excluding the *MBS* from the regression makes the *Level* significant and positive.[8] Therefore a large portion of the effect of the *Level* on the swap spread may come indirectly through the *MBS* factor.

To understand the connection between *Slope, MBS* and the swap spread, recall that *MBS* is the duration of a portfolio of mortgage bonds that, due to a prepayment clause, have what is known as negative convexity. This negative convexity means that the duration of the portfolio declines when interest rates falls. Thus a steepening of the slope of the yield curve increases the duration of the long-term contracts and decreases the duration of the short-term contracts. The net effect on the portfolio will depend on the relative weights of long- and short-term contracts, and the relative changes of their duration. The portfolios of mortgage loans have most likely larger weights on long-term, long-duration contracts, which are more yield-

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[6] The majority of the earlier studies on swap spreads find the *LIB-GC* spread to be insignificant.

[7] The regression equation $\Delta MBS = b_0+b_1\Delta Level+b_2\Delta Slope$, gives a R^2 equal to 0.75.

[8] The result of regression excluding *MBS* is not presented in the paper but is available upon request.

sensitive than short-term contracts. All in all, this means that the increase in the long-term yields will dominate the decrease in the short-term yields. Therefore an increasing slope will lead to an increasing duration in the MBS portfolios. Therefore, *Slope* should have two opposite effects on the swap spread: a positive effect that is transmitted through *MBS* and a (marginal) negative effect.

4.3. Sensitivity analysis

To examine the sensitivity of the results to the chosen model specification we use an automatic model selection and an extreme bounds analysis (*EBA*) suggested by Leamer (1983).

To investigate if there are redundant variables in the general model specified in equation (1) we run regressions of the five-year swap spread on each possible combination of the explanatory variables. With nine explanatory variables of the full model we have a total number of 2^9 or 512 specifications. We identify the specification with the maximum possible adjusted R^2 value. This results in a model where the variables *ON-OFF* and *LIB-GC* are left out, but with almost the same adjusted R^2 as the general model.[9]

Next we perform the EBA to examine the fragility of the estimated coefficients to changes in the number of the explanatory variables included in the model. We first define the important variables that should be included in all the regressions, and the doubtful variables that may be included or omitted. We choose to include the intercept term in all the specifications and consider all other variables as doubtful. We estimate the coefficients of all the possible regression models, in our case a total of 512 different models. We then define the extreme bounds for each coefficient, β, as the lowest and highest estimated values resulting from 512

[9] The results of the regression with maximum adjusted R^2 are not reported but are available on request.

different regressions (β_{min} and β_{max}). We define a coefficient as fragile if it changes signs or becomes insignificant at the extreme bounds [Levine and Renelt (1992)].

Exhibit 6 illustrates the extreme bounds after adding two standard deviations to β_{max} and deducting two standard deviations from β_{min}.[10] A coefficient is assumed to be robust if the defined interval does not contain zero. Three explanatory variables, i.e. *MBS*, *ST.VOL* and *TR.VOL* are robust to all the different model specifications, while the significance of other explanatory variables relies on the inclusion or exclusion of other variables. The variables *Slope*, *Curve* and *GC-TB,* which were significant in the full models, are shown to be fragile to the model specifications. Of course, the sensitivity of these variables to model specification does not suggest that these variables are redundant, but that the importance of these variables can only be revealed if other related variables are included.[11]

4.4. Analysis of different maturities

Having thoroughly examined the effects of the factors for the five-year swap spread, one is curious on their effect on other maturities. We therefore estimate a system of equations where we also include the two-year and the ten-year swap spread. This should also increase the efficiency of the estimates, thereby giving another robustness check of the results from the single equation regression.[12]

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[10] Since the distribution of the extreme bounds is not known, we use a conservative method to present the bounds.

[11] We also test the model for parameter stability. We use recursive parameter estimates and in addition perform a CUSUM test and the Andrew's (1993) break point test. There is no evidence from these tests that indicates problems due to parameter instability. In addition to these tests, we also perform an Outlier/Influential Observations analysis to check the robustness of our results (see for instance Baltagi (2008) chapter 8 for an overview). The results of these tests are available on request.

[12] This is not entirely without risks; a misspecification in one of the equations will contaminate the entire system (Hayashi (2000)).

Looking at the outcome of this estimation (see Exhibit 7), we find some intuitive results. The coefficient on the variable *Slope* increases in absolute terms with maturity. There are two alternative explanations for this finding. The first explanation is based on the relative demand for long-term vs. short-term interest rates. For example, in an upward-sloping yield curve environment, the premium is larger at the longer end of the curve. This puts larger downward pressure on the long-term swap-rates relative to the short-term ones. The alternative explanation is based on the idea that the variable *Slope* is a business cycle indicator. If the *Slope* signals weaker economic conditions in the future (a downward-sloping yield curve), it increases the market expectation of a higher banking sector credit risk in the future. Since the long-term swap contracts are more exposed to this risk, a larger premium is demanded on these contracts, making the long-term spreads increase more relative to the short-terms spreads.

The point estimates of the coefficients on the *MBS* variable increases with maturity. Although a formal test cannot reject the equality of the coefficients of this variable over the different maturities, the point estimates are in accordance with intuition; if you want to increase the duration of your portfolio, your demand should be relatively higher for long duration contracts.

The stock volatility is insignificant for the two-year swap spread. Given that the stock volatility, in the short run, captures "flight-to-quality" effects, it seems that it is the longer-term treasury contracts that are the subject for a reallocation in times of increasing stock return uncertainty. This result is in agreement with that of Longstaff (2004), which finds that the Flight-to-Liquidity premia in Treasury bonds, at maturities above one year, is an increasing function of the maturity.[13]

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[13] See Table 1 in Longstaff (2004).

The coefficient for the *GC-TB* is fairly stable across maturities. If we were to find a strong connection in the short-term but a weaker effect on the long-term, it would raise concerns that the effect was driven mostly by variations in the *TB* rate. The fact that innovations to the *GC-TB* have almost the same effect on all maturities implies that the liquidity component is stable across maturities.

Curve is insignificant for the longer contracts. The *ON-OFF* spread is insignificant for all the maturities. Finally, the degree of explanation of the explanatory variables is also stronger for the medium and long term spreads relative to the short term spread, due to stronger effect from the *Slope* variable and the stock volatility variable.

4.5. Frequency analysis

We now turn to a wavelet analysis, which allows for a frequency/scale decomposition of a given time series. This method enables us to filter out both short-run noises and long term trends from our variables. Details on the wavelet method are found in the appendix.

There is a risk that some of the variables are contaminated by short-run noises which may conceal the true relationship between the factors and the swap-spread. For instance, Feldhütter and Lando (2007) show that there are occasional changes in the *LIB-GC* spread that are not linked to changes in the default premium. Furthermore, the existence of trends in the variables may be related to the movements of underlying economic fundamentals. This may induce spurious causal relationship between the variables of interest. For example, an estimated co-integration relationship between the swap spread and a potential explanatory variable may only reveal the common impact of overall economic conditions instead of an in-between casual link.[14] To illustrate this argument we plot in Exhibit 8 the 5-year swap spread and the variable *Level* together with two variables closely related to the overall economic conditions, i.e. the US unemployment rate and the US budget balance.[15] As we see all the four variables seem to share a common long-term trend, while their short-term variations seems to deviate from each other.

In addition, by using the wavelet method we may shed light on the time horizon that the variables are related to each other. For example, an increase in the level of interest rates can, due to increasing default risk or because of simple scaling effect, lead to an increase in the swap spread. However, if the level increases due to an increase in the supply of Treasury bonds, it may shrink the spread. A priori, there is no reason to believe that these different effects on the swap spread should be the same at different frequencies.[16]

We decompose the swap-spread and each of the explanatory variables into three different scales using wavelets methods, which we hereafter denote as the short-term component (variations from one week to two months), the medium term component (variations from two months to one-year) and the trend, which contains all the variations with lower frequencies (longer than approximately one year). We regress each frequency component of the swap-spread onto the corresponding frequency component of the explanatory variables. However, we will not conduct any regression analysis on the trend component in order to avoid potential problems associated with non-stationarity.

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[14] For instance, Cortes (2003) shows a co-integration equation between the swap spread and the expected budget balance, while at the same time he finds that changes in the expected budget balances have no effect on changes in the swap spread.

[15] The unemployment rate is employed as an explanatory variable by Lang et al (1998) and the (expected) budget balance has been investigated by for example Cortes (2003).

[16] It is recognized in other fields that the effect of one variable can have changing effect on another variable as one moves from the short term to the medium- and long term, or equivalent when one moves “down-the-frequencies”. The most obvious example is the relationship between money and growth.

To get a visual image of the outcome from a wavelet-based decomposition of a given time-series, the Exhibit 9 plots the frequency components of the 5-year swap spread using the 3-component decomposition (short, medium and trend). By comparing this Exhibit 9 with Exhibits 1 and 8, one can see that the wavelet method is fairly effective in isolating/retrieving certain frequency components.

Exhibit 10 shows that the variables *ON-OFF* and *LIB-GC* are still insignificant for both medium-term and short- term horizons. *Level* is negative and significant only for the medium-term horizon, while the *Curve* is significant only on the short-term. The negative impact of the *Level* may be driven by changes in the supply of Treasuries. For example, a decrease in the supply of Treasury bonds increases the scarcity premium of Treasuries, causing a high convenience yield and hence increases swap spreads. The significance of the result for the medium term horizon is intuitive, since the scarcity premium should changes slowly over time. This result also supports the argument by Brown et al. (1994) that the level of interest rates are positively related to the market makers' hedging costs, which in turn is negatively related to the swap spread. Looking at the Treasury volatility and the stock volatility, we see that they have significant effects on the swap spread both in the high and the medium term frequencies. Finding that the stock volatility is significant even at the medium term frequency is of importance since this reveals the variable's effect on the credit risk component of swap spreads (see section 2.7). This variable can therefore not only be regarded as causer of short-term swap spread movements, as often stated by market analysts.

It is interesting to analyze whether the ability of each factor to explain the swap spread varies over different time horizons. We perform an analysis of variances for different time horizons, i.e. the regression of the first differences as well as the two regressions from the wavelet analysis. In general we can write the regression model as:

$$y_t = a_i + \sum_{k=1}^{K} b_{ik} x_{kt} + \varepsilon_t . \tag{2}$$

The contribution of each factor k to the total variance of the dependent variable, y_t:

$$c_k = b_k \sum_{j=1}^{K} b_j \sigma_{kj} , \tag{3}$$

where b_j is the coefficient of the factor k in the regression contribution of factor j in the regression and σ_{kj} is the covariance between factor k and factor j. By dividing c_k with the total variance of y_t we can compute the part of the total variance that is explained by each factor. Note that the R_2 is the sum of these partial contributions:

$$R^2 = \sum_{k=1}^{K} \frac{c_k}{\text{var}(y_t)} \quad . \tag{4}$$

Exhibit 11 illustrates the results of the variance analysis. As can be seen from the Exhibit, the variance in the level of the swap spread is dominated by lower frequencies, as can be expected by a unit root process. Furthermore, we see that *MBS* and *Slope* are the most important factors for the medium-term variations in the swap rate.

Conclusion

In this paper we analyze the determinants of weekly US swap spread movements over the period 1999-01-01 to 2007-08-13. We investigate a wide range of theoretically and/or empirically motivated potential factors and swap spreads at different maturities. Using the wavelet method we decompose the swap spread, as well as its potential determinants, into different frequency components to analyze if a factor's effect on the swap spread varies by the time-horizons. We investigate the sensitivity of the regression results to changes in the model specification through an extreme bounds analysis.

We find that the suggested variables can to a fair degree explain movements in the swap spread. The results suggest that the activities of the government-sponsored enterprises in the swap market strongly influence the US swap spread. Importantly, our analysis of the interdependence between the explanatory variables indicates that the underlying initiator of these activities is changes in the shape of the yield curve. Thus, this result points to an additional, perhaps somewhat overlooked, channel in which changes in the yield curve influences the swap spread. Furthermore, we find that Treasury- and stock market volatility have significant effect on the swap spread. The results also show that the curvature and the slope of the yield curve, as well as the spread between the short term repo rate and the T-bill rate, have a significant effect on the swap spread, but that these factors are sensitive to model specification. Furthermore, we find that the same factors explain swap spreads at different maturities.

The frequency-by-frequency analysis reveals interesting results. The relationship between the spread and the explanatory variables are stronger at the medium-term horizon. We find that the level of the yield curve has a negative effect in the medium term horizon, in contrast to its positive effect in the short run. Furthermore, we find that stock volatility, in addition to its short-term impact, has a significant effect in the medium-term, where the latter can be attributed to its effect on the credit risk component of the swap spread.

An analysis of the variances shows that the variable *MBS* and the two variables measuring volatility, i.e. *TR-VOL* and *ST-VOL* together account for about 50% of the total variations in the five-year swap spread.

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Appendix: Wavelet

Using a wavelet multi-scaling approach we divide the time-series variables on a scale-by-scale basis into different frequency components. We then combine different frequency components to construct the time-series corresponding to different time horizon, i.e. short-term, middle-term and long-term (trend).

By applying a discrete wavelet transform (DWT) we project a time series process, x_t, onto a set of functions to generate a set of coefficients that capture information associated with different time scales. In contrast to the Fourier analysis, which uses the trigonometric functions and assumes regular periodicity, the DWT functions are local in time and can be used to represent time series processes whose characteristics change over time.

Wavelet analysis divides a single signal into a set of components of different time frequencies. The smooth (trend) parts of a time series are represented by the father wavelet, given by:

$$A_J(t) = \sum_k a_{J,k} \theta_{J,k}(t) \quad \text{(A1)}$$

$$a_{J,k} = \int_{-\infty}^{\infty} x(t)\, \theta_{J,k}(t) dt$$

$$\theta_{J,k}(t) = 2^{-\frac{j}{2}} \theta\left(2^{-J} t - k\right)$$

and the detailed parts are represented by mother wavelets:

$$D_j(t) = \sum_k d_{j,k} \varphi_{j,k}(t) \quad \text{(A2)}$$

$$d_{j,k} = \int_{-\infty}^{\infty} x(t) \varphi_{j,k}(t) dt$$

$$\varphi_{j,k}(t) = \frac{1}{\sqrt{s^j}} \varphi\left(\frac{t - kps^j}{s^j}\right)$$

where s is the scale factor, p is the translation factor and the factor $\sqrt{s^j}$ is for normalization across the different scales. The index j, $j = 1, 2, \ldots, J$, is for the scale, where J is the chosen number of scales, and k is the number of translations of the wavelet for any given scale. The notations $a_{j,k}$ and $d_{j,k}$ are the wavelet coefficients and $\theta_{j,k}(\mathrm{t})$ and $\phi_{j,k}(\mathrm{t})$ are corresponding wavelet functions.

The father wavelet integrates to one and the mother wavelet integrates to zero. The details and scaling functions are orthogonal and the original time series can be reconstructed as a linear combination of these functions and the related coefficients:

$$x(t) = A_J(t) + \sum_{j=1}^{J} D_j(t) \qquad \text{(A3)}$$

To be able to use j scales we should have at least 2^j observations. The scale $D_j(t)$ captures information with $2^{j-1}$and 2^j time intervals.

To construct time-series of the different horizon we sum the details over the different scales. We define the short-term horizon as all the variations up to scale 3:

$$x_S(t) = \sum_{j=1}^{3} D_j(t)$$

With weekly data, this corresponds to variations up to 2^3 weeks or approximately two months.

The medium-term horizon captures all the variations between scale 4 and 6, this corresponds to frequencies longer than two months and less than or equal to approximately one-year (64 weeks).

$$x_M(t) = \sum_{j=4}^{6} D_j(t)$$

The trend component is per construction $A_J(t)$, where $J = 6$.

For a detailed discussion on the wavelet methods see for example Gencay et al (2001).

Exhibit 1. Plots of the swap spreads

The exhibit plots the swap spread with different maturities. We use weekly data from 1999-01-01 to 2007-08-13.

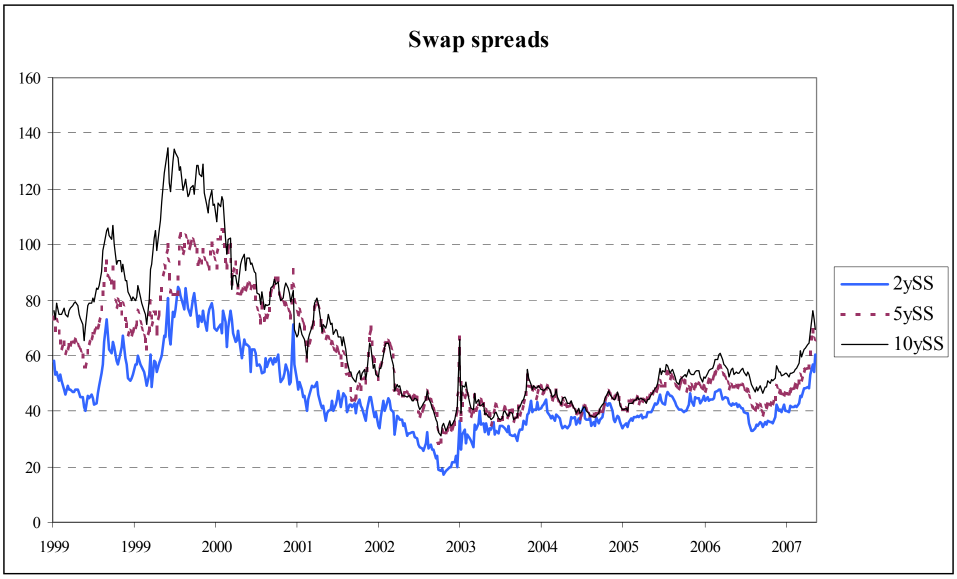

Exhibit 2. Descriptive statistics

The exhibit presents the descriptive statistics of the first difference of the swap spreads (*SS*) and the candidate factors. We use swap spread for three different maturities (2, 5 and 10 years). We use weekly data from 1999-01-01 to 2007-08-13.

	SS-2Y	*SS-5y*	*SS-10Y*	*MBS*	*ON-OFF*	*SLOPE*	*LEVEL*	*CURVE*	*TR.VOL*	*ST.VOL*	*LIB-GC*	*GC-TB*
Mean	0.008	-0.016	-0.013	0.004	-0.404	-0.178	-0.139	0.045	-0.023	-0.041	0.008	-0.026
Median	0.000	0.000	0.000	-0.010	0.000	-2.381	-0.005	0.143	0.000	-0.310	-0.050	-0.200
Std. Dev.	3.6	4.1	3.8	0.2	9.9	41.4	22.3	10.1	7.8	2.4	9.5	6.4
Skewness	0.8**	-0.3**	-0.4**	0.5**	0.0	0.2	0.6**	-0.2	0.6**	0.3**	0.6**	2.0**
Kurtosis	9.3**	14.8**	14.2**	5.1**	47.3**	4.4**	3.7**	4.2**	7.0**	5.8**	18.0**	26.1**
P-val. JB	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Obs.	449	449	449	449	449	449	449	449	449	449	449	449

Notes:JB is the Jarque-Berra test for normality. The estimates marked with one asterix are significant at the 5% level and with two asterices are significant at the 1% level.

Exhibit 3. Unit root test

The exhibit presents the results of the unit root test for the swap spreads (*SS*) with different maturities (2, 5 and 10 years) and for the candidate factors. We use the adjusted Dickey-Fuller test (ADF), where the null hypothesis is non-stationariry, and the test by Kwiatkowski, Phillips, Schmidt and Shin (KPSS), where the null hypothesis is stationarity.

Variable	ADF	*p*-val	Indication	KPSS	Critical val. 1 pct. level	Critical val. 5 pct. level	Indication	Conclusion
SS-2Y	-2,01	0,28	non-stationary	1,24	0,74	0,46	non-stationary	NS
SS-5y	-1,93	0,32	non-stationary	1,74	0,74	0,46	non-stationary	NS
SS-10Y	-1,47	0,55	non-stationary	1,59	0,74	0,46	non-stationary	NS
MBS	-2,53	0,11	non-stationary	0,39	0,74	0,46	stationary	S
ON-OFF	-0,78	0,82	non-stationary	2,08	0,74	0,46	non-stationary	NS
SLOPE	-1,33	0,62	non-stationary	0,79	0,74	0,46	non-stationary	NS
LEVEL	-1,04	0,74	non-stationary	0,86	0,74	0,46	non-stationary	NS
CURVE	-2,84	0,05	non-stationary	0,16	0,74	0,46	stationary	S
TR.VOL	-2,96	0,04	stationary	1,30	0,74	0,46	non-stationary	S
ST.VOL	-2,91	0,04	stationary	1,77	0,74	0,46	non-stationary	S
LIB-GC	-5,14	0,00	stationary	0,66	0,74	0,46	non-stationary	S
GC-TB	-5,00	0,00	stationary	0,79	0,74	0,46	non-stationary	S

Notes: NS means "Not Stationary" and S means "Stationary".

Exhibit 4. Regression analysis of the 5-year swap

The exhibit presents the result of the regression analysis of the swap spread. The maturity of the swap is five year. The variables are in the first differences. We use weekly data from 1999-01-01 to 2007-08-13. The last column reports the t-values with Newey-West corrected standard errors.

	Coeff.	**t-val**	**t-val NW**
Intercept	-0.09	-0.61	-0,78
MBS	15.31	10.44**	5,12**
ON-OFF	-0.02	-1.04	-0,94
SLOPE	-7.79	-6.68**	-4,91**
LEVEL	-1.12	-1.30	-0,82
CURVE	6.36	3.31**	2,09*
TR.VOL	0.15	7.03**	4,04**
ST.VOL	0.27	4.07**	3,37
LIB-GC	0.55	0.19	0,20
GC-TB	6.17	2.75**	2,68**
Adjusted R^2	0.40		
F-statistic	34.11**		
Breusch-Godfrey LM Test			
F-statistic	8.01**		
$T \times R^2$	15.88**		
White Heteroskedasticity Test			
F-statistic	6.6**		
$T \times R^2$	97.5**		

Notes: The estimates marked with one asterix are significant at the 5% level and with two asterices are significant at the 1% level.

Exhibit 5. Correlation matrix

The exhibit presents the correlation matrices between different variables included in the model. We only report the result of the swap spread with a five-year maturity. The first panel exhibits the correlations in the first differences, while the second and the third panel report the correlations of the variables after filtering by wavelet. D1-D3 denotes the sum of the scales 1 to 3 and D4-D6 denotes the sum of the scales 4 to 6.

First difference

	Spread	*Lagged Spread*	*MBS*	*ON-OFF*	*SLOPE*	*LEVEL*	*CURVE*	*TR-VOL*	*STOCK-VOL*	*LIB-GC*	*GC-TB*
Spread	1.00										
Lagged spread	-0.21	1.00									
MBS	0.37	-0.15	1.00								
ON-OFF	-0.06	0.13	-0.21	1.00							
SLOPE	0.14	-0.04	0.76	-0.26	1.00						
LEVEL	0.14	-0.09	0.83	-0.26	0.70	1.00					
CURVE	0.04	0.11	-0.43	0.06	-0.35	-0.56	1.00				
TR.VOL	0.44	-0.18	0.27	-0.08	0.25	0.10	-0.04	1.00			
ST.VOL	0.22	0.02	-0.13	0.03	-0.07	-0.23	0.20	0.26	1.00		
LIB-GC	-0.11	0.10	0.04	-0.10	0.06	0.12	-0.10	-0.10	-0.01	1.00	
GC-TB	0.09	0.00	-0.11	0.09	0.06	-0.28	-0.03	0.13	0.03	-0.51	1.00

D1-D3

	Spread	*Lagged Spread*	*MBS*	*ON-OFF*	*SLOPE*	*LEVEL*	*CURVE*	*TR-VOL*	*STOCK-VOL*	*LIB-GC*	*GC-TB*
Spread	1.00										
Lagged spread	0.33	1.00									
MBS	0.26	-0.01	1.00								
ON-OFF	0.00	0.10	-0.32	1.00							
SLOPE	0.07	0.03	0.77	-0.34	1.00						
LEVEL	0.05	-0.06	0.86	-0.35	0.71	1.00					
CURVE	0.11	0.16	-0.50	0.17	-0.34	-0.62	1.00				
TR.VOL	0.37	0.03	0.33	-0.20	0.28	0.15	-0.12	1.00			
ST.VOL	0.33	0.16	-0.25	0.09	-0.22	-0.36	0.29	0.20	1.00		
LIB-GC	-0.07	-0.01	0.08	-0.09	0.11	0.13	-0.14	-0.01	-0.07	1.00	
GC-TB	0.11	0.02	-0.12	0.13	0.08	-0.28	0.02	0.18	0.05	-0.40	1.00

D4-D6

	Spread	*Lagged Spread*	*MBS*	*ON-OFF*	*SLOPE*	*LEVEL*	*CURVE*	*TR-VOL*	*STOCK-VOL*	*LIB-GC*	*GC-TB*
Spread	1,00										
Lagged spread	0,99	1,00									
MBS	0,16	0,12	1,00								
ON-OFF	0,26	0,26	-0,41	1,00							
SLOPE	-0,15	-0,19	0,86	-0,58	1,00						
LEVEL	0,08	0,04	0,89	-0,30	0,69	1,00					
CURVE	0,15	0,19	-0,71	0,50	-0,78	-0,62	1,00				
TR.VOL	0,37	0,33	0,21	0,02	0,28	0,00	-0,22	1,00			
ST.VOL	0,37	0,35	-0,25	0,33	-0,24	-0,34	0,49	0,37	1,00		
LIB-GC	-0,14	-0,12	0,26	-0,63	0,39	0,11	-0,22	0,01	-0,10	1,00	
GC-TB	0,32	0,39	-0,13	0,06	-0,16	-0,17	0,23	0,09	0,19	-0,09	1.00

Exhibit 6. Extreme Bounds Analysis

The exhibit plots the results of the Extreme Bounds Analysis (EBA), which examines the fragility of the estimated coefficients to changes in the number of the explanatory variables included in the model. The maturity of the swap is five year. The variables are in the first differences. We use weekly data from 1999-01-01 to 2007-08-13.

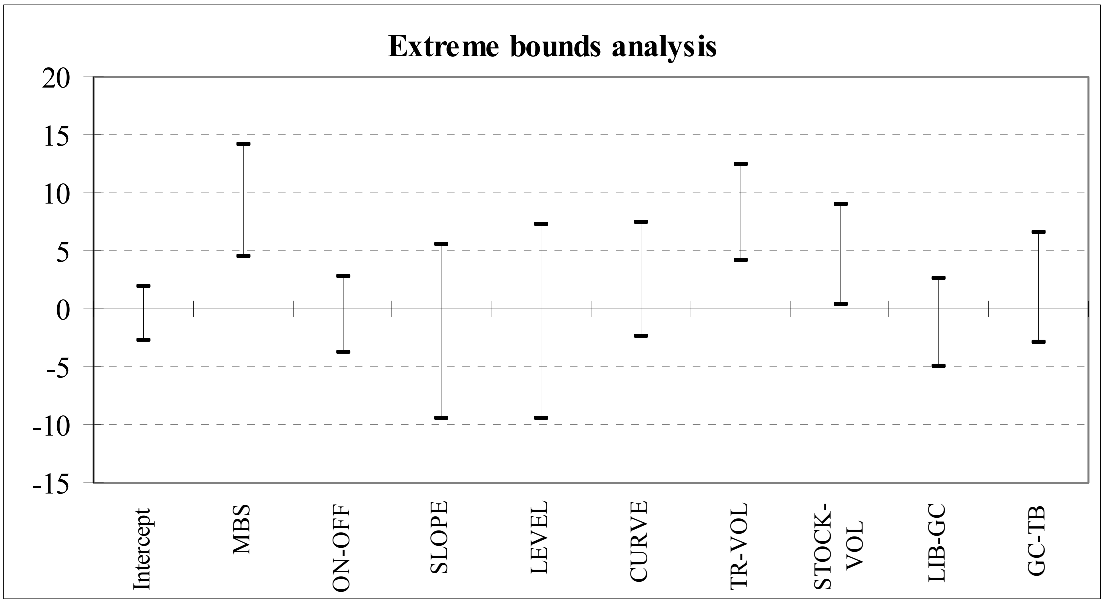

Exhibit 7. Analysis of different maturity

The exhibit presents the result of the regression analysis of the swap spread. We use three different maturities for the swaps, two year, five year and ten year. The variables are all in the first differences. We use weekly data from 1999-01-01 to 2007-08-13. We only report the *t*-values with Newey-West corrected standard errors.

	Two-year swap		**Five-year swap**		**Ten-year swap**	
	Coeff.	*t*-val NW	Coeff.	*t*-val NW	Coeff.	*t*-val NW
Intercept	-0.02	-0,15	-0.09	-0,79	-0.08	-0,68
MBS	8.37	4,14**	15.31	5,18**	14.27	4,95**
ON-OFF	0.02	1,10	-0.02	-0,95	-0.01	-0,88
SLOPE	-3.07	-2,82**	-7.79	-4,97**	-10.10	-6,33**
LEVEL	-1.21	-1,17	-1.12	-0,83	0.49	0,42
CURVE	5.64	2,91**	6.36	2,12*	2.09	0,78
TR-VOL	0.13	4,01**	0.15	4,09**	0.11	3,44**
STOCK-VOL	0.05	0,53	0.27	3,41**	0.28	3,68**
LIB-GC	3.91	1,27	0.55	0,20	3.82	1,34
GC-TB	5.67	2,36*	6.17	2,71**	6.77	2,68**
Adjusted R^2	0.20		0.40		0.38	
Durbin-Watson	2.41		2.27		2.16	

Notes: The estimates marked with one asterix are significant at the 5% level and with two asterices are significant at the 1% level.

Exhibit 8. Swap spread and overall economic conditions

The exhibit plots the 5-year swap spread and the variable *Level* together with two variables closely related to the overall economic conditions, i.e. the US unemployment rate and the US budget balance.

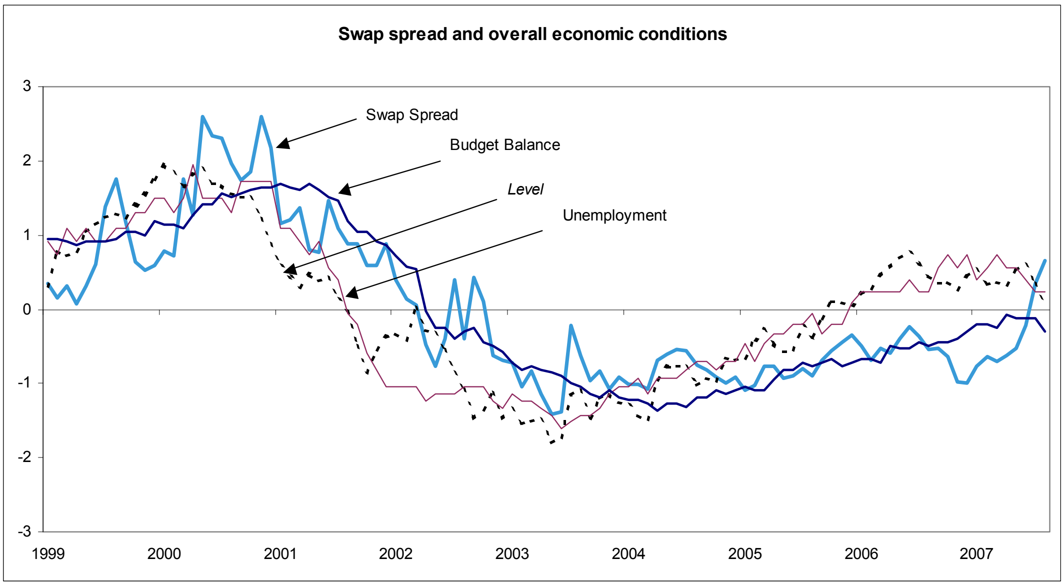

Exhibit 9. Frequency decomposition of the US 5 year swap spread

The exhibit plots the 5-year swap spread and its frequency components. D1-D3 denotes the sum of the scales 1 to 3 (variations from one week to two months), D4-D6 denotes the sum of the scales 4 to 6 (variations from two months to one-year) and the trend is all the variations with frequencies lower than D6.

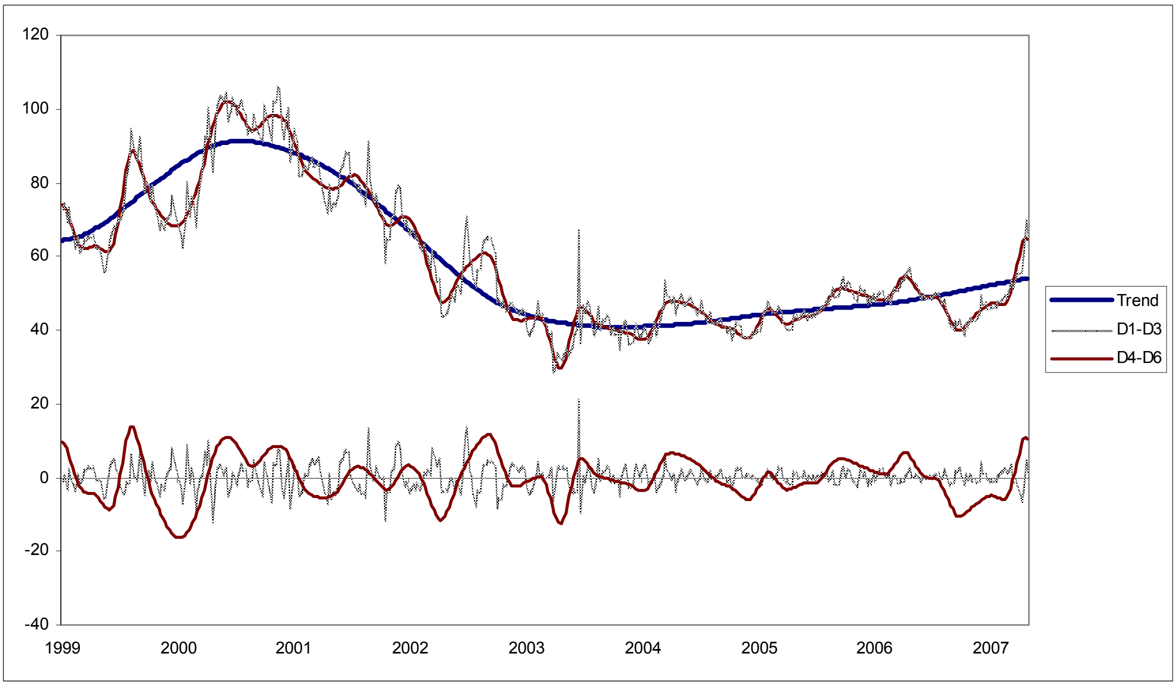

Exhibit 10. Wavelet analysis of the 5-year swap spread

The exhibit presents the result of the regression analysis of the swap spread. The maturity of the swap is five year. The variables are filtered using the wavelet method. We use weekly data from 1999-01-01 to 2007-08-13. The last column reports the *t*-values with Newey-West corrected standard errors.

	Detail	D1-D3	Detail	D4-D6
	Coeff.	**t-val NW**	**Coeff.**	**t-val NW**
Intercept	-0.02	-0.12	-0.04	-0.12
MBS	14.66	**5.76****	19.83	**8.05****
ON-OFF	0.02	0.88	-0.02	-0.84
SLOPE	-7.16	**-4.21****	-12.05	**-11.07****
LEVEL	0.34	0.25	-3.22	**-2.47***
CURVE	11.39	**3.24****	-0.19	-0.09
TR.VOL	0.10	**2.84****	0.20	**4.98****
ST.VOL	0.52	**6.26****	0.35	**2.43***
LIB-GC	3.87	1.55	-1.33	-0.16
GC-TB	9.46	**3.35****	13.19	**2.65****
Adjusted R^2	0.38		0.70	
F-statistic	31.15**		120.40**	

Notes: The estimates marked with one asterix are significant at the 5% level and with two asterices are significant at the 1% level. D1-D3 denotes the sum of the scales 1 to 3 and D4-D6 denotes the sum of the scales 4 to 6.

Exhibit 11. Variables contribution to the variance

The exhibit presents the contribution of each factor in explaining the total variations of swap spread. The maturity of the swap spread is five year. The first panel shows the contribution, while the second panel reports its percentage share. The analysis is performed for the variables in first differences as well as for the series filtered by wavelet. We use weekly data from 1999-01-01 to 2007-08-13.

		MBS	*ON-OFF*	*SLOPE*	*LEVEL*	*CURVE*	*TR.VOL*	*ST.VOL*	*LIB-GC*	*GC-TB*	*Total Variance*
	Diff	4.95	0.04	-0.96	-0.26	0.09	2.11	0.59	-0.02	0.21	16.43
Contrib.	D1-D3	2.25	0.00	-0.34	0.02	0.37	0.78	1.14	-0.05	0.27	11.42
	D4-D4	10.22	-0.70	7.94	-1.19	-0.05	4.27	2.41	0.08	2.27	35.48

		MBS	*ON-OFF*	*SLOPE*	*LEVEL*	*CURVE*	*TR.VOL*	*ST.VOL*	*LIB-GC*	*GC-TB*	*Total Variance*
	Diff	30%	0%	-6%	-2%	1%	13%	4%	0%	1%	41%
% Share	D1-D3	20%	0%	-3%	0%	3%	7%	10%	0%	2%	39%
	D4-D4	29%	-2%	22%	-3%	0%	12%	7%	0%	6%	71%

Notes: D1-D3 denotes the sum of the scales 1 to 3 and D4-D6 denotes the sum of the scales 4 to 6.