# European Asset Swap Spreads and the Credit Crisis

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## Abstract

The dynamics of credit risk are especially important for investors and bond issuing corporations, e.g. for valuation or hedging purposes. In this study we focus on asset swap (ASW) spreads as an increasingly important credit risk measure based on spot market data. In particular we investigate the determinants of (ASW) spreads for a set of 23 European corporate bond indices. Our results suggest that ASW spreads display significant regime specific dynamics. During turbulent periods they are highly sensitive to equity market volatility whilst in tranquil periods they exhibit a significant association with stock returns. In contrast, the level of interest rates affects ASW spreads in both regimes, whereas the difference between the swap curve and the government bond yield curve (the swap spread) influences ASW spreads only in periods of increased volatility. We also find evidence of negative autocorrelation of ASW spreads in tranquil and positive autocorrelation in turbulent periods.



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## 1. Introduction

By the end of 2008 the global credit derivatives market totaled approximately $39 trillion.[1] The largest part of the market consists of Credit Default Swaps (CDS). They are essentially insurance contracts, where buyers agree to pay a predefined periodic fee (i.e. CDS spread) while the sellers provide compensation in case of a default. Kakodkar et al. (2003) demonstrate that CDS are comparable to asset-swapped fixed-rate bonds financed in the repo market.[2] In the strict sense asset swaps (ASW) are not credit derivatives because they do not provide investors with protection against credit risk. However, they are very closely associated with the credit derivatives market, because they separate credit from interest rate risk.[3] The ASW spread is a tradeable spread and, therefore, the best cash market equivalent compared to CDS. Furthermore, they are usually traded in a close range (see, e.g. Norden and Weber, 2009, or Zhu, 2004). For the above reasons, the ASW spread is a widely accepted credit risk measure used by market participants.

More recently, CDS trading volumes dropped significantly to volumes that are now bellow 30% of the record levels during pre-crisis levels.[4] At the same time, the issuance of corporate bonds and the liquidity of the ASW market increased to record levels in 2009. The increase is associated with increased holdings of both large and small retail investors due to high returns in bond and ASW markets as well as losses on equity markets. According to IFSL Research (2009a; 2009b), during crisis periods, it was much easier to participate in the ASW than the CDS market.[5] The recorded changes in the liquidity are consistent with evidence that ASW spreads tend to reveal information about credit risk more efficiently than CDS spreads (Gomes, 2010).[6] Furthermore, the previous evidence report that ASW spreads measure credit risk more accurately than bond spreads (De Wit, 2006; Felsenheimer, 2004; Fracis et al., 2003).

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[1] International Swaps and Derivatives Association's (ISDA) Market Survey, 2009.

[2] For example, by combining a fixed rate bond with a fixed-to-floating interest rate swap the bondholder effectively transforms the payoff, where she pays the fixed rate and receives the floating rate consisting of Libor plus the asset swap (ASW) spread. In case of a default the owner of the bond receives the recovery value and still has to honor the interest rate swap. Usual maturities are three and six months.

[3] See, e.g. O'Kane and Sen (2004) for a thorough explanation of various forms of credit spreads.

[4] See Boughey, S., Farewell to the CDS glory days, Financial News, 21 February 2011.

[5] For example, the standard CDS notional amount is 2,000 times higher (for high-yield debt) then the standard corporate bond's face value of €1,000.

[6] This study examines a sample of 64 corporate bonds issued by 49 non-financial companies.

Whilst previous studies examine determinants of CDS index spreads (Byström, 2005; Alexander and Kaeck, 2008), to the best of our knowledge, there are so far no other studies that examine credit spreads based on ASW spreads derived from corporate bond indices. The purpose of this study is to analyze the time-series dynamics of ASW spreads for 23 European corporate bond indices. We extend the model of Alexander and Kaeck (2008) by imposing a quality premium and by evaluating the time-varying behavior of credit spreads. The examination of the time-varying behavior of credit spreads is particularly important given the significant changes in nature of credit risk and the increasing importance of the ASW market since 2008. This examination is also important given recent regulatory changes introduced in the credit derivatives market.

We utilize an approach based on Markow switching models. Markov models provide an intuitive and systematic way to model structural breaks and regime shifts in the data generating process. Such models can be linear in each regime, but due to the stochastic nature of the regime shifts nonlinear dynamics are incorporated. Another advantage of this approach is the constantly updated estimate of the conditional state probability of being in a particular state at a certain point in time. This approach conveys more precise information about the switching process than a simple binary operator.

Our main findings are: (i) ASW spreads behave significantly different during periods of financial turmoil compared to 'normal' periods, having a residual volatility which is up to eight times higher compared to tranquil periods; (ii) structural determinants seem to fit credit spreads better for financial sector companies than for the remaining industry sectors; (iii) we find less evidence of regime switching in non - cyclical industry sectors; (iv) especially, the financial sector shows a high degree of autocorrelation in credit spreads, which is mostly negative in tranquil periods but highly positive in turbulent market periods; (v) stock market volatility determines credit spreads mainly in turbulent periods whereas stock returns are more important in periods of lower volatility; (vi) interest rates are an important determinant in both market regimes; (vii) the quality premium, defined as the difference between swap and government bond yield curve tend to be relevant only in turbulent regimes; and (viii) positive returns in the stock market and increases in interest rates tend to reduce the probability of entering the volatile regime.

The remainder of this paper is organized as follows: Section 2 motivates our hypotheses. Section 3 describes the main characteristics of our sample. Results of OLS models for determinants of European ASW spreads are provided in Section 4. In section five we present results of our Markov switching models. Main drivers of the regime switching are examined in section 6. Finally section 7 sums up and concludes.

## 2. Literature and hypotheses

The pricing of credit risk has evolved in two main approaches. First, reduced form models treat default as an unpredictable event, where the time of default is specified as a stochastic jump process.[7] Second, structural models build on Merton (1974) and use market and company fundamentals and allow the empirical testing of various determinants of default.[8] According to this approach, a default can only occur at maturity when the firm value falls under a certain threshold.

Since structural models offer an economically intuitive framework to the pricing of credit risk, a large body of empirical literature has grown testing theoretical determinants of credit spreads with market data.[9] For example, the risk-free interest rate is expected to be negatively related to default risk. Higher risk-free rates increase the risk-neutral drift and lower the probability of default (Longstaff and Schwartz, 1995). Another argument supporting the inverse relationship between interest rates and credit spreads refers to the business cycle. In periods of economic recessions interest rates tend to be lower and corporate defaults tend to occur more often. In early empirical papers government bond yields were used as a proxy for the risk-free rate. Although swap interest rates are not completely free of risk, as they reflect the interbank market risk, they are often regarded as a better benchmark for the risk-free rate than government yields

[7] For a detailed description on several well known reduced-form models see, e.g. Jarrow, Lando, and Turnbull (1995), Duffie and Singleton (1999), or Hull and White (2000).

[8] Several extensions of Merton's original model have been formulated. In the model of Black and Cox (1976) default can take place at any time. Leland (1994) relates debt value and capital structure to the leverage a company is assuming. Longstaff and Schwartz (1995) allow a more complex liability structure and introduce stochastic interest rates in their model. Zhou (2001) specifies the movement of the firm value as a jump-diffusion process. Hui and Lo (2002) introduce macro-economic variables and model the default threshold as a stochastic process.

[9] See, e.g. Huang and Kong (2003); King and Khang (2002); Duffee (1998); Collin-Dufresne et al. (2001); Elton et al. (2001); Longstaff et al. (2005).

(Houweling and Vorst, 2005). For example, they do not suffer from temporary pikes sometimes caused by characteristics of repo agreements involving government bonds. Furthermore, swaps have no short sale constraint, are less influenced by regulatory or taxation issues, and tend not to be affected by scarcity premiums in times of shrinking budget austerity. Finally, swap rates closely correspond to the funding costs of market participants (see, e.g. Houweling and Vorst, 2005; or Hull et al., 2004). This leads to our first hypothesis:

*Hypothesis 1: ASW spreads based on European iBoxx bond indices are negatively associated with the level of interest rates, measured by swap interest rates.*

Another key variable in the structural framework is the leverage ratio, defined as the ratio of a firm's debt to its firm value. When the ratio approaches unity default is triggered, thus a lower firm value (and therefore also a lower equity value) increases the probability of default. Similarly, an increase in volatility increases the probability of default, and, therefore, also increases the credit spread. Firm value and firm value volatility are typically not directly observable. As proxies for these two variables we are using the implied volatility of traded options and stock market returns (a higher stock market valuation implies higher firm values and, therefore, a lower probability of default). This leads to two further hypotheses:

*Hypothesis 2: ASW spreads based on European iBoxx corporate bond indices are negatively associated with stock market returns.*

*Hypothesis 3: ASW spreads based on European iBoxx corporate bond indices are positively associated with stock market volatility.*

A further possible determinant of credit spreads is the swap spread, which is defined as the difference between the swap interest rate and the interest rate of a par value Treasury bond of the same maturity. This difference is normally associated with liquidity and default risk (see, e.g. Duffie and Singleton, 1999). More recently, Feldhütter and Lando (2008) decompose the swap spread into a credit risk element, a convenience premium and idiosyncratic risk factors. They conclude that the major determinant of swap spreads is the convenience yield defined as investors' willingness to pay a premium for the liquidity of Government bonds (see also Grinblatt, 2001). Longstaff (2004) shows that this effect (labeled flight to quality) is especially apparent when markets are unsettled. This has direct consequences for the swap spread. A change in the market's perception of risk is reflected in a widening spread and occurs when investors become concerned about liquidity in financial markets. They redirect their funds to the highest credit quality and most liquid securities – government bonds. Due to the high demand, government bond yields usually fall in such an environment more than those of other credit securities, which further leads to an increase in the swap spread. For the above reasons, Liu et al. (2006) recommend the swap spread as an ideal indicator of default and liquidity risks associated with returns of fixed income securities.[10]

Empirical evidence for the association of swap spreads and credit spreads is provided for several markets. For example, Brown et al. (2002) report a significant positive relationship between swap and credit spreads in the Australian market. Kobor et al. (2005) find a positive long-term relationship between swap spreads and credit spreads for U.S. AA-rated bonds with maturities of two, five and ten years. And finally, Schlecker (2009) documents a cointegration relationship of credit spreads with swap spreads for the U.S. as well as the European corporate bond market. This leads to our fourth hypothesis:

*Hypothesis 4: ASW spreads based on European iBoxx corporate bond indices are positively associated with swap spreads.*

## 3. Data and sample characteristics

Our sample consists of Asset Swap (ASW) spreads for 23 different European iBoxx Corporate Bond indices.[11] In our analysis we focus on the period from January, 1st 2006 until January, 30th 2009, including 779 trading days. Sample bond indices are grouped

[10] Another commonly used barometer of the market's perception of risk is the Euribor-OIS spread. It reflects investor's perception of the default risk of banks. The spread of the Euribor and the overnight indexed swap (OIS) becomes wider if banks are reluctant to lend money to each other due to higher risk in financial markets. For the empirical part of this study, however, we resort to the swap spread as determinant for ASW spreads, because the Euribor-OIS spread is too noisy for our daily data sample.

[11] iBoxx is a leading fixed income index provider serving to establish benchmarks for asset managers and investors.

based on the classification and criteria provided by Markit.[12] For example, the market capitalization weighted iBoxx Benchmark indices consist of liquid bonds with a minimum amount outstanding of at least €500 million and a minimum time to maturity of one year. Furthermore, the bonds need to have an investment grade rating and a fixed coupon rate. The indices are rebalanced monthly. The bond index values are calculated daily based on market prices, thus they represent the most accurate and timely bond pricing available. The ASW spreads provided by Markit are derived from prices of the underlying bonds included in the respective iBoxx index and ICAP swap rates.[13] Time series of swap and government bond yield curves are from Datastream.

Descriptive statistics for the sample of ASW spreads are provided in Table 1. The indices are stratified as non-financial industrial sectors (Automobiles & Parts, Chemicals, Food & Beverage, Health Care, Oil & Gas, Personal & Household Goods, Retail, Telecommunications, and Utility), financials (Senior, Subordinated, Banks, Tier 1 Capital, and Lower Tier 2 Capital), credit rating (AAA, AA, A, and BBB), and seniority (Senior and Subordinated). Corporate Composite is a composite index and includes 1,082 corporate bonds that constitute all sample indices. The average size of our bonds included in the Corporate Composite index amounts to €910.4 million. AAA-rated bonds have the highest volume with an average issue size of more than €1.3 billion. The notional amount of all bonds in our sample totals €985 billion by the end of January 2009.

The average time to maturity of all bonds included in the Corporate Composite index is 5.28 years. Given that the most liquid CDS spreads have 5-year maturity we can compare our results directly to the results reported in previous studies based on CDS spreads (see, e.g. Alexander and Kaeck, 2008). The median daily change is highest for Tier 1 Capital ASW spreads and lowest for Health Care and Telecommunication sectors. The values for the annualized standard deviation highlight significant time series variation. For the Tier 1 Capital industry sample the annualized standard deviation amounts to 100.9 basis points (bps) per year, whereas ASW spreads in the Utility sector only exhibit a value of 42.6 bps. Turning to higher moments, daily spread changes are highly leptokurtic for all sectors. The skewness of spreads is generally positive, with extreme

[12] Markit sorts all bonds into industry classes based on ICB (Industry Classification Benchmark).
[13] ICAP is the world largest broker house with a daily transaction volume in range of $1.5 billion.

values for Banks, Tier 1 Capital and AAA-rated corporate bonds. These three sectors exhibit the highest level of skewness and excess-kurtosis in our sample.

*** Insert Table 1 about here ***

The mean spread for the Corporate Composite Index is 87.8 basis points. It is worth mentioning that the Corporates AAA index only contains one non-financial bond (issued by health care company Johnson & Johnson). The remaining 35 bonds in this sector represent debt raised by highly rated financial institutions.

Across industries, our ASW spread sample clearly shows higher diversity since early 2008. Figure 1 tracks the co-movement of ASW spreads for ten different industry sectors. As expected, the ASW spreads for the financial sector dominate spreads for all other industries. Other sectors with above-average spreads during the credit crises (especially in the year 2008) are Oil & Gas as well as Automobiles & Parts.

*** Insert Figure 1 about here ***

## 4. Determinants of Asset Swap spreads

We start our analysis with the following linear regression model to determine changes in ASW spreads:

$$\begin{aligned}\Delta \text{ASW}_{k,t} = \ &\beta_{k,0} + \beta_{k,1}\Delta \text{ASW}_{k,t-1} + \beta_{k,2}\text{Stock return}_{k,t} + \beta_{k,3}\Delta \text{VStoxx}_t \\ &+ \beta_{k,4}\Delta \text{IR} - \text{Level}_t + \beta_{k,5}\Delta \text{Swap Spread}_t + \varepsilon_{k,t}\end{aligned} \quad (1)$$

where $\Delta \text{ASW}_{k,t}$ is the change in the ASW spread of industry sector $k$ on day $t$, $\Delta \text{ASW}_{k,t-1}$ is the one period lagged ASW spread return, $\text{Stock return}_{k,t}$ represents daily returns of the stock index for sector $k$, $\Delta \text{VStoxx}_t$ is the change in the VStoxx volatility index, $\Delta \text{IR} - \text{Level}_t$ denotes the change in the level of the interest rate swap curve (based on the first principal component)[14], and $\Delta\text{Swap Spread}_t$ represents swap spread changes.

Equity values are proxied by the DJ Euro Stoxx indices which are also provided by Markit and exist for almost all sectors analyzed in this study ($\Delta\text{Stock return}_{k,t}$). The equity value proxy for non-financials is the FTSE World Europe ex Financials stock index, as Markit does not offer such an index (see also Table 1). We choose the VStoxx index ($\Delta\text{VStoxx}_t$) as a proxy for the implied volatility, since it is the reference measure for the volatility in European markets. The final determinant included in model (1) is the swap spread ($\Delta\text{Swap Spread}_t$), measured as the difference between the five year European interest rate swap rate and the yield of German government bonds of the same maturity. Due to empirical evidence we consider the swap spread as a quality premium, as it mainly comprises default risk and a convenience premium for holding risk-less Treasury bonds.[15]

Byström (2006) examines determinants of CDS iTraxx index spreads and includes lagged spread changes in his model. He reports a high degree of autocorrelation in daily changes for all industry sectors. Byström (2006) concludes that it is not possible to exploit this inefficiency, after controlling for transaction costs. Since ASW spreads represent the cash-market equivalent to CDS spreads, a similar pattern is expected. Unreported results suggest that 15 of the 23 sample ASW spreads exhibit a highly significant degree of autocorrelation with mixed signs. Thus, the inclusion of lagged spread changes ($\Delta\text{ASW}_{k,t-1}$) as a control variable is motivated by empirical observations in previous studies.

The results of the regressions are presented in Table 2. They reveal that the sign of the coefficients are mostly consistent with our predictions. All but one sector exhibit a negative relationship between ASW spreads and the level of interest rates ($\Delta\text{IR} - \text{Level}_t$). This observation supports hypothesis 1. In addition, the stock market variables influence ASW spreads of most industry sectors negatively, implying higher spreads when stock markets decrease. This observation is consistent with hypothesis 2, although a signifi-

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[14] European interest rate swap rates with maturities between one and ten years are used to calculate the first principal component.
[15] See, for example, Brown et al. (2002), Kobor et al. (2005), or Schlecker (2009).

cant negative association only can be observed for three sectors (Utilities, A-rated Corporate, and Corporate Subordinated). Consistent with hypothesis 3, the results document a positive association between stock market volatility and ASW spreads in 21 of 23 cases.[16] Overall, volatility seems to have a larger impact on ASW spreads than equity returns.

*** Insert Table 2 about here ***

Turning to the swap spread, ASW spread changes of all 23 groups are positively associated with swap spread changes ($\Delta \text{Swap Spread}_t$). This observation is in line with hypothesis 4. Furthermore, lagged changes of ASW spreads are only in five cases significant positive (at the 5% level), whereas six groups exhibit a negative but not significant autocorrelation (see $\Delta \text{ASW}_{t-1}$ in Table 2). The explanatory power of the models is clearly higher for the financial sector than for non-financial sectors - with the exception of the Automobiles & Parts sector. By far the best explained sector is Tier 1 Capital with an adjusted $R^2$ of 35%.

Cossin et al. (2002) find for the US market, that changes in structural variables affect companies with a high rating less than low rated companies. Our results in subsamples with different credit ratings are mixed. Although Subordinated Corporates are better explained than Senior Corporates the opposite is true for AAA-rated companies compared to BBB-rated firms. Furthermore, Financials Senior and Subordinated spreads are nearly equally well explained.

## 5. Structural breaks and regime switching

### 5.1 Structural breaks

The evolution of ASW spreads of the iBoxx Corporate Bond indices and its determinants during the credit crisis is illustrated in Figure 2. The stock market increased stea-

[16] 12 of the 21 cases are significant, and the two cases with negative coefficients are not significant at the 5% level.

dily until summer of 2007 and lost more than half of its value in the following 18 months. The level of interest rates peaked in the summer of 2008 and sharply declined until the end of our sample period. Conversely, implied volatility, measured by the VStoxx index, the swap spread, specified as the difference between the swap curve and German government bond yields, as well as ASW spreads of the Corporate Composite bond index are relatively tranquil until the middle of 2007. They increase sharply for the following 14 months and jump in September 2008 to remain at a high level until the beginning of January 2009.

*** Insert Figure 2 about here ***

Figure 3 depicts the evolution of regression coefficients of the stock index variable in model (1). For reasons of brevity we only show the Corporates Senior index and the Corporates Subordinated sector. The influence of the stock market seems to be only slightly increasing until the summer of 2007, when there is reason to expect a structural break. From mid 2007 to the very end of our sample period the stock market has a highly time-varying influence on ASW spreads with regression coefficients ranging from -3 to -96 (Corporates Senior) and -54 to -115 (Corporates Subordinated), respectively. The results for all other indices exhibit a very similar pattern.

*** Insert Figure 3 about here ***

To statistically quantify potential structural breaks in the time-series of the data we employ a Chow breakpoint test for all dates in the sample apart from the first and last 100 observations. The null hypothesis of no structural break in the data is rejected at the 1% level of significance for 81.72% of daily observations (see Table 4: Corporate Composite sample). Results for most other sectors are similar. Extreme values are observable for the Tier 1 Capital index where in 99.48% of all observations the null hypothesis of no structural breaks can be rejected at the 1% significance level. On the other hand, for Food & Beverage, Utility, and Health Care sectors the null hypothesis is rejected (at the 1% significance level) for less than 10% of observations.

*** Insert Table 4 about here ***

### 5.2 Markov switching model

The previously reported results suggest the time-varying properties of the parameters and the leptokurtosis of our sample. It is, therefore, important to estimate a nonlinear model where different regimes can be defined allowing for dynamic shifts of economic variables at any given point in time conditional on an unobservable state variable $s_t$. Markov switching models provide an intuitive and systematic way to model structural breaks and regime shifts in the data generating process.[17] Such models can be linear in each regime, but due to the stochastic nature of the regime shifts nonlinear dynamics are incorporated. Furthermore, the specification consists of a mixture of distributions which generates the leptokurtosis, as the variances in the two regimes differ. Another advantage of using a latent variable $s_t$ is the constantly updated estimate of the conditional state probability of being in a particular state at a certain point in time. This approach conveys more precise information about the switching process than a simple binary operator.

We estimate a two-state Markov model to explain ASW spread changes ($\Delta\mathrm{ASW}_{k,t}$) for each sector $k$:[18]

$$\begin{aligned}\Delta\mathrm{ASW}_{\mathrm{k,t}} = {} & \beta_{S,k,0} + \beta_{S,k,1}\Delta\mathrm{ASW}_{\mathrm{k,t-1}} + \beta_{S,k,2}\mathrm{Stock\ return}_{k,t} + \beta_{S,k,3}\Delta\mathrm{VStoxx_t} \\ & + \beta_{S,k,4}\Delta\mathrm{IR-Level}_t + \beta_{S,k,5}\Delta\mathrm{Swap\ Spread}_t + \varepsilon_{S,k,t} \end{aligned} \quad (2)$$

where $\beta_{S,k,j}$ is a matrix of *j* regression coefficients as used in model (1) of the $\mathrm{k^{th}}$ sector, which are dependent on the state parameter $s$. The explanatory variables are $\Delta\mathrm{ASW}_{k,t-1}$, which is the one period lagged ASW spread change, $\mathrm{Stock\ return}_{k,t}$ represents the daily returns of the stock index for sector $k$, $\Delta\mathrm{VStoxx_t}$ is the change in the VStoxx volatility index, $\Delta\mathrm{IR-Level}_t$ denotes the change in the level of the interest rate swap curve

[17] For various applications of Markov switching models related to interest rates, bond markets, and credit risk modeling, see, e.g. Clarida (2006), Brooks and Persand (2001), Eyigunor (2006), or Dionne et al. (2007).

[18] The formulation used in our analysis is adopted from Hamilton (1989) who uses an iterative algorithm, similar in spirit to a Kalman filter.

based on the first principal component, and $\Delta\text{Swap Spread}_t$ represents swap spread changes. Finally, $\varepsilon_{S,k,t}$ is a vector of disturbance terms, assumed to be normal with state-dependent variance $\sigma^2_{S,k,t}$.

In our specification the state parameter $s_t$ is assumed to follow a first-order, two-state Markov chain where the transition probabilities are assumed to be constant:[19]

$$Prob\,\{s_t = j | s_{t-1} = i, s_{t-2} = h, \ldots\} = \; Prob\,\{s_t = j | s_{t-1} = i\} = \; p_{ij} \tag{3}$$

and can be summarized in matrix $P$: [20]

$$P = \begin{pmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{pmatrix} = \begin{pmatrix} p_{11} & 1 - p_{22} \\ 1 - p_{11} & p_{22} \end{pmatrix} = \; p_{ij} \tag{4}$$

Due to the fact that we cannot observe $s_t$ directly, we can only make an inference about the state of the regime at time $t$ and have to assign probabilities of being in one regime. If we let the vector $\xi_t$ represent a Markov chain with $\xi_t = (1,0)'$ when $s_t = 1$ and $\xi_t = (0,1)'$ when $s_t = 2$, the conditional expectation of $\xi_{t+1}$ given $s_t = i$ is

$$\mathbb{E}(\xi_{t+1} | s_t = i) = \begin{pmatrix} p_{i1} \\ p_{i2} \end{pmatrix} = P\,\xi_t \tag{5}$$

Assuming Gaussian residuals $\varepsilon_{S,k,t}$ for both states $i$, the conditional densities of $f(y_t)$ are collected in a $2 \times 1$ vector $\eta_{i,t}$ whose elements are given by[21]

$$\eta_{i,t} = f(y_t | s_t = \; i, \Omega_{t-1}, \theta) = \frac{1}{\sigma_i \sqrt{2\pi}} \; e^{\frac{-\left(y_t - x_t' \beta_i\right)^2}{2\sigma_i^2}}, \tag{6}$$

[19] Adapted from Hamilton (1989) and Alexander and Kaeck (2008).
[20] Our specification consists of two states that (as we can see later) can be interpreted as volatile and tranquil market regime.
[21] See, e.g. Hamilton (1989) or Alexander and Kaeck (2008).

where $\theta$ is a vector of state-dependent population parameters, which in our model is $\theta = (\mathrm{P}, \beta_i, \sigma_i)$. $\Omega_{t-1}$ denotes the information up to time $t-1$. To obtain the conditional state probabilities one has to solve recursively the pair of equations (7) and (8):

$$\hat{\xi}_{t|t} = \frac{\hat{\xi}_{t|t-1} \odot \eta_t}{1'(\hat{\xi}_{t|t-1} \odot \eta_t)} \quad (7)$$

$$\hat{\xi}_{t+1|t} = P\hat{\xi}_{t|t}, \quad (8)$$

where $\hat{\xi}_{t|t}$ represents the filtered probability for each state estimated at time $t$, given all information up to time $t$ and $\odot$ denotes element-by-element multiplication. The numerator in equation (7) represents the density of the observed vector $y_t$ conditional on all past observations. The $t^{th}$ element of the product $\hat{\xi}_{t|t-1} \odot \eta_t$ can be interpreted as the conditional joint density distribution of $y_t$ and $s_t = i$.

Iterating through equations (7) and (8) leads to the sample conditional log likelihood:[22]

$$L(\theta) = \sum_{t=1}^{T} ln\, f(y_t|\Omega_{t-1};\theta) = \sum_{t=1}^{T} ln\,(1'(\hat{\xi}_{t|t-1} \odot \eta_t)), \quad (9)$$

where the set of optimal parameter values $\theta$ can be calculated numerically by maximizing the log likelihood function under the constraints that $0 < p_{ii} < 1$ and $\sigma_i \geq 0$.

### 5.3 Results of the Markov switching model

We proceed by estimating model (2) with the above mentioned specification. Results of the Markov switching regression are provided in Table 4.[23]

*** Insert Table 4 about here ***

[22] See, e.g. Hamilton (1989) or Alexander and Kaeck (2008).
[23] Matlab R2009b was used for computing the Markov Switching regressions.

The output of the Markov switching model indicates that the estimated coefficients differ considerably between the two market regimes. The residual volatility (Std. Dev.) is between four and eight times higher during turbulent than in tranquil market periods. Perhaps the most striking result is the significantly different structure of the autocorrelation coefficient ($\Delta \text{ASW}_{t-1}$) in the two regimes. The majority of all sectors under investigation exhibit a negative autocorrelation during the low volatility regime (Regime 2) and positive autocorrelation in times of high volatility (Regime 1), indicating that the data generating process consists of a mixture of different distributions. This phenomenon also explains why most of the lagged credit spread changes ($\Delta \text{ASW}_{t-1}$) have not been significant in the OLS model. The positive autocorrelation effect in the volatile regime is most pronounced for the sectors Automobile & Parts, AAA-rated Corporates, as well as most financial sectors.

Stock market returns have a significant negative effect on credit spreads in the second (tranquil) regime. This is especially true for financial sector firms and within this group for subordinated financials, banks, Tier 1 Capital, and Lower Tier 2 Capital. For these sectors increasing stock prices in low volatile periods are associated with lower ASW spreads. Again, non-financial firms behave differently. For them stock market returns are not significantly related to ASW spread changes, neither in the high nor in the low volatile regime.

Opposite to stock market returns, changes in the VStoxx influence ASW spreads especially in the high volatility regime (Regime 1). For all but one of the 23 sectors the relationship is positive (in 10 out of the 22 sectors significant at the 5% level). On the other hand, in the low volatility regime (Regime 2) the relationship is predominantly negative. Thus, an increasing volatility in the stock market increases ASW spreads in a volatile regime but tend to decrease ASW spreads in tranquil periods. This result is in line with Alexander and Kaeck (2008), who report similar results for changes in CDS spread indices.

The interest rate level ($\Delta \text{IR} - \text{Level}_t$) affects ASW spreads negatively in both regimes (in 45 out of 46 cases, 31 of the 45 cases are significant at the 5% level). This implies that an increase in interest rates is regime independent associated with a drop in spreads, which is in line with hypotheses 1, but is in contrast to Alexander and Kaeck (2008) focusing on CDS spreads. Table 4 also reveals that the negative coefficient in the volatile regime (Regime 1) is always larger in absolute terms compared to the negative coefficient in the tranquil regime (Regime 2). This indicates that decreasing interest rates in stormy periods tend to increase spreads more than in more quiet periods.

Finally, the influence of the swap spread ($\Delta \text{Swap Spread}_t$) is always positive during periods of stress in financial markets (Regime 1).[24] This evidence is in line with the prediction formulated in hypothesis 4. The swap spread, which serves as a quality premium, is an optimal proxy for the perceived liquidity risk in the market. It is highly significant in periods of turmoil but does not explain spreads in tranquil times. Although 19 out of 23 sectors exhibit also a positive coefficient in Regime 2 (low volatility period) these coefficients are not significant at the 5% level.

In order to evaluate the effectiveness of the Markov switching model compared to classical non-switching regressions we test if there is any switching in the parameters. Unfortunately formal standard statistical tests of OLS models against a regime switching model are not valid due to unidentified parameters under the null hypothesis, thus they do not converge to their assumed distribution and asymptotic theory cannot be applied. An alternative is proposed by Engel and Hamilton (1990). They suggest a classical log likelihood ratio test with the null hypothesis ($H_0$) of no switching in the coefficients ($\beta_{S_t=1}$ and $\beta_{S_t=2}$) but allow for switching in the residual variance ($\sigma_{S_t=1}$ and $\sigma_{S_t=2}$). Thus we test the following hypothesis:

$$H_0 : \beta_{S_t=1,j} = \beta_{S_t=2,j} \text{ for all } j, \ \sigma_{S_t=1} \neq \sigma_{S_t=2} \tag{10}$$

This specification is clearly more conservative than the hypothesis that both are switching. The likelihood ratio is asymptotically $\chi^2_{(5)}$ distributed. The corresponding results are reported in Table 5.

*** Insert Table 5 about here ***

[24] The coefficients of all 23 cases are positive, 16 of them are significant at the 5% level.

For all 23 sectors the null hypothesis of equal coefficients in both regimes can be rejected at the 5% level. Generally Financials provide most evidence of regimes switching with the Tier 1 Capital sector having the highest LR-statistic.

Regime specific moments of ASW spreads are compared in Table 6. The standard deviations of the residuals in the tranquil regime are significantly lower than the residuals in the first regime (high volatility regime). Spread changes in regime 2 (tranquil) are closer to normality with an average change of 0.10 basis points (Corporate Composite), an average skewness of 0.44 and an average excess kurtosis of 0.64. Contrary, the spread changes in the turbulent regime are much more non-normal. Daily spread changes have an average of 1.19 basis points, a skewness of 0.87 and an excess kurtosis of 2.29. Notable, the distribution of spread changes of AAA-rated Corporates and Banks is highly leptokurtic with an excess kurtosis of 6.75 and 13.2, respectively, whereas the excess kurtosis is lowest for the Retail sector.

*** Insert Table 6 about here ***

The first column of Table 6 presents the amount of time (in percentage terms) a volatile regime is predominant. The mean value for all sectors, excluding financials, is 26.8%, whereas it is 39.3% for finance-related sectors. This result may not come as a surprise, given that our sample includes the credit crisis during which financial companies have lost a significant part of their market value.

## 6. Determinants of regime changes

Having identified two distinct regimes, a high volatility regime and a relatively tranquil regime with low volatility, we investigate which explanatory indicators drive the regime transition. At first, Figure 4 presents the relationship between the regime probabilities and the ASW spread volatility. The figure depicts a positive association between the probabilities and ASW spread volatility.

*** Insert Figure 4 about here ***

The US housing bubble came to a sudden end when housing prices started to flatten and eventually dropped by a median of 3.3% in the first quarter of 2006 compared to the last quarter of 2005. Consequently the first three months of our sample are dominated by a phase of high volatility in financial markets (see event 1 in Figure 4). The scale of the financial crisis was heralded as Ameriquest Mortgage, once one of the largest subprime lenders, revealed plans in May 2006 to close its retail branches and announced significant job cuts (see event 2 in Figure 4). We did not enter the volatile state again until November 2006 when financial markets rallied to a five year high leading to an ASW spread reduction of 7 basis points.

Another volatile period started when credit markets froze in summer 2007 (see event 3 in Figure 4). Lenders stopped offering home equity loans. In a coordinated move the Federal Reserve and the European Central Bank injected $100 billion and €95 billion, respectively, into the banking system. Countrywide, America's largest mortgage lender had to take out an emergency loan to avoid bankruptcy. At the end of August 2007 Ameriquest Mortgage finally went out of business and on September 4th, 2007, Libor rates rose to 6.79%, the highest level since 1998. During the following four months ASW spreads returned to the tranquil regime lasting until the January 2008 stock market downturn, which eventually lead to the emergency sale of Bear Stearns (at that time the fifth largest investment bank in the world), to rival JP Morgan on March 16th, 2008 (see event 4 in Figure 4). Within the first 11 trading days in March 2008, the Corporate Composite ASW spread jumped by more than 33 basis points, with a maximum daily change of 19.15 basis points. For the following five months of our sample we only enter the volatile regime occasionally. During this period Indymac Bank, the seventh-largest mortgage originator was placed into receivership of the FDIC by the Office of Thrift Supervision.

Starting in late August of 2008 we basically remain in the volatile regime until the end of our sample. Freddie Mac and Fannie Mae guaranteeing a combined $12 trillion were nationalized at the beginning of September 2008 (see event 5 in Figure 4). Rumors about liquidity problems of investment bank Lehman Brothers surfaced. Eventually the company filed for bankruptcy protection on September 15th, 2008 marking the peak of the financial crisis (see event 6 in Figure 4). Within 23 trading days the Corporate Composite ASW spread exploded by 144 basis points with a single day jump of 17.4 points on September 16th, 2008. Days later it became public that AIG was on the brink of bankruptcy, causing the ASW spread to increase nearly 16 basis points within a day and the Federal Reserve lending $85 billion to the troubled company.

The last and largest spike in Asset Swap spreads in our sample occurred on November 21st, 2008 when the value of the Corporate Composite ASW spread jumped by 20.06 basis points caused by liquidity problems of Citigroup (see event 7 in Figure 4). The stock value of the once biggest bank in the world lost 60% within a week, before the US government agreed to invest several billion dollars and save the system-relevant financial institution. The remaining trading days of our sample exhibit a high level of volatility as the downturn on financial markets continued.

To statistically test variables that induce a regime shift, a logit model with the estimated state probability of being in either the volatile or the tranquil regime as dependent variable and explanatory variables from our model is used. This procedure is based on the methodology presented by Clarida et al. (2006). We define the dependent variable as a binary variable, based on the estimated probabilities of model (2). The dependent variable equals one when the probability is higher than one-half, indicating being in the high volatility state and equal to zero if the probability value is equal to or lower than 0.5. The model has the form[25]

$$P_t = P[y_t = 1] = \frac{1}{1+e^{-(\alpha_0+\alpha_1 x_{t-1})}}, \tag{11}$$

where $P_t[y_t = 1]$ denotes the filtered probability of being in the volatile regime at time $t$ and $\alpha_0$ and $\alpha_1$ represent regression coefficients. Various models are estimated with one lagged explanatory variable $x_{t-1}$.

Our first explanatory variable is the squared change of lagged ASW spreads ($\Delta \mathrm{ASW}_{t-1}^2$). We have demonstrated that the residuals of the Markov switching model exhibit two

[25] See Clarida et al. (2006).

very different levels of volatility, so we expect the volatility of the ASW spreads to be higher when residuals exhibit a high level of volatility. The $\Delta \mathrm{ASW}_{t-1}^{2}$ column in Table 7 reveals that a large (past) jump in ASW spreads, irrespective of the direction, may lead to a shift in market regimes. The logit models in Table 7 further exhibits that lagged changes of credit spreads ($\Delta \mathrm{ASW}_{t-1}$) have a significant and positive influence on the regime probability. As expected, stock market returns have a negative sign in all sectors, indicating that positive daily market returns reduce the probability of switching to the high volatility regime. In contrast, changes in VStoxx (ΔVStoxx) do not seem to have any influence on the switching behavior. The level of interest rates (ΔIR-Level) on the other hand is negatively associated with credit spreads in all 23 sectors (but only significant in two cases). The coefficient for the swap spread is not statistically significant.

*** Insert Table 7 about here ***

To address the robustness of our inference that the determinants of ASW spreads have a causal relationship and not only exhibit correlation, we employ a set of bivariate Granger-causality tests of dependent and explanatory variables. Overall, the causality runs in both ways (see Table 8). However the p-values indicate that the explanatory variables tend to have a stronger influence on ASW spreads changes than ASW spread changes have on the explanatory variables. This is especially the case for the explanatory variables stock market returns and stock market volatility.

*** Insert Table 8 about here ***

## 7. Conclusion

While CDS spreads are subject to the functioning of the credit derivatives market, Asset Swap (ASW) spreads can be interpreted as a credit risk measure based on spot market prices. ASW spreads correspond to the difference between the floating part of an asset swap and the Libor or Euribor rate. Data providers like Markit derive ASW spreads from corporate bonds and publish them for various bond portfolios, typically based on industry classification or rating classes. Thus, ASW spreads do not (directly) depend on the credit derivatives market.

In this study we examine the time-series dynamic of credit risk based on ASW spread data for a set of 23 European iBoxx Corporate Bond indices during the period from January, 1st 2006 to January, 30th 2009. These indices consist of various industry sectors, different rating classes and differentiate between financial and non-financial firms. Theoretical as well as empirical studies suggest four main potential determinants for credit spreads: stock market prices (as lower prices should more easily trigger default), stock market volatility (as a higher volatility increases the probability of default), the interest rate level (as in periods of economic down turn interest rates tend to be lower and corporate defaults tend to occur more often), and the spread between swap rates and government bond yields (as government bonds typically offer more liquidity, which is especially valuable in times of crisis). These variables explain between 6% and 35% of the variations in ASW spread changes in our sample.

To allow for dynamic shifts in volatility, we employ a two-state Markov model to explain credit spreads. This is especially important in periods of financial turmoil, as the time-series behavior of credit spreads tends to be totally different in turbulent periods. For example, mean ASW spreads are more than ten times larger in turbulent times compared to calm periods. In addition, they are also characterized by huge excess kurtosis.

The corresponding results reveal that the estimated coefficients differ considerably between the two regimes. For example, stock market returns are negative and in most cases significantly associated with ASW spread returns in tranquil periods. This observation holds in stormy periods only to a lesser extent. In contrast, and in line with previous studies (see, e.g. Alexander and Kaeck, 2008), the stock market volatility has a positive effect on ASW spread returns in turbulent periods, whereas the opposite is true in calm periods. Independent of the regime, the level of interest rates is clearly negatively related to ASW credit spreads. The more interest rates are declining, the higher is the credit spread. This result is in contrast to the findings of Alexander and Kaeck (2008), focusing on CDS spreads. As predicted, a higher swap spread, which can be considered as a quality premium required for in non-government issues, indicates larger credit spreads in the spot market. But this observation only holds for the volatile regime. In calm periods, the relationship is never significant.

The regime transitions between the volatile and the calm regime are mainly driven by the lagged ASW spread volatility. A higher past ASW spread volatility is associated with a higher probability of entering the turbulent regime. The transition into the volatile regime is furthermore positive affected by past ASW spread returns and negatively affected by past stock market returns. On the other hand, stock market volatility, the interest rate level, or swap spreads are no drivers for regime shifts.

Finally, a Granger-causality test reveals that the specified set of explanatory variables tend to stronger influence ASW spread changes than the other way round. This is especially the case for the variables stock market return and stock market volatility.

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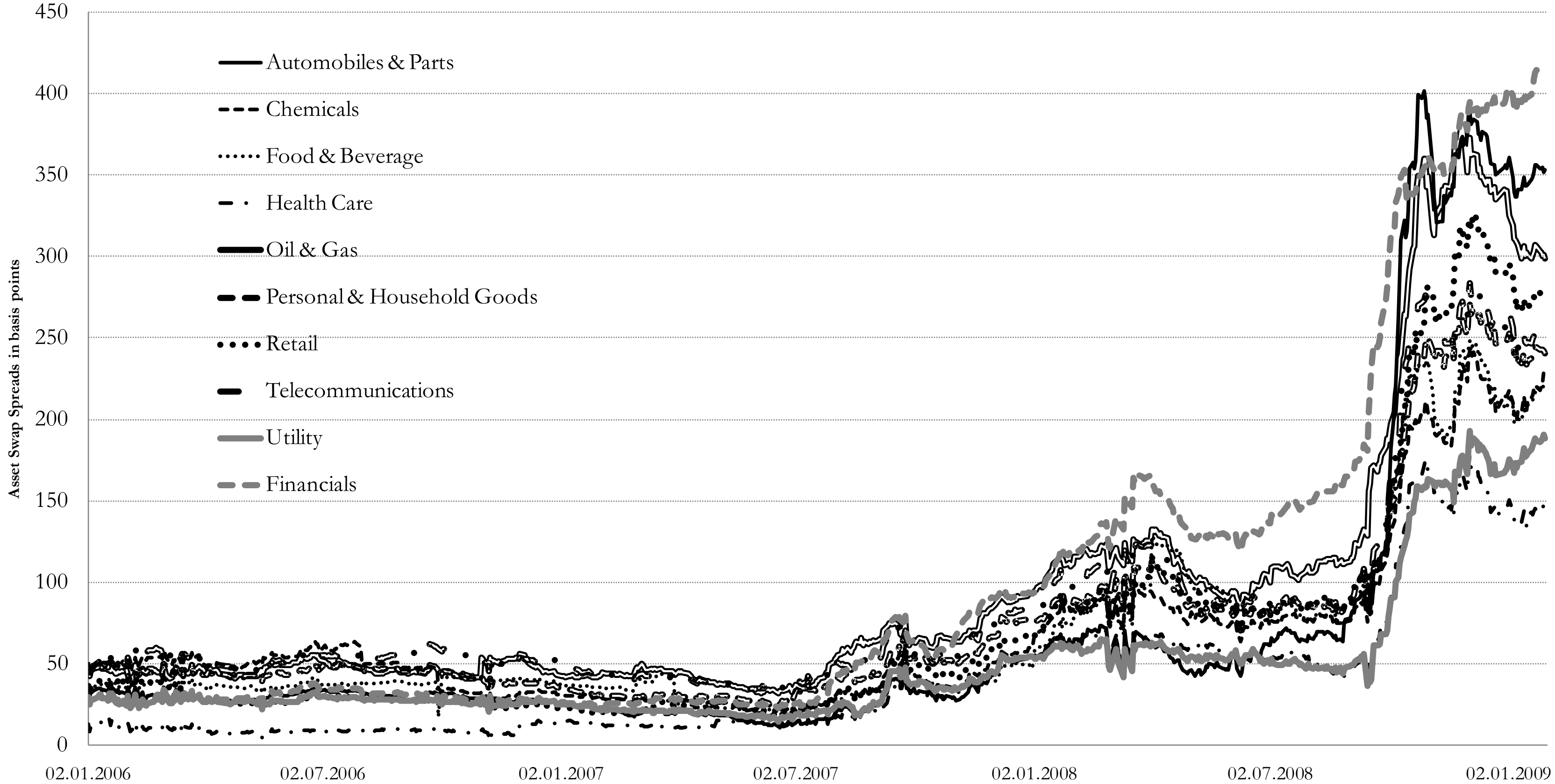
## Table 1: Descriptive statistics for iBoxx Corporate Bond Index Asset Swap Spreads

Statistics for the respective iBoxx Corporate Bond Index Asset Swap (ASW) Spreads from January 1st, 2006 until January 30th, 2009. The number of constituents in the respective iBoxx index is given in the first column. The Notional for the respective bond index is given in Billion EUR. The average volume of the bond index is given in Million EUR. Annualized Modified Duration and Time to Maturity are given in years. The mean and median daily change of ASW spreads is given in basis points. The standard deviation of daily changes is given in basis points and the annualized Standard Deviation is given in annualized basis points. ** and * denote significance at the 1% and 5% level, respectively (779 daily observations for each sector). The mean and median of ASW spreads are denoted in basis points. Finally the respective stock index for every ASW sector is reported in the last column.

| Sector | No. of Bonds | Notional Billion € | Average Volume Million € | Ann.Mod. Duration | Time to Maturity | Mean Daily Change | Median Daily Change | Std. Dev. | Ann. Std. Dev. | Skewness | Excess Kurtosis | Mean Spread | Median Spread | Respective Stock Index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Automobiles & Parts | 50 | 48.1 | 962.5 | 2.72 | 3.54 | 0.41 | 0.00 | 4.27 | 67.74 | 2.29** | 22.71** | 70.02 | 32.42 | DJ Euro Stoxx Automobiles & Parts |
| Chemicals | 31 | 24.7 | 795.2 | 3.96 | 4.94 | 0.23 | 0.01 | 3.06 | 48.60 | 1.53** | 12.75** | 67.35 | 51.05 | DJ Euro Stoxx Chemicalsicals |
| Food & Beverages | 17 | 14.3 | 838.2 | 3.81 | 4.65 | 0.23 | 0.05 | 3.72 | 59.03 | 1.69** | 19.93** | 67.17 | 39.58 | DJ Euro Stoxx Food & Beverages |
| Health Care | 17 | 15.3 | 900.0 | 4.56 | 5.83 | 0.17 | -0.01 | 2.79 | 44.29 | 1.44** | 12.54** | 39.93 | 15.27 | DJ Euro Stoxx Health Care Care |
| Oil & Gas | 32 | 27.9 | 872.0 | 3.75 | 5.13 | 0.32 | 0.06 | 3.61 | 57.28 | 0.22* | 21.06** | 94.08 | 53.67 | DJ Euro Stoxx Oil & Gas |
| Personal & Household Goods | 28 | 24.8 | 886.1 | 4.15 | 5.36 | 0.25 | 0.03 | 2.98 | 47.32 | 1.81** | 14.47** | 74.55 | 48.03 | DJ Euro Stoxx Personal & Household Goods |
| Retail | 27 | 21.0 | 777.8 | 3.56 | 4.99 | 0.31 | 0.04 | 3.27 | 51.98 | 1.91** | 11.64** | 70.46 | 36.50 | DJ Euro Stoxx Retail |
| Telecommunications | 93 | 92.2 | 991.8 | 3.97 | 5.68 | 0.26 | -0.01 | 3.02 | 47.88 | 1.94** | 14.66** | 83.88 | 55.81 | DJ Euro Stoxx Telecommunications |
| Utility | 117 | 95.0 | 811.9 | 5.11 | 6.87 | 0.20 | 0.01 | 2.68 | 42.60 | 1.47** | 17.76** | 48.30 | 29.53 | DJ Euro Stoxx Utility |
| Corporates AAA | 36 | 49.0 | 1360.4 | 4.22 | 5.67 | 0.22 | 0.01 | 3.67 | 58.27 | 3.53** | 43.59** | 28.81 | 4.79 | DJ Euro Stoxx 600 |
| Corporates AA | 251 | 273.0 | 1087.5 | 3.74 | 4.91 | 0.29 | 0.06 | 2.91 | 46.27 | 1.57** | 21.43** | 55.74 | 12.55 | DJ Euro Stoxx 600 |
| Corporates A | 552 | 471.3 | 853.9 | 3.94 | 5.41 | 0.46 | 0.09 | 2.88 | 45.78 | 1.72** | 12.37** | 98.71 | 40.53 | DJ Euro Stoxx 600 |
| Corporates BBB | 243 | 191.7 | 789.1 | 3.73 | 5.38 | 0.50 | 0.06 | 3.21 | 50.97 | 2.57** | 16.48** | 119.55 | 65.54 | DJ Euro Stoxx 600 |
| Corporates Senior | 811 | 760.9 | 938.3 | 3.87 | 5.16 | 0.30 | 0.03 | 2.70 | 42.86 | 2.08** | 14.81** | 68.49 | 32.05 | DJ Euro Stoxx 600 |
| Corporates Subordinated | 271 | 224.1 | 826.9 | 3.78 | 5.68 | 0.86 | 0.21 | 3.28 | 52.10 | 2.23** | 10.35** | 153.60 | 62.49 | DJ Euro Stoxx 600 |
| Corporates Composite | 1082 | 985.0 | 910.4 | 3.85 | 5.28 | 0.40 | 0.09 | 2.73 | 43.27 | 2.13** | 13.99** | 87.79 | 39.52 | DJ Euro Stoxx 600 |
| Non-financials | 527 | 449.7 | 853.4 | 4.12 | 5.57 | 0.29 | 0.02 | 2.79 | 44.25 | 1.70** | 13.25** | 74.64 | 42.93 | FTSE World Europe ex Financials |
| Financials | 555 | 535.3 | 964.5 | 3.60 | 5.04 | 0.50 | 0.14 | 2.94 | 46.70 | 2.50** | 16.40** | 98.90 | 36.23 | DJ Euro Stoxx Financials |
| Financials Senior | 284 | 318.5 | 1121.6 | 3.54 | 4.63 | 0.32 | 0.09 | 2.99 | 47.41 | 2.41** | 20.41** | 61.28 | 16.08 | DJ Euro Stoxx Financials |
| Financials Subordinated | 271 | 216.8 | 799.9 | 3.73 | 5.64 | 0.87 | 0.22 | 3.28 | 52.04 | 2.25** | 10.63** | 151.13 | 57.98 | DJ Euro Stoxx Financials |
| Banks | 429 | 423.9 | 988.0 | 3.58 | 4.94 | 0.47 | 0.13 | 3.11 | 49.41 | 3.93** | 37.98** | 92.10 | 34.15 | DJ Euro Stoxx Banks |
| Tier 1 Capital | 83 | 62.2 | 749.4 | 3.47 | 6.31 | 1.77 | 0.36 | 6.36 | 100.90 | 3.87** | 24.41** | 243.54 | 98.66 | DJ Euro Stoxx Financials |
| Lower Tier 2 Capital | 125 | 102.8 | 822.6 | 3.77 | 5.05 | 0.56 | 0.17 | 2.94 | 46.73 | 2.49** | 16.07** | 95.83 | 25.80 | DJ Euro Stoxx Financials |

## Figure 1: Sample Asset Swap (ASW) spreads stratified by industry sectors

This table presents the development of ASW spreads for ten selected industry sectors included in our sample, from January, 1st 2006 until January, 30th 2009. ASW spreads are in basis points (left scale).



## Table 2: OLS results for determinants of Asset Swap Spreads

Results of regressing daily changes in European iBoxx Corporate Bond index Asset Swap (ASW) spreads on determinants from equation 1: $\Delta ASW_{t-1}$ is the lagged ASW spread change, $\Delta \text{Stock return}$ represents the daily returns of the respective stock index, $\Delta \text{VStoxx}$ is the change in the VStoxx volatility index, $\Delta \text{IR} - \text{Level}$ denotes the change in the level of the swap curve, and $\Delta \text{Swap Spread}$ is the difference of the interest rate swap and the German government bond yield curve. Regression coefficients and corresponding t-statistics (in parentheses) are reported. We use a Newey-West consistent estimate of the covariance matrix to control for autocorrelation and heteroscedasticity. ** and * denote significance at the 1% and 5% level, respectively (779 daily observations – from January 1st, 2006 until January 30th, 2009).

| const. | $\Delta ASW_{t-1}$ | Stock return | ΔVStoxx | ΔIR-Level | ΔSwap Spread | Adj. $R^2$ |
|---|---|---|---|---|---|---|
| **Automobiles & Parts** | | | | | | |
| 0.2615 | 0.3068* | 0.9210 | 0.3794** | -3.7011* | 19.7132* | 0.195 |
| (1.92) | (2.26) | (0.17) | (3.60) | (-2.47) | (2.01) | |
| **Chemicals** | | | | | | |
| 0.24 | -0.0926 | -0.7344 | 0.2196* | -2.9816 | 8.6772 | 0.078 |
| (2.03) | (-1.05) | (-0.08) | (2.02) | (-1.94) | (1.16) | |
| **Food & Beverages** | | | | | | |
| 0.2330 | -0.0439 | 8.6440 | 0.3856** | -2.4384 | 10.7061 | 0.074 |
| (1.54) | (-0.47) | (0.47) | (3.44) | (-1.68) | (1.20) | |
| **Health Care** | | | | | | |
| 0.1791 | -0.1090 | 5.2131 | 0.2657** | -2.0438 | 9.0762 | 0.086 |
| (1.74) | (-1.07) | (0.34) | (3.30) | (-1.62) | (1.27) | |
| **Oil & Gas** | | | | | | |
| 0.3016 | -0.0116 | -24.0346 | 0.1687 | -2.9204 | 19.9049 | 0.110 |
| (2.12) | (-0.13) | (-1.11) | (0.82) | (-1.88) | (1.59) | |
| **Personal & Household Goods** | | | | | | |
| 0.2575 | -0.0747 | 9.3766 | 0.2160* | -2.9069* | 11.2291 | 0.066 |
| (2.28) | (-0.85) | (0.94) | (2.40) | (-2.53) | (1.68) | |
| **Retail** | | | | | | |
| 0.2969 | 0.0085 | 7.5184 | 0.2395** | -2.5535 | 14.1902 | 0.055 |
| (2.23) | (0.10) | (0.47) | (3.22) | (-1.67) | (1.63) | |
| **Telecommunications** | | | | | | |
| 0.2284 | 0.0592 | -1.0540 | 0.2379** | -2.4909 | 11.6075 | 0.073 |
| (2.05) | (0.50) | (-0.06) | (3.42) | (-1.75) | (1.87) | |
| **Utility** | | | | | | |
| 0.2366 | -0.1510 | -22.2952* | 0.0167 | -2.7670* | 0.7191 | 0.080 |
| (2.44) | (-1.59) | (-2.03) | (0.17) | (-2.53) | (0.11) | |
| **Corporates AAA** | | | | | | |
| 0.1387 | 0.2365** | -5.3751 | 0.2459 | -1.2295 | 3.1947* | 0.145 |
| (1.00) | (2.95) | (-0.18) | (1.58) | (-0.90) | (2.10) | |
| **Corporates AA** | | | | | | |
| 0.2549 | 0.0265 | -17.7064 | 0.1351 | -2.8248** | 20.9809 | 0.118 |
| (2.52) | (0.29) | (-1.21) | (1.86) | (-2.60) | (1.63) | |
| **Corporates A** | | | | | | |
| 0.3890 | 0.0804 | -34.5794* | 0.0438 | -2.3197 | 19.7208* | 0.125 |
| (3.93) | (0.73) | (-1.98) | (0.56) | (-1.75) | (2.11) | |
| **Corporates BBB** | | | | | | |
| 0.4071 | 0.1280 | -31.5625 | 0.1004 | -1.9036 | 19.5567* | 0.114 |
| (3.80) | (1.00) | (-1.68) | (1.04) | (-1.09) | (2.56) | |
| **Corporates Senior** | | | | | | |
| 0.2652 | 0.0263 | -22.1838 | 0.1375* | -2.2001 | 17.6829 | 0.129 |
| (2.86) | (0.24) | (-1.50) | (2.03) | (-1.78) | (1.77) | |
| **Corporates Subordinated** | | | | | | |
| 0.5975 | 0.2628** | -37.7510* | -0.0169 | -2.4047 | 27.9731* | 0.180 |
| (4.96) | (2.71) | (-2.02) | (-0.19) | (-1.73) | (2.42) | |
| **Corporates Composite** | | | | | | |
| 0.3439 | 0.0605 | -2.6193 | 0.1048 | -2.3592 | 1.9791 | 0.137 |
| (3.68) | (0.55) | (-1.77) | (1.66) | (-1.91) | (1.94) | |
| **Non-financials** | | | | | | |
| 0.2658 | 0.0274 | -5.0430 | 0.1935* | -2.5934* | 12.1330 | 0.086 |
| (2.59) | (0.21) | (-0.65) | (2.44) | (-2.07) | (1.58) | |
| **Financials** | | | | | | |
| 0.3831 | 0.1745 | -5.9668 | 0.1908** | -2.7554* | 31.9844* | 0.176 |
| (4.05) | (1.52) | (-0.63) | (2.88) | (-2.22) | (2.35) | |
| **Financials Senior** | | | | | | |
| 0.2358 | 0.1749 | -3.9140 | 0.2298** | -2.3897* | 34.7900* | 0.180 |
| (2.63) | (1.40) | (-0.41) | (3.00) | (-2.03) | (2.30) | |
| **Financials Subordinated** | | | | | | |
| 0.6127 | 0.2642** | -10.3032 | 0.1044 | -3.0703* | 29.5229* | 0.172 |
| (5.01) | (2.77) | (-0.83) | (1.31) | (-2.17) | (2.44) | |
| **Banks** | | | | | | |
| 0.3983 | 0.1096 | -0.2551 | 0.2195** | -2.9245* | 27.7989* | 0.122 |
| (3.60) | (1.22) | (-0.02) | (2.86) | (-2.46) | (2.30) | |
| **Tier 1 Capital** | | | | | | |
| 0.7897 | 0.5297** | -71.2776 | -0.1031 | 0.9116 | 34.9503 | 0.350 |
| (4.51) | (6.30) | (-1.85) | (-0.38) | (0.38) | (1.92) | |
| **Lower Tier 2 Capital** | | | | | | |
| 0.4981 | 0.0626 | -24.5580 | 0.0546 | -3.2000* | 15.4047 | 0.094 |
| (4.54) | (0.54) | (-1.62) | (0.68) | (-2.48) | (1.66) | |

**Figure 2: The iBoxx Corporates Composite Asset Swap (ASW) Spread and its determinants**

Left hand scale: Determinants of Asset Swap spreads. Right hand scale: Asset Swap spread for the iBoxx Corporates Composite index. All series are normalized to start at 100.

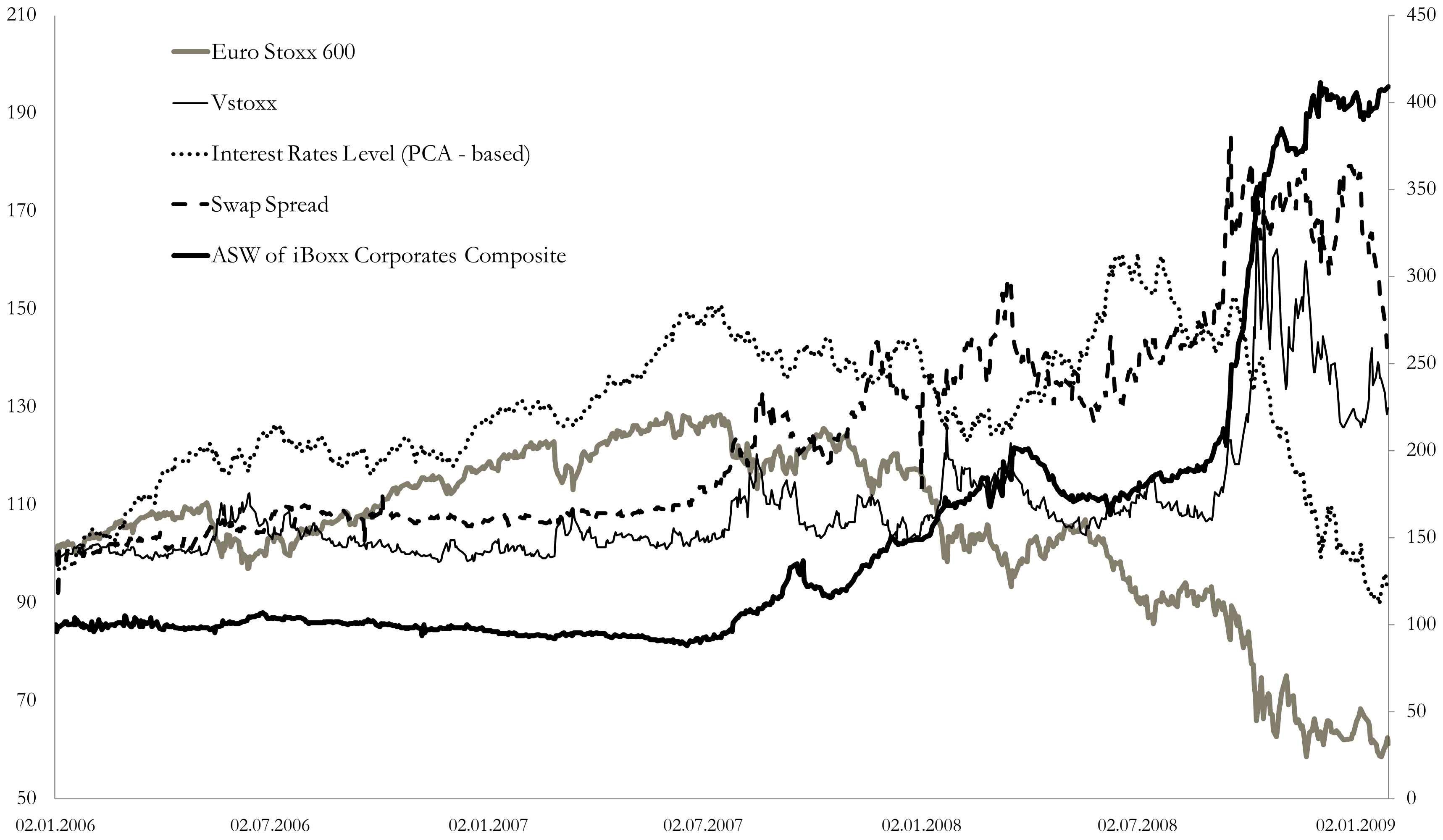
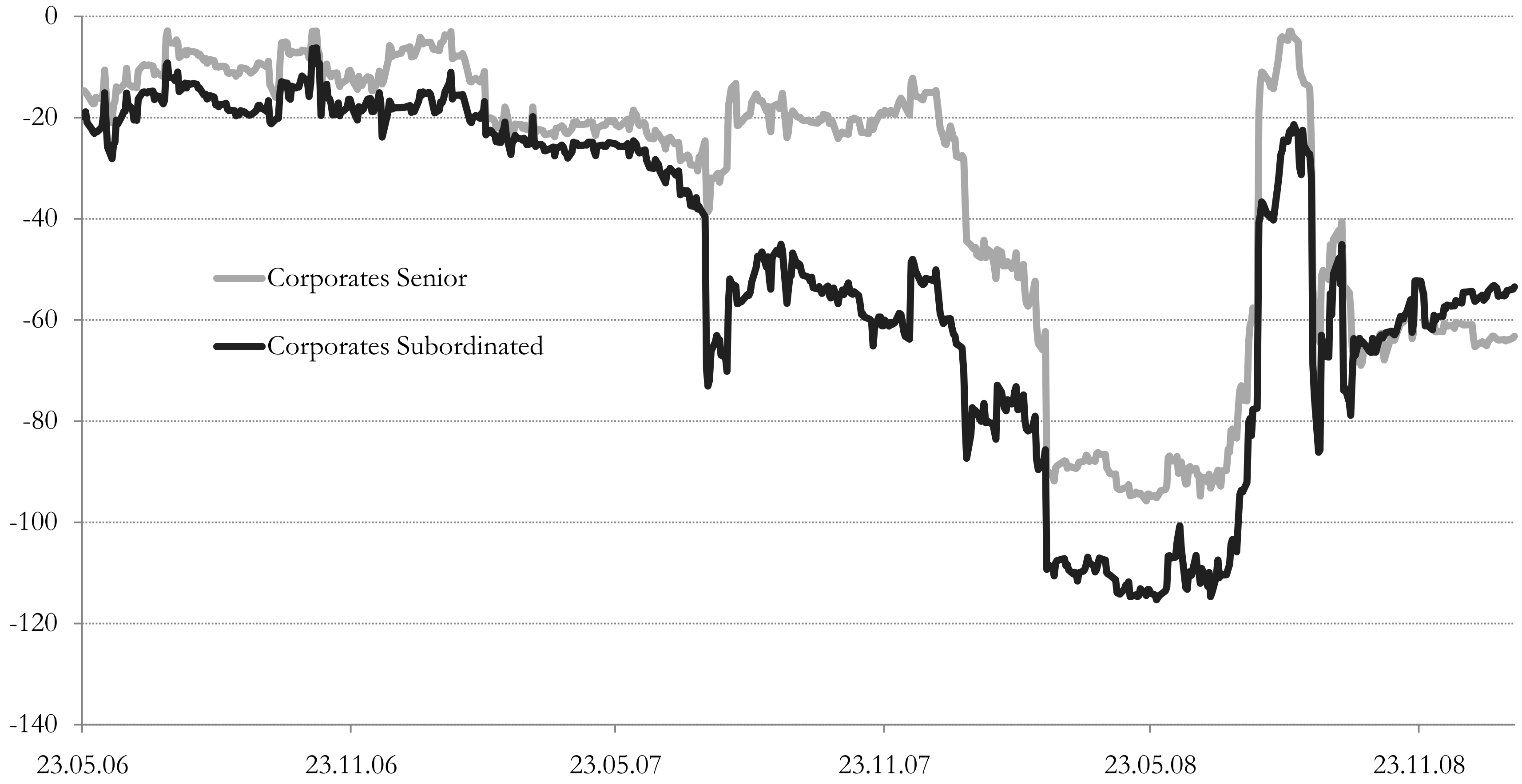


**Figure 3: Evolution of OLS regression coefficients for stock market returns**

This figure presents the evolution of regression coefficients of the stock index variable in model (1). For reasons of brevity we only show the Corporates Senior and the Corporates Subordinated sector. The estimates are based on a rolling window of the last 100 observations.



## Table 3: Chow breakpoint test

Rolling Chow breakpoint test for the whole sample, excluding the first and last 100 observations. The table provides the percentage of trading days the null hypothesis of no structural break can be rejected under the specified confidence level.

| | 1% Level | 5% Level | 10% Level |
|---|---|---|---|
| Automobiles & Parts | 70.34% | 89.14% | 95.69% |
| Chemicals | 10.69% | 48.79% | 66.03% |
| Food & Beverages | 0.69% | 16.38% | 29.14% |
| Health Care | 0.00% | 9.48% | 39.48% |
| Oil & Gas | 61.21% | 85.00% | 96.55% |
| Personal & Household Goods | 13.28% | 52.41% | 68.45% |
| Retail | 23.62% | 58.10% | 73.79% |
| Telecommunications | 11.21% | 49.31% | 65.52% |
| Utility | 9.83% | 31.55% | 60.17% |
| Corporates AAA | 27.24% | 45.86% | 68.97% |
| Corporates AA | 42.07% | 72.59% | 88.62% |
| Corporates A | 85.00% | 94.66% | 98.28% |
| Corporates BBB | 80.17% | 91.03% | 96.03% |
| Corporates Senior | 66.72% | 87.24% | 95.86% |
| Corporates Subordinated | 96.03% | 100.00% | 100.00% |
| Corporates Composite | 81.72% | 93.97% | 97.76% |
| Non-financials | 52.41% | 72.93% | 85.17% |
| Financials | 88.97% | 97.41% | 99.66% |
| Financials Senior | 73.10% | 95.52% | 98.28% |
| Financials Subordinated | 96.21% | 100.00% | 100.00% |
| Banks | 78.28% | 91.90% | 96.03% |
| Tier 1 Capital | 99.48% | 100.00% | 100.00% |
| Lower Tier 2 Capital | 85.17% | 95.86% | 98.62% |

# Table 4: Results of Markov switching regressions

Results for the Markov switching regression of changes in European iBoxx Corporate Bond index Asset Swap (ASW) spreads on theoretical determinants. Regression coefficients and corresponding z-statistics (in parentheses) are reported. We use a Newey-West consistent estimate of the covariance matrix to control for autocorrelation and heteroscedasticity. The theoretical determinants are: lagged ASW changes ($\Delta ASW_{t-1}$), daily stock index returns (Stock return), the change in the VStoxx volatility index ($\Delta$VStoxx), the change in the level of the swap curve ($\Delta$IR – Level), and the difference of the swap and the German government yield curve ($\Delta$Swap Spread). The sample consists of 779 daily observations – from January 1st, 2006 until January 30th, 2009. Regime 1 and 2 represent the volatile and tranquil market regime, respectively. The regime dependent residual standard deviation - denoted as Std. Dev. - is quoted in annualized basis points. $p_{ii}$ gives the probability of staying in the respective regime. The regime dependent State Duration is quoted in days. ** and * denote significance at the 1% and 5% level, respectively.

| | const. | $\Delta ASW_{t-1}$ | Stock return | $\Delta$VStoxx | $\Delta$IR-Level | $\Delta$Swap Spread | Std. Dev. | $p_{ii}$ | State Duration |
|---|---|---|---|---|---|---|---|---|---|
| **Automobiles & Parts** | | | | | | | | | |
| Regime 1 | 0.0087** | 0.3532** | -1.2998 | 0.4315** | -5.9386** | 32.6251** | 110.8669 | 0.8705 | 7.72 |
| | (3.04) | (6.65) | (-0.44) | (8.60) | (-3.36) | (3.53) | | | |
| Regime 2 | 0.0001 | -0.0945** | -11.6288** | -0.0913 | -2.1758** | 1.1762 | 16.2370 | 0.9551 | 22.26 |
| | (0.10) | (-4.49) | (-2.65) | (-1.76) | (-4.17) | (0.54) | | | |
| **Chemicals** | | | | | | | | | |
| Regime 1 | 0.0071 | -0.0790 | 8.0676 | 0.2692 | -4.9517 | 16.6294 | 85.2649 | 0.9237 | 13.11 |
| | (1.06) | (-0.58) | (0.15) | (1.62) | (-0.52) | (0.43) | | | |
| Regime 2 | 0.0008 | -0.1514 | -13.7743 | -0.0012 | -1.7942** | 0.9236 | 17.4629 | 0.9728 | 36.74 |
| | (0.20) | (-0.71) | (-0.67) | (-0.02) | (-3.61) | (0.06) | | | |
| **Food & Beverages** | | | | | | | | | |
| Regime 1 | 0.0054 | 0.0025 | -20.9444** | 0.3224** | -3.7208** | 21.7357* | 102.9351 | 0.8822 | 8.49 |
| | (1.08) | (0.07) | (-3.64) | (6.00) | (-4.15) | (2.78) | | | |
| Regime 2 | 0.0007* | -0.1369* | -23.2275** | -0.1020** | -1.2169 | -2.9104 | 14.9158 | 0.9556 | 22.54 |
| | (2.02) | (-2.07) | (-6.55) | (-3.26) | (-2.21) * | (-0.38) | | | |
| **Health Care** | | | | | | | | | |
| Regime 1 | 0.0055** | -0.0890 | 6.7733 | 0.2910** | -3.7628** | 15.9705 | 75.1542 | 0.8744 | 7.96 |
| | (3.34) | (-1.37) | (0.30) | (4.21) | (-3.47) | (1.17) | | | |
| Regime 2 | 0.0001 | -0.1787* | -10.8026 | -0.0061 | -0.6915 | 1.3854 | 13.7207 | 0.9505 | 20.21 |
| | (1.20) | (-2.21) | (-0.46) | (-0.04) | (-1.63) | (0.32) | | | |
| **Oil & Gas** | | | | | | | | | |
| Regime 1 | 0.0108 | 0.0344 | -20.3847** | 0.2052** | -6.1498** | 41.2796** | 112.5837 | 0.9197 | 12.45 |
| | (1.55) | (0.94) | (-3.32) | (4.30) | (-2.83) | (4.25) | | | |
| Regime 2 | 0.0012 | -0.1990* | -15.0015 | -0.0278 | -2.8551* | 0.7606 | 22.6032 | 0.9827 | 57.92 |
| | (1.98) | (-2.44) | (-1.17) | (-0.41) | (-2.26) | (0.38) | | | |
| **Personal & Household Goods** | | | | | | | | | |
| Regime 1 | 0.0089* | -0.0870 | 23.8413 | 0.2644* | -4.8654* | 17.2511 | 78.8854 | 0.8963 | 9.64 |
| | (2.38) | (-1.39) | (1.05) | (2.48) | (-2.40) | (1.50) | | | |
| Regime 2 | -0.0001 | -0.0677* | -9.8711* | -0.0226 | -1.1003** | 3.2185 | 14.3114 | 0.9563 | 22.87 |
| | (-0.35) | (-2.02) | (-2.10) | (-0.51) | (-2.68) | (1.02) | | | |
| **Retail** | | | | | | | | | |
| Regime 1 | 0.0094* | 0.0077 | 20.2265 | 0.2877* | -3.5028 | 22.7682 | 90.9326 | 0.8829 | 8.54 |
| | (2.01) | (0.11) | (0.93) | (2.35) | (-1.71) | (1.82) | | | |
| Regime 2 | 0.0005 | -0.0733* | -12.3934** | -0.0016 | -1.8851** | 0.5360 | 15.6158 | 0.9561 | 22.77 |
| | (1.16) | (-2.28) | (-3.14) | (-0.04) | (-4.70) | (0.18) | | | |
| **Telecommunications** | | | | | | | | | |
| Regime 1 | 0.0063 | 0.0731 | -2.5538 | 0.2558 | -3.9102 | 18.9734 | 81.7654 | 0.9167 | 12.01 |
| | (1.51) | (1.05) | (-0.10) | (1.88) | (-1.83) | (1.46) | | | |
| Regime 2 | 0.0005 | -0.0150 | -2.4146 | 0.0375 | -1.4312** | 3.2672 | 16.7733 | 0.9687 | 31.99 |
| | (0.95) | (-0.41) | (-0.51) | (0.91) | (-3.25) | (1.03) | | | |
| **Utility** | | | | | | | | | |
| Regime 1 | 0.0078 | -0.1778** | -22.6610** | 0.0412 | -4.9167* | 0.1832 | 75.7516 | 0.9146 | 11.70 |
| | (1.30) | (-2.86) | (-5.52) | (1.30) | (-2.43) | (0.04) | | | |
| Regime 2 | 0.0004* | -0.1468** | -17.0674** | -0.0436 | -1.0210 | -0.3179 | 15.6115 | 0.9719 | 35.53 |
| | (2.45) | (-5.70) | (-2.84) | (-0.75) | (-0.97) | (-0.45) | | | |
| **Corporates AAA** | | | | | | | | | |
| Regime 1 | 0.0056 | 0.2873** | 3.6822 | 0.2858 | -3.2080 | 52.8956** | 115.4664 | 0.9217 | 12.77 |
| | (1.30) | (13.4) | (0.03) | (0.65) | (-0.85) | (3.27) | | | |
| Regime 2 | 0.0008** | -0.2699** | -17.7525* | -0.1043* | -1.5183** | -2.8673 | 16.8719 | 0.9827 | 57.82 |
| | (2.86) | (-3.23) | (-2.17) | (-2.43) | (-2.93) | (-0.81) | | | |
| **Corporates AA** | | | | | | | | | |
| Regime 1 | 0.0067** | 0.0579 | -12.4094 | 0.1690** | -4.7488** | 36.1258** | 71.1397 | 0.8873 | 8.88 |
| | (4.27) | (1.16) | (-1.15) | (4.60) | (-5.72) | (3.49) | | | |
| Regime 2 | 0.0005* | -0.1470 | -14.7228 | -0.0247 | -1.6224** | -0.9396 | 12.3050 | 0.9454 | 18.31 |
| | (2.06) | (-0.70) | (-0.85) | (-0.33) | (-9.36) | (-0.26) | | | |

## Table 4 (cont.): Result of Markov switching regressions

| | const. | $\Delta ASW_{t-1}$ | Stock return | ΔVStoxx | ΔIR-Level | ΔSwap Spread | Std. Dev. | $p_{ii}$ | State Duration |
|---|---|---|---|---|---|---|---|---|---|
| **Corporates A** | | | | | | | | | |
| Regime 1 | 0.0106** | 0.0798 | -30.1514* | 0.0993 | -3.8684* | 32.1492** | 73.1683 | 0.9057 | 10.60 |
| | (3.60) | (1.79) | (-2.53) | (1.71) | (-2.45) | (5.98) | | | |
| Regime 2 | 0.0013** | -0.0497 | -38.5933** | -0.2036* | -1.5196** | 2.5043 | 14.7798 | 0.9625 | 26.66 |
| | (3.12) | (-0.17) | (-4.37) | (-2.62) | (-4.44) | (0.71) | | | |
| **Corporates BBB** | | | | | | | | | |
| Regime 1 | 0.0129* | 0.1064 | -30.6951 | 0.1754 | -3.0372 | 27.2616* | 85.3892 | 0.9008 | 10.08 |
| | (2.69) | (1.75) | (-1.22) | (1.26) | (-1.40) | (2.31) | | | |
| Regime 2 | 0.0011* | 0.0372 | -37.6421** | -0.2341** | -1.8140** | 5.6972 | 16.2048 | 0.9641 | 27.88 |
| | (2.21) | (1.02) | (-4.52) | (-3.98) | (-3.82) | (1.95) | | | |
| **Corporates Senior** | | | | | | | | | |
| Regime 1 | 0.0072* | 0.0533 | -22.9137 | 0.1612 | -3.5763 | 29.7785** | 68.5249 | 0.9156 | 11.85 |
| | (2.19) | (0.82) | (-1.04) | (1.11) | (-1.96) | (3.65) | | | |
| Regime 2 | 0.0006 | -0.1486** | -21.3212** | -0.1119* | -1.5390** | 1.9404 | 13.2823 | 0.9659 | 29.31 |
| | (1.57) | (-3.85) | (-3.43) | (-2.40) | (-3.99) | (0.72) | | | |
| **Corporates Subordinated** | | | | | | | | | |
| Regime 1 | 0.0125** | 0.2536** | -25.0488 | 0.0315 | -3.7312* | 38.9976** | 65.7289 | 0.9514 | 20.58 |
| | (4.44) | (5.81) | (-1.36) | (0.23) | (-2.40) | (7.41) | | | |
| Regime 2 | 0.0015** | -0.1271** | -57.1431** | -0.2574** | -0.9427 | 3.5802 | 13.4608 | 0.9593 | 24.58 |
| | (3.21) | (-3.65) | (-6.29) | (-4.06) | (-1.92) | (1.16) | | | |
| **Corporates Composite** | | | | | | | | | |
| Regime 1 | 0.0095** | 0.0632 | -21.1703 | 0.1647 | -4.0552* | 32.0181** | 67.7992 | 0.9150 | 11.76 |
| | (2.95) | (1.05) | (-0.97) | (1.05) | (-2.21) | (4.24) | | | |
| Regime 2 | 0.0009* | -0.0626 | -30.6173** | -0.1553** | -1.4657** | 3.1737 | 13.9057 | 0.9652 | 28.75 |
| | (2.29) | (-1.66) | (-4.95) | (-3.79) | (-3.88) | (1.12) | | | |
| **Non-financials** | | | | | | | | | |
| Regime 1 | 0.0079* | 0.0430 | -11.6668 | 0.2103 | -3.7366 | 17.7671 | 73.4352 | 0.9167 | 12.01 |
| | (2.33) | (0.54) | (-0.75) | (1.75) | (-1.89) | (1.49) | | | |
| Regime 2 | 0.0004 | -0.1578** | -2.4209 | -0.0345 | -1.6864** | 2.3315 | 14.2543 | 0.9674 | 30.65 |
| | (0.80) | (-2.74) | (-0.57) | (-0.64) | (-3.78) | (0.91) | | | |
| **Financials** | | | | | | | | | |
| Regime 1 | 0.0085 | 0.2071* | 4.5976 | 0.2377 | -3.9571* | 48.7543** | 61.6147 | 0.9245 | 13.24 |
| | (1.81) | (2.33) | (0.35) | (1.98) | (-2.29) | (3.14) | | | |
| Regime 2 | 0.0008 | -0.1671 | -21.7275* | -0.0940 | -1.4653 | 1.7697 | 11.6361 | 0.9471 | 18.91 |
| | (0.92) | (-1.49) | (-2.03) | (-0.97) | (-1.11) | (0.34) | | | |
| **Financials Senior** | | | | | | | | | |
| Regime 1 | 0.0071* | 0.2167** | 8.1620 | 0.3798* | -4.7083** | 60.5424** | 72.1853 | 0.8483 | 6.59 |
| | (2.24) | (2.95) | (0.64) | (2.19) | (-3.00) | (4.09) | | | |
| Regime 2 | 0.0007 | -0.1514 | 1.0613 | 0.0671** | -1.7790** | 2.2155 | 12.6594 | 0.9395 | 16.54 |
| | (1.34) | (-1.24) | (0.76) | (3.15) | (-6.43) | (0.57) | | | |
| **Financials Subordinated** | | | | | | | | | |
| Regime 1 | 0.0130** | 0.2547** | 2.8750 | 0.1561 | -4.5369** | 42.3740** | 65.8223 | 0.9520 | 20.85 |
| | (4.69) | (4.85) | (0.24) | (1.59) | (-2.91) | (4.91) | | | |
| Regime 2 | 0.0013* | -0.1265* | -39.6987** | -0.1838* | -1.0896 | 3.0546 | 13.2163 | 0.9599 | 24.92 |
| | (2.51) | (-2.38) | (-5.11) | (-2.37) | (-1.96) | (0.86) | | | |
| **Banks** | | | | | | | | | |
| Regime 1 | 0.0095** | 0.1238* | 12.2365 | 0.2895* | -4.4491* | 44.2449** | 70.7211 | 0.9091 | 11.00 |
| | (2.78) | (2.05) | (0.73) | (2.20) | (-2.49) | (6.25) | | | |
| Regime 2 | 0.0009* | -0.1434** | -17.7257** | -0.0974** | -1.6054** | 1.2231 | 12.0942 | 0.9450 | 18.20 |
| | (2.37) | (-4.10) | (-5.28) | (-2.72) | (-4.21) | (0.43) | | | |
| **Tier 1 Capital** | | | | | | | | | |
| Regime 1 | 0.0180 | 0.5154** | -65.3662** | -0.0783 | 0.7569 | 47.8202** | 118.6375 | 0.9329 | 14.90 |
| | (1.35) | (8.7) | (-2.85) | (-0.51) | (0.26) | (7.39) | | | |
| Regime 2 | 0.0014 | -0.0646 | -74.4322 | -0.3402 | -0.0774 | 2.1095 | 17.1272 | 0.9491 | 19.65 |
| | (0.68) | (-0.96) | (-1.39) | (-0.65) | (-0.06) | (1.11) | | | |
| **Lower Tier 2 Capital** | | | | | | | | | |
| Regime 1 | 0.0106** | 0.0555 | -14.3953 | 0.0985** | -4.7018 | 22.6938** | 63.8301 | 0.9510 | 20.39 |
| | (3.21) | (0.76) | (-1.55) | (3.56) | (-1.77) | (5.71) | | | |
| Regime 2 | 0.0010** | -0.1613** | -35.8535** | -0.1566 | -0.9703* | 0.7634 | 11.6346 | 0.9609 | 25.60 |
| | (4.22) | (-2.71) | (-2.97) | (-1.52) | (-2.63) | (0.52) | | | |

## Table 5: Test for equality of determinants in both regimes

Results of Likelihood Ratio (LR) tests of equality of all coefficients in both regimes ($H_0$: No switching in all variables). LR represents the likelihood ratio test statistic. Corresponding p-values are presented in the last column.

| | LR | *p-value* |
|---|---|---|
| Automobiles & Parts | 51.363 | 0.000 |
| Chemicals | 11.842 | 0.037 |
| Food & Beverages | 22.754 | 0.000 |
| Health Care | 18.663 | 0.002 |
| Oil & Gas | 25.864 | 0.000 |
| Personal & Household Goods | 18.203 | 0.003 |
| Retail | 14.934 | 0.011 |
| Telecommunications | 14.997 | 0.010 |
| Utility | 11.348 | 0.045 |
| Corporates AAA | 53.369 | 0.000 |
| Corporates AA | 32.940 | 0.000 |
| Corporates A1 | 33.420 | 0.000 |
| Corporates BBB | 30.852 | 0.000 |
| Corporates Senior | 36.033 | 0.000 |
| Corporates Subordinated | 82.552 | 0.000 |
| Corporates Composite | 39.948 | 0.000 |
| Non-financials | 28.125 | 0.000 |
| Financials | 65.799 | 0.000 |
| Financials Senior | 57.524 | 0.000 |
| Financials Subordinated | 88.267 | 0.000 |
| Banks | 50.427 | 0.000 |
| Tier 1 Capital | 110.791 | 0.000 |
| Lower Tier 2 Capital | 49.998 | 0.000 |

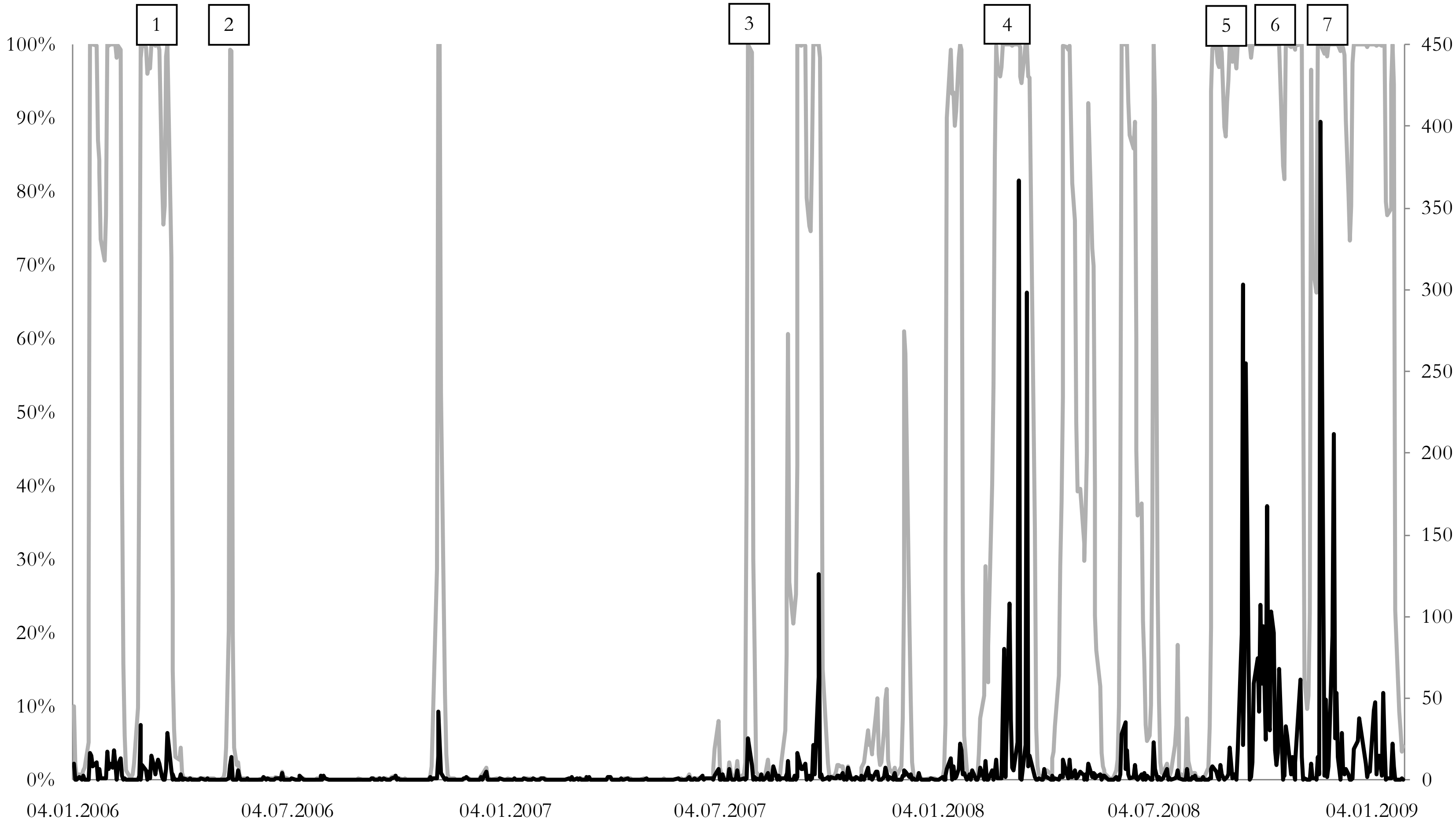
## Table 6: Regime specific moments of Asset Swap Spreads

This table compares the regime specific moments (mean, skewness and kurtosis) of the asset swap spread changes. The value of the mean is reported in basis points. The second column presents the percentage of time sample indices spend in Regime 1 (volatile regime).

| | | Regime 1 | | | Regime 2 | | |
|---|---|---|---|---|---|---|---|
| | | High volatility regime | | | Low volatility regime | | |
| | Time in regime 1 | Mean | Skewness | Excess kurtosis | Mean | Skewness | Excess kurtosis |
| Automobiles & Parts | 17.8% | 2.27 | 0.59 | 2.31 | 0.01 | 0.08 | 1.29 |
| Chemicals | 26.8% | 0.76 | 0.66 | 2.00 | 0.04 | 0.33 | 0.54 |
| Food & Beverages | 25.9% | 0.75 | 0.73 | 3.54 | 0.06 | 0.02 | 0.55 |
| Health Care | 27.9% | 0.55 | 0.64 | 1.91 | 0.03 | 0.31 | 0.56 |
| Oil & Gas | 16.3% | 1.80 | -0.42 | 2.95 | 0.04 | 0.06 | 0.97 |
| Personal & Household Goods | 27.3% | 0.92 | 0.73 | 2.36 | 0.00 | 0.25 | 0.36 |
| Retail | 24.6% | 1.12 | 0.73 | 1.00 | 0.05 | 0.25 | 0.83 |
| Telecommunications | 25.0% | 0.95 | 0.82 | 2.22 | 0.03 | 0.21 | 0.34 |
| Utility | 22.6% | 0.74 | 0.56 | 2.96 | 0.05 | 0.26 | 0.49 |
| Corporates AAA | 18.1% | 0.97 | 1.46 | 6.75 | 0.06 | 0.23 | 1.23 |
| Corporates AA | 28.5% | 0.92 | 0.60 | 4.99 | 0.04 | 0.36 | 0.95 |
| Corporates A | 26.8% | 1.33 | 0.59 | 1.82 | 0.14 | 0.42 | 0.78 |
| Corporates BBB | 25.3% | 1.63 | 1.03 | 2.51 | 0.13 | 0.46 | 0.67 |
| Corporates Senior | 28.0% | 0.95 | 0.89 | 2.60 | 0.05 | 0.41 | 0.73 |
| Corporates Subordinated | 43.9% | 1.84 | 1.17 | 3.22 | 0.10 | 0.34 | 0.59 |
| Corporates Composite | 27.3% | 1.19 | 0.87 | 2.29 | 0.10 | 0.44 | 0.64 |
| Non-financials | 26.8% | 0.98 | 0.64 | 2.02 | 0.04 | 0.37 | 0.66 |
| Financials | 39.3% | 1.16 | 1.34 | 5.06 | 0.08 | 0.29 | 0.86 |
| Financials Senior | 25.7% | 1.10 | 1.00 | 3.60 | 0.06 | 0.20 | 1.18 |
| Financials Subordinated | 48.1% | 1.74 | 1.26 | 3.88 | 0.08 | 0.25 | 0.81 |
| Banks | 36.6% | 1.18 | 2.25 | 13.20 | 0.07 | 0.30 | 0.88 |
| Tier 1 Capital | 44.9% | 3.85 | 2.37 | 9.85 | 0.09 | 0.42 | 0.81 |
| Lower Tier 2 Capital | 39.0% | 1.30 | 1.35 | 5.19 | 0.09 | 0.59 | 2.45 |

## Figure 4: Regime probabilities and Asset Swap (ASW) Spreads

Estimated probability of being in the volatile regime - based on the filtered probability (grey bars and left hand scale: a value of 100% indicates being in the volatile regime, a value of zero being in the tranquil regime) and squared changes in the iBoxx Corporate Composite ASW spread (black line and right hand scale). The events are: (1) House price stagnation, (2) Ameriquest, (3) Credit markets start to freeze, (4) Bear Stearns, (5) Freddie Mac and Fannie Mae, (6) Lehman Brothers, and (7) Citigroup.



## Table 7: Logit Models

This Table presents the $\alpha_1$ coefficients from the logit regressions (see equation 11) with t-statistics (in parentheses) and $R^2$ (in square brackets). We use a Huber-White consistent estimate of the covariance matrix to control for auto-correlation and heteroscedasticity. The theoretical determinants are: lagged squared ASW changes ($\Delta ASW^2_{t-1}$), lagged ASW changes ($\Delta ASW_{t-1}$), lagged daily stock index returns ($\Delta Stock\ return_{t-1}$), lagged change in the VStoxx volatility index ($\Delta VStoxx_{t-1}$), lagged change in the level of the swap curve ($\Delta IR - Level_{t-1}$), and lagged changes in the difference of the swap and the German government yield curve ($\Delta Swap\ Spread_{t-1}$).

| | $\Delta ASW^2_{t-1}$ | $\Delta ASW_{t-1}$ | Stock $return_{t-1}$ | $\Delta VStoxx_{t-1}$ | $\Delta IR\text{-}Level_{t-1}$ | ΔSwap $Spread_{t-1}$ |
|---|---|---|---|---|---|---|
| **Automobiles & Parts** | | | | | | |
| | 0.0215 | 0.0592* | -3.7964 | 0.0296 | -1.6002* | 4.6729 |
| | (1.3180) | (2.1888) | (-0.7337) | (0.5576) | (-2.0504) | (0.9468) |
| | [0.0963] | [0.0115] | [0.0019] | [0.0008] | [0.0074] | [0.0021] |
| **Chemicals** | | | | | | |
| | 0.3505** | 0.0662 | -12.2542 | 0.0264 | -1.3362 | 0.1193 |
| | (10.103) | (1.7370) | (-1.7548) | (0.5267) | (-1.7605) | (0.0264) |
| | [0.4121] | [0.0072] | [0.0072] | [0.0006] | [0.0053] | [0.0000] |
| **Food & Beverages** | | | | | | |
| | 0.1033 | 0.0648* | -15.3480 | 0.0661 | -1.3118 | 4.8336 |
| | (1.1110) | (2.0746) | (-1.9482) | (1.4352) | (-1.7492) | (1.0914) |
| | [0.2002] | [0.0100] | [0.0072] | [0.0040] | [0.0051] | [0.0023] |
| **Health Care** | | | | | | |
| | 0.4450** | 0.0860* | -9.5170 | 0.0164 | -1.0351 | 2.8991 |
| | (10.178) | (2.1145) | (-1.2537) | (0.3435) | (-1.4359) | (0.6898) |
| | [0.4074] | [0.0099] | [0.0032] | [0.0002] | [0.0032] | [0.0008] |
| **Oil & Gas** | | | | | | |
| | 0.1564** | 0.1143* | -9.0381 | 0.0570 | -1.6222 | 5.3706 |
| | (10.380) | (2.2407) | (-0.9860) | (0.8961) | (-1.5414) | (0.8895) |
| | [0.4072] | [0.0268] | [0.0047] | [0.0030] | [0.0068] | [0.0027] |
| **Personal & Household Goods** | | | | | | |
| | 0.5183** | 0.0998** | -14.1169* | 0.0381 | -0.8799 | 1.8637 |
| | (10.972) | (2.6050) | (-1.9619) | (0.8170) | (-1.2257) | (0.4393) |
| | [0.4659] | [0.0152] | [0.0079] | [0.0013] | [0.0023] | [0.0003] |
| **Retail** | | | | | | |
| | 0.4002** | 0.0915** | -3.5135 | 0.0405 | -1.0232 | -0.0906 |
| | (9.8899) | (2.6755) | (-0.4828) | (0.8210) | (-1.3132) | (-0.0194) |
| | [0.4777] | [0.0161] | [0.0004] | [0.0015] | [0.0031] | [0.0000] |
| **Telecommunications** | | | | | | |
| | 0.4030** | 0.0793* | -13.2334 | 0.0412 | -1.6271* | 2.3138 |
| | (9.1460) | (2.1298) | (-1.6666) | (0.8575) | (-2.1035) | (0.5159) |
| | [0.4471] | [0.0101] | [0.0057] | [0.0015] | [0.0078] | [0.0005] |
| **Utility** | | | | | | |
| | 0.4437** | 0.0963* | -8.2295 | 0.0398 | -0.9558 | 2.8419 |
| | (11.264) | (1.9925) | (-1.0364) | (0.7856) | (-1.1490) | (0.5848) |
| | [0.4465] | [0.0114] | [0.0031] | [0.0014] | [0.0026] | [0.0007] |
| **Corporates AAA** | | | | | | |
| | 0.2820** | 0.0580 | -12.4132 | 0.0249 | -1.9375* | 2.0945 |
| | (8.4606) | (1.6561) | (-1.2783) | (0.3708) | (-2.0579) | (0.3538) |
| | [0.4021] | [0.0086] | [0.0058] | [0.0005] | [0.0105] | [0.0004] |
| **Corporates AA** | | | | | | |
| | 0.4806** | 0.1077** | -16.7895* | 0.0724 | -0.7876 | 0.1266 |
| | (7.3090) | (2.5942) | (-2.4332) | (1.8124) | (-1.1660) | (0.0326) |
| | [0.3798] | [0.0157] | [0.0112] | [0.0048] | [0.0019] | [0.0000] |

## Table 7 (cont.): Logit Models

| | $\Delta ASW^2_{t-1}$ | $\Delta ASW_{t-1}$ | Stock return$_{t-1}$ | $\Delta VStoxx_{t-1}$ | $\Delta$IR-Level$_{t-1}$ | $\Delta$Swap Spread$_{t-1}$ |
|---|---|---|---|---|---|---|
| **Corporates A** | | | | | | |
| | 0.4426** | 0.1512** | -10.4261 | 0.0206 | -0.7296 | 0.6953 |
| | (10.785) | (3.4699) | (-1.4730) | (0.4458) | (-0.9945) | (0.1627) |
| | [0.4540] | [0.0307] | [0.0043] | [0.0003] | [0.0016] | [0.0000] |
| **Corporates BBB** | | | | | | |
| | 0.3865** | 0.1426** | -10.2304 | 0.0181 | -0.2489 | -0.1028 |
| | (9.1046) | (3.8020) | (-1.3968) | (0.3614) | (-0.3224) | (-0.0224) |
| | [0.4488] | [0.0346] | [0.0041] | [0.0003] | [0.0001] | [0.0000] |
| **Corporates Senior** | | | | | | |
| | 0.5321** | 0.1186** | -14.6936* | 0.0434 | -0.9136 | 0.5897 |
| | (10.959) | (2.8624) | (-2.0244) | (0.9708) | (-1.2660) | (0.1396) |
| | [0.4330] | [0.0175] | [0.0086] | [0.0017] | [0.0025] | [0.0000] |
| **Corporates Subordinated** | | | | | | |
| | 0.4466** | 0.1824** | -10.8897* | 0.0298 | -1.0134 | 0.4952 |
| | (8.9094) | (5.7129) | (-2.0384) | (0.9239) | (-1.7635) | (0.1587) |
| | [0.3776] | [0.0473] | [0.0049] | [0.0008] | [0.0032] | [0.0000] |
| **Corporates Composite** | | | | | | |
| | 0.4929** | 0.1496** | -14.5235* | 0.0551 | -0.8982 | 0.9719 |
| | (10.416) | (3.4645) | (-2.0490) | (1.3099) | (-1.2496) | (0.2334) |
| | [0.4291] | [0.0272] | [0.0084] | [0.0028] | [0.0024] | [0.0000] |
| **Non-financials** | | | | | | |
| | 0.5471** | 0.1204** | -9.6836* | 0.0272 | -1.3270 | 2.5513 |
| | (10.476) | (2.8247) | (-2.0118) | (0.5743) | (-1.7852) | (0.5834) |
| | [0.4717] | [0.0191] | [0.0080] | [0.0006] | [0.0052] | [0.0006] |
| **Financials** | | | | | | |
| | 0.1577 | 0.1302** | -8.0129 | 0.0381 | -0.5163 | 0.9177 |
| | (1.0619) | (3.4984) | (-1.7909) | (1.1008) | (-0.8573) | (0.2741) |
| | [0.1566] | [0.0222] | [0.0047] | [0.0013] | [0.0008] | [0.0000] |
| **Financials Senior** | | | | | | |
| | 0.1285 | 0.1014** | -13.4546* | 0.0806 | -0.2518 | 1.9505 |
| | (1.3689) | (2.6230) | (-2.4337) | (1.8468) | (-0.3383) | (0.4784) |
| | [0.1756] | [0.0159] | [0.0124] | [0.0060] | [0.0001] | [0.0003] |
| **Financials Subordinated** | | | | | | |
| | 0.4534** | 0.1913** | -5.6658 | 0.0104 | -0.7220 | 0.2365 |
| | (8.5665) | (5.7485) | (-1.4263) | (0.3127) | (-1.2659) | (0.0758) |
| | [0.3798] | [0.0506] | [0.0024] | [0.0001] | [0.0016] | [0.0000] |
| **Banks** | | | | | | |
| | 0.5355** | 0.1333** | -10.3453* | 0.0539 | -0.3633 | 1.5944 |
| | (8.3182) | (3.4855) | (-2.2662) | (1.5029) | (-0.5814) | (0.4554) |
| | [0.3873] | [0.0232] | [0.0082] | [0.0027] | [0.0004] | [0.0002] |
| **Tier 1 Capital** | | | | | | |
| | 0.1082 | 0.1502** | -10.2846 | 0.0208 | -0.9716 | 2.5760 |
| | (1.7119) | (5.8182) | (-1.8359) | (0.5906) | (-1.6346) | (0.7679) |
| | [0.2752] | [0.0787] | [0.0044] | [0.0004] | [0.0029] | [0.0007] |
| **Lower Tier 2 Capital** | | | | | | |
| | 0.6208** | 0.1542* | -10.1723 | 0.0150 | -0.4266 | 0.8332 |
| | (8.1869) | (4.2409) | (-1.8620) | (0.4384) | (-0.7336) | (0.2600) |
| | [0.3931] | [0.0287] | [0.0043] | [0.0002] | [0.0005] | [0.0000] |

## Table 8: Granger-causality tests of dependent and explanatory variables

This table presents p-values of various Granger-causality tests between dependent and our set of explanatory variables. Overall, eight hypotheses are tested: (1) Stock returns do not Granger-cause ASW spread returns, (2) ASW spread returns do not Granger-cause Stock returns, (3) ΔVStoxx do not Granger-cause ASW spread returns, (4) ASW spread returns do not Granger-cause ΔVStoxx, (5) ΔIR-Level do not Granger-cause ASW spread returns, (6) ASW spread returns do not Granger-cause ΔIR-Level, (7) ΔSwap Spread do not Granger-cause ASW spread returns, and (8) ASW spread returns do not Granger-cause ΔSwap Spread.

| | Null Hypotheses: | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | Stock returns | ΔASW spreads | ΔVStoxx | ΔASW spreads | ΔIR-Level | ΔASW spreads | ΔSwap Spread | ΔASW spreads |
| | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| Sector | ΔASW spreads | Stock returns | ASW spreads | ΔVStoxx | ΔASW spreads | ΔIR-Level | ΔASW spreads | ΔSwap spreads |
| Automobiles & Parts | 0.000 | 0.463 | 0.001 | 0.000 | 0.046 | 0.289 | 0.005 | 0.000 |
| Chemicals | 0.000 | 0.149 | 0.001 | 0.386 | 0.054 | 0.075 | 0.034 | 0.000 |
| Food & Beverages | 0.000 | 0.079 | 0.000 | 0.140 | 0.042 | 0.035 | 0.032 | 0.000 |
| Health Care | 0.001 | 0.000 | 0.000 | 0.454 | 0.159 | 0.144 | 0.009 | 0.000 |
| Oil & Gas | 0.018 | 0.000 | 0.005 | 0.000 | 0.006 | 0.000 | 0.053 | 0.000 |
| Personal & Household Goods | 0.000 | 0.000 | 0.000 | 0.007 | 0.008 | 0.058 | 0.000 | 0.000 |
| Retail | 0.000 | 0.011 | 0.000 | 0.425 | 0.045 | 0.268 | 0.002 | 0.000 |
| Telecommunications | 0.009 | 0.353 | 0.006 | 0.070 | 0.025 | 0.210 | 0.000 | 0.000 |
| Utility | 0.034 | 0.003 | 0.012 | 0.000 | 0.002 | 0.111 | 0.022 | 0.000 |
| Corporates AAA | 0.002 | 0.000 | 0.047 | 0.000 | 0.106 | 0.072 | 0.000 | 0.000 |
| Corporates AA | 0.001 | 0.366 | 0.063 | 0.366 | 0.064 | 0.108 | 0.000 | 0.000 |
| Corporates A | 0.000 | 0.334 | 0.001 | 0.015 | 0.032 | 0.052 | 0.000 | 0.000 |
| Corporates BBB | 0.000 | 0.305 | 0.028 | 0.098 | 0.004 | 0.000 | 0.010 | 0.000 |
| Corporates Senior | 0.000 | 0.109 | 0.001 | 0.145 | 0.006 | 0.023 | 0.000 | 0.000 |
| Corporates Subordinated | 0.000 | 0.014 | 0.001 | 0.012 | 0.039 | 0.000 | 0.000 | 0.000 |
| Corporates Composite | 0.000 | 0.415 | 0.013 | 0.163 | 0.016 | 0.035 | 0.000 | 0.000 |
| Non-financials | 0.000 | 0.047 | 0.005 | 0.223 | 0.038 | 0.143 | 0.000 | 0.000 |
| Financials | 0.003 | 0.642 | 0.107 | 0.022 | 0.053 | 0.002 | 0.000 | 0.000 |
| Financials Senior | 0.002 | 0.018 | 0.360 | 0.166 | 0.032 | 0.004 | 0.000 | 0.000 |
| Financials Subordinated | 0.083 | 0.223 | 0.003 | 0.087 | 0.132 | 0.000 | 0.000 | 0.000 |
| Banks | 0.000 | 0.213 | 0.034 | 0.001 | 0.002 | 0.005 | 0.000 | 0.000 |
| Tier 1 Capital | 0.018 | 0.000 | 0.001 | 0.000 | 0.615 | 0.000 | 0.048 | 0.179 |
| Lower Tier 2 Capital | 0.011 | 0.327 | 0.060 | 0.518 | 0.007 | 0.251 | 0.000 | 0.000 |