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The comovement of credit default swap, bond and stock markets: an empirical analysis *

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Abstract:
This paper analyzes the empirical relationship between credit default swap, bond and stock markets during the period 2000-2002. Focusing on the intertemporal comovement, we examine weekly and daily lead-lag relationships in a vector autoregressive model and the adjustment between markets caused by cointegration. First, we find that stock returns lead CDS and bond spread changes. Second, CDS spread changes Granger cause bond spread changes for a higher number of firms than vice versa. Third, the CDS market is significantly more sensitive to the stock market than the bond market and the magnitude of this sensitivity increases when credit quality becomes worse. Finally, the CDS market plays a more important role for price discovery than the corporate bond market.

JEL Classification: G10; G14; C32

Keywords: Credit risk; Credit spreads; Credit derivatives; Lead-lag relationship

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1. Introduction

In efficient markets default risk of firms should be reflected by market prices of financial claims on these firms. Theory suggests that there is a close link between market prices of different claims, for example stocks and bonds, because their value depends on the distribution of the market value of the firm's assets. Less obvious is the empirical relationship between market prices of different credit-sensitive claims for the same firm. In particular, the link between the heavily growing credit derivatives market[1] and traditional cash markets has only been explored on a limited scale so far. For this reason, we empirically analyze the co-movement of single name credit default swap (CDS), bond and stock markets at the individual firm-level to investigate if and how these markets are connected and whether default-risk related information is reflected earlier in certain markets than in others.

Besides cash markets, we are particularly interested in the credit default swap market for the following reasons: First, from a theoretical perspective, CDS should reflect pure issuer default risk, and no facility or issue specific risk, making these instruments a potentially "ideal" benchmark for measuring and pricing credit risk. Second, CDS have turned out to clearly dominate other types of credit derivatives such as credit linked notes or total return swaps in terms of market volume and standardization.

On the one hand, we replicate parts of the analyses of Blanco, Brennan, and Marsh (2004), Longstaff, Mithal, and Neis (2003), Berndt et al. (2004), and Zhu (2004). Analyzing weekly and daily data from an international sample of 58 firms over the period 2000-2002, we find that stock returns clearly lead both CDS and bond spread changes from the same firm. Furthermore, CDS spread changes Granger cause bond spread changes for a higher number of firms than vice versa which confirms results from related studies. A cointegration analysis of CDS and bond spreads and a corresponding vector error correction model reveal that the CDS

[1] See European Central Bank (2004), Fitch Ratings (2003), British Bankers' Association (2002) for an overview.

market mainly contributes to price discovery which is in line with Blanco, Brennan, and Marsh (2004).

On the other hand, we extend related work in the following two ways. First, note that our data set is richer because it covers a larger number of firms, a longer time-period, and observations from US and non-US underlyings. Second, we investigate a couple of new issues. It turns out that the strength of lead-lag relationships statistically depends on the average credit rating of the firm but not on its size. Moreover, we find that the contribution to price discovery of the CDS market relative to the bond market is substantially stronger for US than for non-US reference entities. Finally, the result that Granger causality of the CDS market for the bond market (and not vice versa) prevails can be detected for firms with and without cointegrated credit spreads.

These findings contribute to research on market efficiency and might be useful for market participants who rely on price data from different markets for trading, monitoring, or hedging against credit risk [see, e.g., Berndt et al. (2004) who compare the implied default risk in CDS spreads and Moody's KMV's EDFs]. In addition, regulators increasingly pay attention to the evolution of markets for credit risk transfer, investigating the opportunities from an improved risk allocation in the financial system and threats from a potential increase in systemic risk.[2] Moreover, for the first time, the Basel Committee on Banking Supervision (2004) has provided a proposal that explicitly recognizes the risk reducing effect of credit risk transfer instruments like CDS in a new capital adequacy framework for banks.

The remainder of the paper is organized as follows. In Section 2, we briefly review the literature on the empirical relationship between market prices of different claims for the same firm and propose a set of hypotheses. Section 3 describes the data set and presents descriptive

[2] See European Central Bank (2004), Deutsche Bundesbank (2004), and Bank for International Settlements (2003). Since July 2003 the Reserve Bank of Australia regularly publishes CDS spreads as complementary indicators of credit risk, see Arsov and Gizycki (2003).

statistics. In Section 4, we analyze lead-lag relationships, the strength of the intertemporal comovement and the adjustment process between CDS and bond spreads. The paper concludes with Section 5.

2. Overview of related literature and hypotheses

Before turning to the analysis, we briefly review the empirical literature that relates to our following three research questions and propose a set of hypotheses:

a) What is the relationship between CDS, bond and stock markets at the firm-level? In particular, can we detect lead-lag relationships?

b) If lead-lag relationships exist, what is their strength and which factors affect their magnitude?

c) How do CDS and bond markets contribute to price discovery?

Research on question a) deals with the contemporaneous and intertemporal comovement of stock and corporate bond markets and, since recently, the CDS market. Note that earlier studies are based on portfolio performance data at a relatively low frequency [see, e.g., Blume, Keim and Patel (1991), Cornell and Green (1991)]. For example, Fama and French (1993) investigate which risk factors are able to explain monthly returns of stock and corporate bond portfolios in the period 1963-1991. They identify three stock-market factors (overall excess market return, firm size, and book-to-market equity ratio) and two bond-market factors (term structure spread, default risk spread) whereas the two bond-market factors establish the link between both markets. All five factors seem to explain the common contemporaneous variation in bond and stock returns and the cross-sectional average returns reasonably well.

Subsequently, academics began to analyze the bond-stock market relationship at the individual firm-level, in a lead-lag framework, and with data from a higher frequency (weekly, daily, hourly). For example, Kwan (1996) runs pooled and individual time-series regressions to explain weekly changes of corporate bond yields with changes of same-maturity treasury yields and contemporaneous, leading and lagging stock returns. Main results are that changes of treasury yields have a significant positive impact whereas contemporaneous and lagged stock returns have a significantly negative impact on bond yield changes. These results are interpreted as evidence for the hypothesis that individual bond and stock prices are driven by firm-specific information that is related to the expected value of the firm's assets rather than to the volatility of the firm's asset returns. Additionally, firm-specific-information seems to be embedded first into stock prices because lagged stock returns have significant impact on bond yield changes whereas lagged bond yield changes have neither statistical nor economic impact on current stock returns.

Alexander, Edwards, and Ferri (2000) investigate the relationship between daily stock and high-yield bond returns at the individual firm-level during the period 1994-1997. Relying on different regression models, they find a significantly positive but economically weak correlation between daily high-yield bond returns and firms' stock excess returns. In addition, they look at the bond-stock return relationship around wealth transferring events. Essentially, they detect a negative comovement around these events and a positive one in other periods. This result is interpreted as one possible explanation for the low time-series correlation between stock and bond returns.

Hotchkiss and Ronen (2002) analyze the informational efficiency of the high yield corporate bond market using daily and hourly price data from the year 1995. Applying a vector autoregressive (VAR) model, they do not find support for the view that stock portfolio returns lead bond portfolio returns. However, they detect a significantly positive but economically weak contemporaneous correlation between stock and bond returns which is, however, judged as non-causal. Since a comparative analysis of pricing errors indicates that market quality is not poorer for bonds, they conclude that the considered bond market sample is informationally efficient, even relative to the stock market. However, it is not clear whether these results would hold for firms from the investment-grade level as well.

Longstaff, Mithal, and Neis (2003) examine weekly lead-lag relationships between CDS spread changes, corporate bond spreads and stock returns of US firms in a VAR framework. They find that both stock and CDS markets lead the corporate bond market which provides support for the hypothesis that information seems to flow first into stock and credit derivatives markets and then into corporate bond markets. However, in their sample there is no clear lead of the stock market with respect to the CDS market and vice versa.

Given this literature, we propose the following hypotheses concerning the intertemporal relationship between the stock, bond and CDS market:

> H1: Positive stock returns are associated with negative CDS spread changes and negative bond spread changes. [3]

As stated by Kwan (1996), we expect that stock and bond prices move in the same direction when new information relates to the expected firm value. If the latter rises due to unexpectedly high earnings, the stock price will go up because stockholders will benefit from improved earnings and the price (yield to maturity) of corporate debt will rise (fall) because default risk is reduced. Note that this inverse relationship between stock returns and credit spread changes is consistent with studies that have analyzed the determinants of credit spreads [see, e.g., Collin-Dufresne, Goldstein, and Martin (2001), Aunon-Nerin et al. (2002), Blanco, Brennan, and Marsh (2004), Avramov, Jostova, and Philipov (2004)].

> H2: The stock market and the CDS market lead the bond market.

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[3] Alternatively, Kwan (1996) argues that positive stock returns may be associated with positive CDS and bond spread changes when new information relates to the volatility of the firm's asset return. A firm's equity can be interpreted as a call long on the firm value, corporate debt can be interpreted as a combined position of a default-free bond long and a put short on the firm value. Since equity and corporate debt are long and short positions in options that relate to the value of the firm, their prices should move in opposite directions with respect to volatility changes. However, Kwan cannot provide empirical evidence for this volatility-based reasoning.

In an intertemporal setting, we expect the stock market to lead the bond market for the following reasons. First, there is some prior empirical evidence which suggests that information is reflected earlier in the stock than in the bond market [see Kwan (1996), Longstaff, Mithal, and Neis (2003)]. Second, institutional features of the stock market facilitate a continuous flow of transactions which is not the case in the bond market where short positions are more difficult to establish. Third, the number of traders, trades and the trading volume is clearly higher in the stock market than in the corporate bond market. The CDS market is also expected to lead the bond market because of the first two arguments mentioned above.

With regard to question b) which refers to the magnitude of the market comovement, we state the following hypotheses:

> H3: The link between the CDS and the stock market is stronger than the link between the bond and the stock market.

In the CDS market pure issuer credit risk is traded whereas in the bond market issue-specific credit risk and market risk are traded in a bundle. Accordingly, hypothesis H3 states that CDS spread changes should exhibit a stronger sensitivity to stock returns than bond spread changes. First empirical evidence is provided by Blanco, Brennan, and Marsh (2004). They follow Collin-Dufresne, Goldstein, and Martin (2001) in analyzing the determinants of CDS spread changes and corporate bond spread changes and find that the impact of firm-specific stock returns is stronger on CDS spreads changes than on corporate bond spread changes.

> H4: The magnitude of the relationship between CDS/bond spread changes and stock returns positively depends on a firm’s creditworthiness.

CDS and bond spread changes from low-grade firms should exhibit a higher sensitivity to stock returns than those from high-grade firms. This relationship has been detected in earlier studies for bond spread changes and stock returns [see Blume, Keim, and Patel (1991), Cornell and Green (1991), Kwan (1996), Collin-Dufresne, Goldstein, and Martin (2001), and

Avramov, Jostova, and Philipov (2004)]. The underlying reasoning is as follows: equity bears the ultimate form of credit risk because it represents the most subordinated claim in the capital structure of a firm. Hence, CDS and bond spread changes from high risk firms should be linked more strongly to stock returns than those from low risk firms.

H5: The magnitude of the relationship between CDS/bond spread changes and stock returns negatively depends on a firm's size.

CDS and bond spread changes from relatively small firms should exhibit a higher sensitivity to stock returns than those from relatively large firms if size is related to default risk.

Finally, question c), i.e. the dynamic adjustment of firm-specific credit spreads from different markets (CDS, corporate bond), has been analyzed by Blanco, Brennan, and Marsh (2004) for a sample of 33 firms (16 from the US, 17 from Europe) from January 2001 to June 2002. The application of cointegration tests to CDS and bond spread time series and results from a corresponding vector error correction model (VECM) reveal that price discovery takes predominantly place in the CDS market. In a similar study, Zhu (2004) examines the same question for a sample of 24 firms (hereof 19 from the US) during the period 1999-2002. According to this study, spread levels in both markets can considerably deviate from each other in the short run. The dynamic analysis reveals that both markets are strongly linked in the long-run. Interestingly, the CDS market plays a more important role in price discovery than the bond market in the case of US firms while the opposite holds for European firms. With respect to question c) we propose the following hypothesis:

H6: Price discovery takes mainly place in the CDS market.

This hypothesis can be substantiated by the following arguments. First, the CDS market is more flexible and less capital-intense because only premia but no bond prices have to be paid. Second, CDS traders can easily go long and short in credit risk (i.e. buy or sell protection) while shortening bonds is more difficult. Third, bond spreads from the secondary market depend on the available number and specifics of the outstanding bonds which is related to the new bond issue activity of the firms whereas the CDS market is more standardized (in terms of tenor, notional, currency etc.) and less dependent on primary bond market issuances.

3. Description of the data

3.1. Data collection, treatment and final composition

We collect data on CDS, stock and corporate bond markets, risk free interest rates and individual firm characteristics. CDS data are provided by a large European bank which is among the world's top 25 credit derivatives counterparties and by CreditTrade, a large CDS trading platform. It covers the time period July 2, 1998 to December 2, 2002 and includes CDS quotes and additional contractual information for more than 1000 reference entities (Corporates, Financials, and Sovereigns). CDS quotes are selected in the following manner: First, we exclude all quotes on sovereigns due to the lack of stock prices for these entities. Second, we calculate the mid spread from bid and offer quotes. Third, we take the mean per day if multiple mid spreads and/or transaction spreads were observed on a given day. Fourth, since the number of CDS price observations per firm is relatively low in 1998 and 1999, we select all firms with at least 100 daily senior CDS price observations for a maturity of five years in each of the years 2000-2002.[4] This selection procedure leads to a sample of 90 firms from Europe, the United States, and Asia. We then add time-series of daily common stock closing prices and the corresponding total return indices obtained from Thomson Financial Datastream.

Furthermore, we examine outstanding corporate debt of these 90 firms using Bloomberg data. We apply the following filter rules to obtain a sample of suitable corporate bonds: (1) bonds are issued with a fixed coupon and are non-callable, non-puttable and not convertible,

[4] The five-year maturity represents the benchmark in the CDS market, see British Bankers' Association (2002).

(2) bonds are quoted in US-Dollar, Pound Sterling or Euro, (3) bonds rank senior unsecured (required seniority for deliverable assets according to the ISDA Master Agreement for CDS), (4) bond price time series exist during 2000-2002 and indicate liquid trade (matrix priced bonds were excluded). In addition to generic mid-market closing bond prices and yield to maturities, we gathered bond characteristics like ISIN, issue and maturity date, coupon, notional, currency, payment frequency, day convention and first coupon day.

Moreover, we collect daily default-free interest rate term structures. Although government bond yield curves seem to be the first choice, we also consider interest rate swap curves for USD, GBP and EUR since related studies provide evidence that swap rates might be the more appropriate benchmark [see, e.g., Houweling and Vorst (2002)]. Government bond yield curves come from the Federal Reserve Board's, the Bank of England's and Deutsche Bundesbank's web page. Additionally, we obtain a synthetic EUR yield curve from the Statistical Office of the European Communities (EuroStat). Interest rate swap curves are taken from Thomson Financial DataStream. Since daily CDS spreads refer to a constant maturity (usually 3, 5, 7, 10 years with 5 year as benchmark), we have to compare these spreads with constant maturity bond spreads. As constant maturity bond spreads are not observable, we create, if the corresponding bond data are available, a synthetic five-year constant maturity bond spread for each firm by linearly interpolating the daily yields of two actual bonds with maturity above and below five years and subtract the five-year default-free interest rate.[5]

The data are completed with individual firm characteristics (market capitalization in local currency and Euro, region, industry code) from Thomson Financial DataStream. Additionally, histories of credit ratings from Moody's (issuer rating, senior unsecured), Standard & Poor's

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[5] See Hull, Predescu, and White (2003), Blanco, Brennan, and Marsh (2004) and Longstaff, Mithal, and Neis (2003, 2004) for a similar methodology. Longstaff, Mithal, and Neis (2004) point out that this model-independent approach, if used for pricing issues, may underestimate the default risk in investment-grade bonds and overestimate it for below-investment-grade bonds.

(long term foreign currency issuer credit) and Fitch Ratings (senior unsecured, long term foreign currency debt) are taken from Bloomberg.[6]

The final data set consists of 58 firms[7] with observations from the years 2000-2002 (see Appendix A for the sample composition). It covers 70% of the world's top 20 most actively traded corporate reference entities in terms of frequency of occurrence [see Fitch Ratings (2003)]. 35 of the 58 firms (=60%) come from Europe, 20 from the USA (=35%) and 3 from Asia (=5%). The most important industries are financials (=31%), telecommunication (=14%) and automotive (=12%). Table 1 presents characteristics of the firms and bonds included in our final sample:

(insert Table 1 here)

Panel A reveals that both average firm size (measured by market capitalization in Euro) and average creditworthiness (measured by the rating) decline over the sampling period. The first observation is due to the overall baisse in the European and North American stock markets and, additionally for US firms, partially due to the development of the US Dollar-Euro exchange rate.[8] The deterioration of the firms' ratings reflects the rise of leverage and/or earnings problems in some industries (e.g. telecommunication or automotive). Panel B presents characteristics of 58 synthetic five-year constant maturity bonds which were created by interpolating, at least, one bond with maturity below five years and another with maturity above five years (see Appendix B for disaggregated bond characteristics). As can be seen,

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[6] We constructed two aggregated rating systems. The first was created by mapping agency credit ratings on a numerical 17 grade scale (AAA / Aaa = 1, AA+ / Aa1 = 2, ..., CCC / Caa1 and below = 17). The second, less fine, resulted from a mapping on a six grade scale (AAA /Aaa = 1, AA / Aa = 2, ..., B / B = 6).

[7] The decrease of the sample is due to the fact that 32 firms had to be dropped because their outstanding bonds did not meet our selection criteria.

[8] Starting from 1.01 USD/EUR on January 3, 2000 the value of the Euro declined down to 0.85 USD/EUR on June 29, 2001. The exchange rate recovered at the end of the sampling period reaching again the parity.

notionals of bonds below and above five years to maturity amount to roughly 0.5 billion EUR. Approximately 45% of the bonds are denominated in Euro and US dollar respectively and the remainder in Pound sterling.

3.2. Descriptive analysis of market data

We now shortly describe the market data, the time-series properties and analyze the contemporaneous link between markets with correlations.

Table 2 exhibits five-year senior CDS spreads (CDS) and five-year constant maturity bond spreads (BSS) over swap rates and government bond yields (BSG) by year and rating. There are several interesting aspects to be mentioned: First, looking at the rows, one can easily see that mean spreads are in line with the ordinal ranking by credit ratings. Second, looking at the columns, we find an increasing average spread per rating category over the sampling period for CDS and BSS. This observation may be due to the different population in each cell, the decline of swap rates, a deterioration of the average credit qualities within each grade, or due to a rise of the average risk premia [see Berndt et al. (2004) who find that risk premiums for a given probability of default vary considerably over time]. Third, and most important, looking at investment-grade spreads (AAA-BBB), we clearly see that CDS spreads are much closer to bond spreads above swap rates than spreads above government bond yields. The latter evidence confirms results of Houweling and Vorst (2002), Hull, Predescu, and White (2003) and Blanco, Brennan, and Marsh (2004). Since corporate bond spreads above swap rates are much closer to CDS spreads, we do not use corporate bond spreads above government yields for subsequent analyses.

(insert Table 2 here)

Figure 1 displays time series of daily cross-sectional means and medians of CDS and BSS over the entire sampling period. As indicated in Table 2, it can be seen that CDS and bond spreads were relatively close to each other in the years 2000 (CDS: 41 bps, BSS: 43 bps) and 2001 (CDS: 71 bps, BSS: 62 bps). On the one hand, since summer 2001, we observe a positive basis for mean spreads (CDS: 119 bps, BSS: 85 bps) which persists until the end of the sampling period (see Figure 1a). On the other hand, Figure 1b reveals that median spreads of CDS and corporate bonds remain quite close to each other although a small positive basis becomes visible.

(insert Figure 1 here)

In a next step, we examine time-series properties like stationarity and autocorrelation of the individual CDS, bond and stock time series. This is an important issue because if time-series are non-stationary and serially correlated, the usual OLS regression approach is no longer applicable. In particular, one might find a spurious (but not an economic) relationship between two variables. Table 3 summarizes results of three different stationarity tests[9] and displays autocorrelation coefficients for weekly/daily level and change data. Panel A reveals that the null hypothesis that level time-series (stock prices, CDS and BSS) are non-stationary (stationary) is rejected for a small (large) number of firms. For example, only one firm exhibits not a non-stationary daily stock price time-series according to the Phillips-Perron test. The opposite is found for daily time-series of stock returns and spread changes. In at least 54 of 58 cases the time-series of returns and first differences are no longer considered to be non-stationary. Panel B presents mean autocorrelation coefficients for weekly and daily data.

[9] Note that the Augmented Dickey-Fuller and the Phillips-Perron test have a null hypothesis of non-stationarity whereas the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test has a null hypothesis of stationarity. We consider tests with different null hypotheses to ensure that results are robust to the power of the tests.

Whereas autocorrelation of level time-series is typically high[10], it is relatively low for weekly and daily change data except for daily bond spread changes at lag 1 (-0.19). Since these results indicate that time-series of stock prices and spread levels are non-stationary and strongly autocorrelated while stock returns and spread changes are not, we subsequently focus on the latter variables.

(insert Table 3 here)

To get a first impression of the contemporaneous comovement of the three markets, we examine pairwise rank correlation of weekly and daily time-series at the firm-level. The corresponding results are summarized in Table 4. The mean rank correlation of weekly stock returns and CDS spread changes is -0.25 with 35 of 58 individual correlation coefficients being significantly different from zero at the 0.01-level. Interestingly, CDS spread changes exhibit a stronger negative correlation with stock returns than bond spread changes (-0.25 vs. -0.13). The difference between the means of $\rho_S(R, \Delta CDS)$ and $\rho_S(R, \Delta BSS)$ is significant at the 0.01-level when using a two-sided non-parametric Wilcoxon sign rank test or a simple t-test. Differentiating by the geographic origin of a firm, we find that stock returns of US firms exhibit a slightly stronger negative correlation with CDS than European firms. Furthermore, correlations get more pronounced for firms with a relatively bad credit rating at the beginning of our sampling period.[11] Looking at industries, we detect a much stronger correlation of stock returns from telecommunication firms with CDS and bond spread changes (-0.36, -0.23) than for other firms (-0.25, -0.08). Additionally, correlation of stock returns and CDS spread

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[10] Autocorrelation coefficients of levels decline from closely below 1.00 at lag 1 to 0.70-0.78 at lag 5 for weekly data and to 0.94 - 0.95 at lag 5 for daily data.

[11] An analysis based on a 17-grade-rating-scale reveals that this relationship is not a monotonous one. Moving from AA to A leads to a more pronounced correlation, but moving from A to BBB reduces the correlation. This observation might be due to a small number of observations in some grades.

changes for financials is higher than for non-financial firms. Similar results are found for the correlation of daily changes.

(insert Table 4 here)

4. Analysis of the intertemporal relationship between markets

4.1. Lead-lag relationships between CDS, bond and stock markets

In this section, we analyze the intertemporal comovement of CDS spread changes, bond spread changes and stock returns for each firm in the sample. More specifically, we try to explain current stock returns, CDS spreads changes and bond spread changes with a three-dimensional vector autoregressive model [see, e.g., Stock and Watson (2001), Gujarati (2003) for an overview]. We think that a VAR approach is appropriate for our purpose because it has exactly been developed to capture lead-lag relationships within and between stationary variables. Moreover, it represents a simultaneous equation estimation. Therefore, we do not have to estimate single equation distributed models that include lags and leads[12] because a VAR model entirely captures the intertemporal relationships simultaneously. Our basic model specification is the following:[13]

[12] Kwan (1996) estimates a single-equation model with contemporaneous bond yield changes as dependent and contemporaneous stock returns as well as its leads and lags as independent variables. We avoid including leading variables on the right-hand side of the model because their impact is difficult to interpret in terms of (Granger-) causality [see Gujarati (2003), p. 712-713].

[13] Note that our analysis differs from Longstaff, Mithal and Neis (2003) with regard to the following three aspects: i) they analyze weekly data, we examine daily and weekly data, ii) their sample is confined to US firms, our data set is an international one, iii) they calculate bond spreads above US Treasury bond yields, we consider swap rates as default-free benchmark rate.

$$R_t = \alpha_1 + \sum_{p=1}^{P} \beta_{1p} R_{t-p} + \sum_{p=1}^{P} \gamma_{1p} \Delta CDS_{t-p} + \sum_{p=1}^{P} \delta_{1p} \Delta BSS_{t-p} + \varepsilon_{1t}$$

$$\Delta CDS_t = \alpha_2 + \sum_{p=1}^{P} \beta_{2p} R_{t-p} + \sum_{p=1}^{P} \gamma_{2p} \Delta CDS_{t-p} + \sum_{p=1}^{P} \delta_{2p} \Delta BSS_{t-p} + \varepsilon_{2t} \quad (1)$$

$$\Delta BSS_t = \alpha_3 + \sum_{p=1}^{P} \beta_{3p} R_{t-p} + \sum_{p=1}^{P} \gamma_{3p} \Delta CDS_{t-p} + \sum_{p=1}^{P} \delta_{3p} \Delta BSS_{t-p} + \varepsilon_{3t}$$

with R_t: stock return in t, ΔCDS_t: CDS spread change in t, ΔBSS_t: change of a synthetic 5-year corporate bond spread in t, p: lag order index, ε_t: disturbance term in t.

Subsequently, we apply this model to weekly and daily time-series from the three markets at the individual firm-level. The analysis of weekly data is carried out to allow for comparability with related studies. In addition, we focus on daily data because different markets may respond differently to new information in the short term but they are likely to align after some days. For the above model specification, the lag structure and the maximum lag order P has to be determined given the trade off between over-parameterization (and the corresponding loss of degrees of freedom) and over-simplification. Various methods, for example, the Akaike- or Hannan-Quinn-information criteria or step-wise likelihood-ratio tests, have been developed for this issue.[14] Either one follows these criteria[15] and selects the appropriate lag order accordingly and/or one relies on theoretical reasoning and, if available, prior empirical findings about the underlying economic relationships. Since the maximum lag order should capture the overall information processing and aggregation time in each of the three markets, we think that a lag structure without gaps and a maximal lag of order 2 seems reasonable for weekly

[14] The objective of these information criteria is to optimize the overall model's ability to fit the observed time-series as accurately as possible. For this purpose, the variance of the residuals is minimized, but any additional inclusion of further lagged variables is penalized by an increase of this variance.

[15] For weekly (daily) data the Akaike information criterion suggests a lag order of 2 (4), the Hannan-Quinn criterion one of 1 (2) and a likelihood-ratio test one of 3 (9). Numbers are medians of the individual criteria from all 58 firms.

data[16] and one of order 5 (spanning lag 1 for weekly data) should be appropriate for daily data.

Table 5 reports model estimation results for the individual firms with weekly (Panel A) and daily data (Panel B). For weekly data[17] and lags 1-2, the R^2 and the p-value from a F-test indicate that stock returns are the least forecastable and bond spread changes the most forecastable variable. Columns 3, 6 and 9 display the number of coefficients that are significantly different from zero at the 0.01-level.[18] We report the number of cases in which the coefficients are jointly different form zero [Granger-causal, see Granger (1969)] in columns 4, 7 and 10. Whereas lagged CDS and bond spread changes have little impact on stock returns, the latter significantly lead CDS spread changes in 19 of 58 cases at the 0.01-level. Note that the relationship is negative for all firms which provides clear evidence in favor of hypothesis H1.[19] In addition, the CDS market seems to lead the bond market at lag order one in 23 of 58 cases. Note that both the frequency of a significant impact and the magnitude of the median coefficient tends to decline if one moves from lag 1 to lag 2 in most of the cases. Summing up, these findings are support for hypothesis H2.

Furthermore, there is clear indication that the residuals of each equation come from a white noise process on the basis of a Ljung-Box test (including lags 1-8). Additionally, applying Bartlett's periodogram-based test the white noise property of the residuals cannot be

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[16] See Kwan (1996), Longstaff, Mithal, and Neis (2003) who include weekly lags of order 1 and 2.

[17] Stock returns and spread changes in table 5 refer to the Wednesday-Wednesday interval. To study the robustness of these results with regard to a potential day-of-the-week effect, we re-estimate the VAR model with observations from the intervals Monday-Monday, ..., and Friday-Friday. Results of each of the week-day intervals are very close to those reported in table 5. The average R^2 for the stock return equations across the five week-day intervals is 0.0507, for the ΔCDS equation 0.1011, and for the ΔBSS equation 0.1389. In addition, the number of firms that exhibit significant coefficients for lagged variables is very similar across the five week intervals.

[18] Note that our findings remain qualitatively the same if we adopt a significance level of 0.05 or 0.10 for the estimated regression coefficients and Granger causality tests.

[19] This result is consistent with the correlation analysis from Section 3.2 and Kwan (1996) who detects a negative relationship between stock returns and bond yield to maturity-changes for the same firms.

rejected for any of the firms. Overall, this analysis of residuals indicates that OLS assumptions are respected.

(insert Table 5 here)

Panel B reports the median coefficients and the number of coefficients that are significantly different from zero at the 0.01-level for the daily VAR model with lags 1 to 5. Interestingly, we obtain qualitatively similar results as for the weekly data. The number of firms whose lagged CDS and bond spread changes significantly explain contemporaneous stock returns is relatively low and median coefficients are close to zero. In contrast, lags 1-5 of stock returns Granger cause CDS spread changes from 39 of 58 firms. Note that, as found for weekly data, the relationship is negative, which is consistent with H1, and the magnitude of the median coefficient and the number of significant coefficients of lagged stock returns decreases as the lag order ascends. Bond spread changes are predictable with past CDS spread changes (lags 1-5 are jointly significant or Granger causal for 33 of 58 firms) and, for a smaller number of firms, with lagged stock returns. Again, the economic impact of the stock market on bond spreads tends to decline if the lag length increases. With regard to the intertemporal relationship between CDS and bond spread changes, Granger causality tests for a 0.01-level of significance reveal that i) ΔCDS cause ΔBSS but not vice versa at 18 firms, ii) ΔCDS cause ΔBSS and vice versa at 15 firms, iii) ΔBSS cause ΔCDS at 4 firms and iv) neither ΔCDS cause ΔBSS nor vice versa at 21 firms. While there is reciprocal Granger causality for a considerable number of firms, we find that the one-way impact of lagged ΔCDS on ΔBSS is observed more often than the opposite relationship. Similarly to weekly data, the fraction of variance explained and the number of firms with very low F-test p-values is smallest for the stock market and highest for the bond market equation. Hence, results for daily data represent support for H2 too.

Finally, as done for weekly data, we check whether the residuals from the three equations respect the underlying regression assumptions. On the one hand, applying a Ljung-Box test, we find that residuals from the stock return equation come predominantly from a white noise process whereas those from the CDS and BSS equation are not considered as white noise for a considerable number of firms. On the other hand, according to Bartlett's test, we cannot reject the hypothesis that residuals come from a white noise process for any firm. Overall, we deem the results in line with OLS assumptions.

For robustness purposes, we examine additional issues that may influence the results obtained from the VAR model in the remainder of this section. First, we investigate whether the observed lead-lag relationships are influenced by asynchronous price observations. Since previous findings suggest that the stock market leads both other markets, but stock prices do not exactly refer to the same point in time as CDS spreads and bond spreads, we repeat our analyses for stock returns that are lagged by one day to explicitly favor both other markets. Essentially, results are very close to those obtained previously: Even stock returns lagged by one day are the least forecastable and bond spread changes remain the most forecastable variable.

Second, we include the contemporaneous change of the five-year swap rate as exogenous variable in the VAR model to control for changes in the interest rate level that may influence both stock returns and spread changes. Overall, for daily (weekly) data we find a significantly positive but economically small impact of contemporaneous swap rate changes on stock returns for 48 (35) firms and a significantly negative impact on ΔCDS for 18 (25) firms and

ΔBSS for 48 (38) firms.[20] More important, previous results (number of significant coefficients, magnitude of coefficients, Granger causality) do not change much in the sense that stock returns remain the least predictable variable (median R^2=0.0704) and bond spread changes the most predictable variable (median R^2=0.2528).

Third, we check whether our findings remain robust if we control for changes in the implied equity volatility which represents an important determinant of credit spreads [see Collin-Dufresne, Goldstein, and Martin (2001)]. Since we do not have data about firm-specific equity volatilities, we include contemporaneous and lagged changes of CBOE's implied volatility index (VIX) as exogenous variable in the VAR model.[21] Essentially, most of the previously found lead-lag relationships turn out to be robust with regard to the inclusion of the volatility measure. The estimated coefficients are significantly negative at the 0.01-level for 50 firms (lag 1: 36) in the stock return equation, significantly positive for 26 firms (lag 1: 14) in the ΔCDS equation, and significantly positive for 8 firms (lag 1: 17) in the ΔBSS equation. In contrast to Table 5, the median-R^2 for stock returns (0.1603) becomes higher than that for the two other markets which may be a consequence of the close connection between stock returns and volatility. However, as found earlier, ΔCDS remains less forecastable (median-R^2=0.1182) than ΔBSS (median-R^2=0.1567).

Fourth, the VAR model is estimated separately with data from the first and second half (Jan 2000 – Jun 2001, Jul 2001 – Dec 2002) of the sampling period to investigate whether our findings are stable over time. Basically, estimation results for the sub-periods are similar to those reported in Table 5. However, it is noteworthy that the leading role of the stock market in comparison to both other markets increases over time. Furthermore, the CDS market does

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[20] Note that the inclusion of lag 1 of the five-year swap rate change as additional exogenous variable does not alter this finding. The coefficients of lagged swap rate changes are insignificant for most of the firms.

[21] Although our sample includes European, US and Asian firms, we simplify the robustness check by relying only on the VIX index which reflects the implied volatility of S&P 500 stocks. The correlation between VIX and VDAX (volatility index for the German stock market index DAX) is 0.84 during the sampling period.

not lead the bond market in the first half but it clearly does in the second half, reflecting the on-going evolution of the CDS market. Finally, the variance explained increases over time in all markets without altering the finding that stock returns are the least and bond spread changes the most forecastable variable.

Summarizing, our findings suggest that there is a negative relationship between stock returns and CDS/bond spreads changes and that the first clearly lead the latter. In addition, it turns out that CDS spread changes are more frequently able to forecast bond spread changes than vice versa in recent years.[22] The latter result is in line with findings from Longstaff, Mithal and Neis (2003). However, in opposite to that study, we find a definite lead of the stock market relative to the CDS market. One reason for this difference may be the sample composition: while Longstaff, Mithal, and Neis (2003) exclusively analyze US firms, we examine an international sample with 35 of 58 firms coming from Europe. If the CDS market for US reference entities is more developed than for European firms, which is not implausible, results can be reconciled. This issue will be addressed in more detail in section 4.3.

4.2. The strength of the intertemporal comovement

Having investigated the existence and the direction of lead-lag relationships between markets so far, we now examine the magnitude of the previously estimated coefficients to test hypotheses H3, H4 and H5.

An analysis of the sensitivity of the CDS and bond spread changes to the lagged stock returns indicates that the CDS market is significantly more sensitive to stock returns than the bond market (weekly data: -15.62 vs. –5.93, daily data: -14.67 vs. -9.27) which represents support for H3 and is in line with findings from Blanco, Brennan, and Marsh (2004). Applying a non-parametric Wilcoxon sign rank test to the difference of $\beta_{2,\, t-1}$ and $\beta_{3,\, t-1}$ shows that

[22] This result is confirmed in a two-dimensional VAR model which only includes ΔCDS and ΔBSS.

$\beta_{2, t-1}$ is significantly smaller (in absolute terms higher) at the 0.01-level for weekly data and at the 0.05-level for daily data.[23] The difference becomes significant at the 0.01-level for daily and weekly data if we compare the firm-specific sum of the significant lag coefficients.

Moreover, as stated in hypotheses H4 and H5, we investigate whether the magnitude of the coefficients $\beta_{2, t-p}$ und $\beta_{3, t-p}$ is related to a firm's creditworthiness and size. With respect to the first issue, we compare the firm-specific coefficients with the duration-weighted 17-grade rating scale. Results for all firms and daily data are plotted in Figure 2.

(insert Figure 2)

It can be seen that the estimated sensitivity of ΔCDS and ΔBSS on lagged stock returns is negatively associated with a firm's average creditworthiness. However, while this relationship is quite pronounced for the CDS market[24], indicated by a rank correlation coefficient of -0.46 that is significant different from zero at the 0.01-level, it is not significant for the bond market at all. Note that this result also holds for the sum of significant coefficients and for the sub-sample of firms that exhibit coefficients that are significant at the 0.01-level. These findings provide partial evidence in favor of H4 since the hypothesized relationship has been found for the CDS but not for the bond market. Repeating the same kind of analysis for firm size, we note a positive but insignificant relationship between the magnitude of $\beta_{2, t-p}$ und $\beta_{3, t-p}$ and firm size (market capitalization in EUR or log market capitalization). This result leads to a rejection of H5 because the expected influence of a firm's size is not significant.

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[23] The difference is significant at the 0.01-level if we compare the firm-specific sum of the significant coefficients of all lags for weekly and daily data.

[24] See Norden and Weber (2004) for related, event-study based evidence. They find that both the CDS and the stock market react more strongly to negative rating announcements for firms with a relatively bad "old" rating than for firms with a relatively good "old" rating.

To study the impact of potential determinants of spread sensitivities in a multivariate setting, we estimate two cross-sectional regressions with $\beta_{2,\,t-1}$ and $\beta_{3,\,t-1}$ as dependent variables respectively and the duration-weighted rating, the firm size, and dummy variables that mark telecommunication firms, financial firms and region as independent variables. Essentially, results indicate a significantly negative impact of the rating, the telecommunication dummy and the US dummy variable on the dependent variable $\beta_{2,\,t-1}$ (R^2=0.42). With regard to the sensitivity of the contemporaneous bond spread changes $\beta_{3,\,t-1}$ on lagged stock returns, we only observe a significantly negative impact of the US dummy variable (R^2=0.24).

4.3. Adjustment process between CDS spreads and bond spreads

In the remainder, we extend our previous analysis with a test of hypothesis H6. Since two related studies have shown that CDS spreads and corporate bonds spreads from the same firm are not uncommonly cointegrated [see Blanco, Brennan, and Marsh (2004) and Zhu (2004)], we take a closer look at the intertemporal relationship between these two kinds of spreads and leave the stock market aside.

The existence of a cointegration relationship between the levels of two non-stationary variables means that a linear combination of these variables is stationary and should be explicitly taken into account in an VAR-analysis of change data [see Engle and Granger (1987), p. 259]. Cointegrated variables move together in the long run but may deviate from each other in the short run (see Figure 1) which can be interpreted as a permanent adjustment process towards an economic equilibrium. A model that considers this adjustment process is called a vector error correction model (VECM) and corresponds to a vector autoregressive model that is augmented by an error correction term. The two-dimensional VECM is specified as follows:[25]

[25] In the remaining analysis we essentially follow Blanco, Brennan, and Marsh (2004).

$$\Delta CDS_t = \alpha_1 + \lambda_1 Z_{t-1} + \sum_{p=1}^{P} \beta_{1p} \Delta CDS_{t-p} + \sum_{p=1}^{P} \gamma_{1p} \Delta BSS_{t-p} + \varepsilon_{1t}$$

$$\Delta BSS_t = \alpha_2 + \lambda_2 Z_{t-1} + \sum_{p=1}^{P} \beta_{2p} \Delta CDS_{t-p} + \sum_{p=1}^{P} \gamma_{2p} \Delta BSS_{t-p} + \varepsilon_{2t} \qquad (2)$$

$$with \quad Z_{t-1} = CDS_{t-1} - \alpha_0 - \beta_0 BSS_{t-1}$$

Given the observation that CDS frequently exceed BSS (see Table 2), the coefficients λ_1 and λ_2 of the error correction term Z_{t-1} can be interpreted as follows. If the bond market contributes to the adjustment process, λ_1 will be significantly negative and if the CDS market contributes to the adjustment process, λ_2 will be significantly positive. In the case that both markets play a role, we expect both coefficients to be significant and signed as explained before. Subsequently, we first test whether there exists a significant cointegration relationship between CDS and BSS for each firm. Second, we estimate a VECM-model for all firms at which spreads are cointegrated and then interpret the coefficients of the error correction term. Main results from these to two steps are summarized in Table 6:

(insert Table 6 here)

Table 6 provides several interesting results concerning the adjustment process between CDS spreads and bond spreads. As reported in Panel A, we detect a significant cointegration relationship between the spreads for 36 of 58 firms.[26] It turns out that the share of firms with cointegrated spreads is higher among US firms (15/20=75%) than among European ones (20/35=57%) which is consistent with results from Blanco, Brennan, and Marsh (2004) and

[26] Analyzing another data set for a shorter period of time Blanco, Brennan, and Marsh (2004) discover cointegration of spreads at 27 of 33 firms. Zhu (2004) detects cointegration of spreads for 15 of 24 firms.

Zhu (2004). Analyzing the relative importance of the CDS and bond market for price discovery, we find that mean and median λ_1 is negative and λ_2 is positive for all firms. The Gonzalo-Granger measure [see Gonzalo and Granger (1995)], defined as $GG = \lambda_2 / (\lambda_2 - \lambda_1)$ with $\lambda_1 \neq \lambda_2$, indicates which of both markets contributes more to price discovery.[27] For all firms at which cointegration between spreads exists, the mean (median) of the GG-measure amounts to 0.69 (0.79) indicating that most of the price discovery occurs in the CDS market which provides empirical evidence in favor of hypothesis H6.[28] Differentiating across regions, it turns out that the CDS market plays a more important role for price discovery than the bond market for US reference entities (mean GG=0.84) than for European firms (mean GG=0.58). This difference is significant at the 0.05-level on the basis of a non-parametric Wilcoxon rank sum test. Note that results get more pronounced, in particular the difference between US and European firms, for the 21 firms at which cointegration is significant at the 0.01-level.

Panel B presents the number of significant coefficients and their sign for firms at which a cointegration of spreads cannot be rejected at the 0.10-level (0.01-level in brackets). Basically, these numbers confirm results of Panel A in the sense of statistical significance. We find that for 19 firms price discovery takes significantly place only in the CDS market and for additional 8 firms in the CDS and the bond market. In the case of 8 firms CDS spreads adjust to changes of the bond spreads.[29] Moreover, the exclusive contribution of the CDS market relative to the bond market is more frequently significant for US firms (10/15=67%) than for European firms (8/20=40%). In addition, we investigate whether the origin of the reference entity or the currency in which the bonds are denominated is better suited to summarize the

[27] If both coefficients are significantly different from zero, correctly signed and the GG-measure is equal to 0.5, both markets contribute to price discovery at the same degree. For GG=0 only the bond market contributes and for GG=1 only the CDS market contributes to price discovery.

[28] Blanco, Brennan, and Marsh (2004) find that the CDS market contributes roughly 80% of price discovery.

[29] See Zhu (2004). For a sample of 24 firms, it has been found that only the CDS market accounts for price discovery at 13 firms, only the bond market at 5 firms, and both markets at 5 firms.

adjustment behavior of spreads. We find that both variables are, as expected, highly correlated but that the origin of the firm and not the currency matters. For example, the spread adjustment process for Ericsson whose sampled bonds are denominated in USD, is more alike to other European firms than to US firms.

Figure 3 displays the error correction coefficients λ_1 and λ_2 for all firms with cointegrated spreads differentiating by the geographical origin of the firm. It is visible that the bond market considerably contributes to price discovery for European firms, while for US firms the CDS market is more important for price discovery than the bond market.

(insert Figure 3 here)

In addition to these findings, it is noteworthy that the fraction of variance explained in the two-equation-VECM is higher for ΔBSS (median R^2=0.1481) than for ΔCDS (median R^2=0.0814). Moreover, the R^2 of the VECM-equation with ΔCDS (ΔBSS) as dependent variable exhibits a significantly negative (positive) rank correlation with the GG-measure. In other words: the higher the fraction of variance explained is in the ΔBSS-equation, the closer the GG-measure is to one, indicating the leading role of the CDS market. However, although we have explicitly taken into account the cointegration of spreads, the model's ability to explain spread changes does not increase very much in comparison to the simpler VAR approach from Section 4.1.[30]

Finally, testing for Granger causality in the VECM leads to the following results for firms at which cointegration of spreads has been detected: i) ΔCDS cause ΔBSS (and not vice

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[30] For comparison purposes, we also re-estimate a modified version of the three-dimensional VAR model from Section 4.1 that additionally includes the error correction term Z_{t-1} in each of the three equations. Again, stock returns remain the least forecastable variable (median R^2=0.0388) and bond spread change the most forecastable variable (median R^2=0.1719). For the CDS equation we obtain a median R^2 of 0.1146. Testing the residuals for white noise produces similar results as for the VAR model from Section 4.1.

versa) for 10 firms, ii) ΔBSS cause ΔCDS (and not vice versa) for only 3 firms, iii) ΔCDS cause ΔBSS and vice versa for 11 firms and iv) neither ΔCDS cause ΔBSS nor vice versa for 12 firms. Applying the same tests to firms at which no significant cointegration of spreads has been found yield: i) ΔCDS cause ΔBSS (and not vice versa) for 8 firms, ii) ΔBSS cause ΔCDS (and not vice versa) at only 1 firm, iii) ΔCDS cause ΔBSS and vice versa at 4 firms and iv) neither ΔCDS cause ΔBSS nor vice versa at 9 firms. Obviously, there are no significant differences in Granger causality for firms with and without cointegrated spreads which indicate that results from Section 4.1 are robust.

5. Conclusion

In this paper, we investigate the empirical relationship between the heavily growing credit default swap (CDS), the corporate bond and the stock market at the firm-level for an international sample over the period 2000-2002. More specifically, we focus on the intertemporal comovement, in particular on lead-lag relationships and on the adjustment process between markets.

First, analyzing the firm-specific market comovement by means of a three-dimensional vector autoregressive model, we find that weekly and daily stock returns are negatively associated with CDS and bond spread changes. Second, stock returns are the least predictable and bond spread changes the most predictable variable which is in line with Longstaff, Mithal, and Neis (2003). Moreover, CDS spread changes Granger-cause bond spread changes for a considerably higher number of firms than vice versa. Third, the negative intertemporal relationship between the CDS and stock market is more pronounced than the one between the bond and stock market. Fourth, the sensitivity of the CDS market to prior stock market movements is significantly related to the firm's average creditworthiness but not to firm size. CDS spread changes from low-grade firms are more sensitive to lagged stock returns than those from firms with a relatively good rating. Interestingly, there is no such rating dependency for the sensitivity of bond spread changes to lagged stock returns. Fifth, for the majority of the sampled firms we detect cointegration of CDS and bond spreads. A vector error correction analysis reveals that the CDS market contributes more to price discovery than the bond market which is consistent with findings from Blanco, Brennan, and Marsh (2004). Whereas the adjustment process for European firms is more dispersed between both markets, it almost entirely takes place in the bond market in the case of US firms indicating the leading role of the CDS market. Finally, a comparison of Granger causality tests for firms with and without cointegrated spreads confirms that in both groups CDS spread changes Granger cause bond spread changes for a higher number of firms than vice versa.

Although our empirical analysis is somehow limited due to data imperfections and methodological issues, we think it essentially captures the relationship between the three markets and basically confirms findings from related studies. Besides the need for a larger international data set, and if available transaction prices instead of quotes, further research should consider institutional features of the CDS market (credit events, settlement terms, currency etc.) and their influence on the relationship of CDS spreads to prices of other credit risk sensitive claims for the same firm. Moreover, a corresponding study without the stock market analysis, could be carried out for a sample of sovereign reference entities which represent the most liquid segment of the CDS market. Furthermore, as the CDS market appears to be a more flexible place for price discovery than the bond market, it would be interesting to analyze the informational efficiency of the CDS market in critical times which could be defined by pronounced increases in the implied equity volatility of a specific firm, an industry, or the general market. Finally, another promising avenue for research is to decompose CDS and bond spreads in default and non-default components and compare their dynamics across markets [for a first investigation see Longstaff, Mithal, and Neis (2004)].

Appendix A: Sample composition and median CDS spreads by year

		Median CDS spreads			No. of obs.
No.	Firm	2000	2001	2002	
1	COMMERZBANK AG	13	22	32	636
2	DRESDNER BANK AG	12	18	18	731
3	VOLKSWAGEN AG	26	35	45	739
4	DEUTSCHE BANK AG	12	20	26	650
5	IBERDROLA SA	26	30	39	742
6	SOCIETE GENERALE	13	18	22	740
7	RENAULT SA	44	67	100	700
8	TOKYO ELECTRIC POWER CO	10	20	32	538
9	TOYOTA MOTOR CORP	10	22	20	564
10	KOREA DEVELOPMENT BANK	112	122	73	654
11	KON PHILIPS ELECTRONICS NV	31	55	87	739
12	VOLVO AB	-	90	73	363
13	MERRILL LYNCH & CO INC	35	45	78	739
14	CITIGROUP INC	23	32	40	703
15	ALTRIA GROUP	110	85	110	741
16	MORGAN STANLEY DEAN WITTER & CO	29	49	59	735
17	GOLDMAN SACHS GROUP INC	36	52	62	757
18	TELEFONICA SA	43	89	106	750
19	FRANCE TELECOM SA	43	146	369	761
20	BNP PARIBAS SA	13	18	19	655
21	BT GROUP - BRITISH TELECOM	37	105	96	759
22	NATIONAL GRID GROUP PLC	26	41	59	742
23	SAINSBURY J LTD	-	33	31	338
24	IMPERIAL CHEMICAL INDUSTRIES PLC	44	96	139	678
25	INVESTOR AB	26	35	80	690
26	ERICSSON AB	22	162	599	722
27	BANK OF AMERICA CORP	27	36	40	712
28	FORD MOTOR CREDIT CO	43	95	251	692
29	SANPAOLO IMI SPA	16	20	23	709
30	WELLS FARGO & CO	26	28	31	641
31	WALT DISNEY CO	21	33	83	678
32	LEHMAN BROTHERS HOLDINGS INC	65	71	73	734
33	BEAR STEARNs INC	57	73	69	731
34	GENERAL MOTORS ACCEPTANCE CORP	39	95	175	705
35	PEARSON PLC	55	59	96	637
36	MARKS & SPENCER PLC	28	55	45	739
37	ENDESA SA	26	35	48	704
38	DEUTSCHE TELEKOM AG	43	115	251	750
39	HOUSEHOLD FINANCE CORP	60	77	185	719
40	BOEING CORP	19	28	63	710
41	IBM CORP	21	42	57	689
42	CARREFOUR SA	26	29	29	739
43	REPSOL YPF SA	27	53	353	730
44	KPN NV	43	245	234	756
45	DAIMLERCHRYSLER AG	27	125	142	746
46	FIAT SPA	41	100	401	759
47	LOCKHEED MARTIN CORP	72	74	73	710
48	TOTALFINAELF SA	19	18	23	715
49	VODAFONE GROUP PLC	42	66	94	761
50	UNITED UTILITIES PLC	63	55	50	588
51	COX COMMUNICATIONS INC	75	121	303	539
52	BANK ONE CORP	35	54	39	729
53	DEERE & CO	34	54	72	692
54	HILTON HOTELS CORP	-	175	290	494
55	KONINKLIJKE AHOLD NV	59	51	85	705
56	BRITISH AMERICAN TOBACCO PLC	85	60	65	687
57	LAFARGE SA	44	65	78	675
58	BANCO SANTANDER CENTRAL HISPANO	13	29	40	708

Appendix B: Characteristics of the corporate bonds

This table presents main characteristics of corporate bonds with a maturity of five years or below during the sampling period which were selected to construct the synthetic five year constant-maturity bond.

No.	Issuer	ISIN	Bloomberg no.	Currency	Notional	Coupon	Issue date	Maturity date	Payment frequency	Convention
1	Commerzbank	DE0003922399	EE1554133	DEM	50.000,00	8,000	11.10.94	11.10.04	A	ISMA 30/360
2	Dresdner Finance B.V.	DE0004132253	TT3177884	EUR	511.291,88	6,250	11.03.94	11.03.04	A	Act/Act
3	Volkswagen Int Fin	DE0004104708	TT3147234	DEM	1.000.000,00	7,000	26.05.93	26.05.03	A	ISMA 30/360
4	Deutsche Bank	DE0003040465	EC1242139	EUR	500.000,00	3,500	28.04.99	28.04.04	A	Act/Act
5	Iberdrola Intl.	XS0106975229	EC2304441	EUR	25.000,00	5,510	27.01.00	27.01.05	A	Act/Act
6	Societe Generale	FR0100786120	FF1037291	EUR	76.224,51	6,500	15.03.95	15.03.04	A	Act/Act
7	Renault SA	XS0048887409	TT3174113	FRF	2.000.000,00	6,250	02.03.94	02.03.04	A	ISMA-30/360
8	Tokyo Electric Power Co	XS0095626569	EC1116507	EUR	750.000,00	4,000	24.03.99	24.03.04	A	Act/Act
9	Toyota Motor Credit Corp	XS0101844792	EC1777001	USD	250.000,00	6,750	30.09.99	30.09.04	A	ISMA 30/360
10	Korea Development Bank	US500630AY49	EC1248458	USD	1.000.000,00	7,125	22.04.99	22.04.04	SA	ISMA 30/360
11	Kon. Philips Electronics N.V.	US718448AC78	DD0020527	USD	250.000,00	7,750	14.04.94	15.04.04	SA	30/360
12	Volvo Treasury	XS0102706776	EC1849933	EUR	1.000.000,00	5,125	12.10.99	12.10.04	A	Act/Act
13	Merrill Lynch & Co.	XS0080348260	MM1295185	USD	500.000,00	6,750	24.09.97	24.09.04	A	ISMA 30/360
14	Citigroup Inc	US172967AW18	EC1178127	USD	750.000,00	5,800	31.03.99	15.03.04	SA	30/360
15	Altria Group Inc	US718154CH83	DD1107547	USD	500.000,00	7,500	07.04.97	01.04.04	SA	30/360
16	Morgan Stanley Dean Witter	US617446DE61	EC0890805	USD	2.000.000,00	5,625	20.01.99	20.01.04	SA	30/360
17	Goldman Sachs Group	US38141GAK04	EC2209640	USD	750.000,00	7,500	28.01.00	28.01.05	SA	30/360
18	Telefonica Europe B.V.	XS0118006377	EC2933116	EUR	1.000.000,00	6,125	21.09.00	21.09.05	A	Act/Act
19	France Telecom	FR0000583270	FF1023184	EUR	228.673,53	5,750	08.11.93	08.11.04	A	Act/Act
19	France Telecom	FR0000483653	EC3052106	EUR	1.000.000,00	6,125	10.11.00	10.11.05	A	Act/Act
20	BNP Paribas	XS0047262513	TT3169071	EUR	609.796,00	6,500	03.12.93	03.12.04	A	ISMA 30/360
21	British Telecom PLC	XS0045856316	TT3162233	GBP	500.000,00	7,125	15.09.93	15.09.03	A	ISMA 30/360
22	British Gas Intl Finance	XS0042735240	TT3140270	GBP	200.000,00	8,125	31.03.93	31.03.03	A	ISMA 30/360
23	J. Sainsbury PLC	XS0110680229	EC2494648	GBP	100.000,00	6,875	27.04.00	27.04.05	A	ISMA 30/360
24	ICI Investments BV	GB0004582788	ZZ2043995	GBP	100.000,00	10,000	15.04.86	15.04.03	A	ISMA 30/360
25	Investor AB	XS0096108120	EC1165249	EUR	400.000,00	4,250	13.04.99	13.04.06	A	Act/Act
26	Ericsson AB	XS0093071768	EC0749464	USD	300.000,00	5,188	10.12.98	10.12.03	A	ISMA 30/360
27	Bank of America Corp	US638585BJ73	EC0087048	USD	450.000,00	6,125	23.07.98	15.07.04	SA	30/360
28	Ford Motor Credit Co.	US345397SH76	EC1040772	USD	2.000.000,00	5,750	23.02.99	23.02.04	SA	30/360
29	San Paolo IMI	XS0109620640	EC2893583	EUR	15.000,00	5,450	31.03.00	31.03.05	A	Act/Act
30	Wells Fargo Company	US949746AA96	EC1616050	USD	1.500.000,00	6,625	28.07.99	15.07.04	SA	ISMA 30/360
31	Walt Disney Company	US254687AM80	TT3274467	USD	1.300.000,00	6,750	27.03.96	30.03.06	SA	30/360
32	Lehman Brothers Holdings Inc	US524908BZ26	EC1170801	USD	1.250.000,00	6,625	26.03.99	01.04.04	SA	30/360
33	Bear Stearns Co Inc	US073902BS60	EC2210960	USD	850.000,00	7,625	01.02.00	01.02.05	SA	30/360
34	General Motors Corp	US370442AX38	MM1353430	USD	500.000,00	6,250	29.04.98	01.05.05	SA	30/360
35	Pearson PLC	XS0052937587	TT3191133	GBP	125.000,00	9,500	04.10.94	04.10.04	A	ISMA 30/360
36	Marks & Spencer Finance	XS0091642354	EC0537158	GBP	50.000,00	6,160	16.10.98	17.10.03	A	ISMA 30/360
37	International Endesa BV	XS0085656600	MM1336922	USD	500.000,00	5,875	31.03.98	31.03.03	A	ISMA 30/360
38	Deutsche Telekom Int Fin	XS0113743289	EC2696911	EUR	2.250.000,00	6,125	06.07.00	06.07.05	A	Act/Act
39	Household Finance Corp	US441812FV10	DD1070158	USD	250.000,00	7,250	18.07.96	15.07.03	SA	30/360
40	Boeing Corp	US097023AL95	DD5296247	USD	300.000,00	6,350	21.06.93	15.06.03	SA	30/360
41	IBM Corp	XS0095989793	EC1178002	USD	160.000,00	5,100	08.04.99	08.04.03	SA	ISMA 30/360
42	Carrefour SA	XS0100126431	EC1596823	EUR	1.000.000,00	4,375	29.07.99	15.09.04	A	Act/Act
43	Repsol Intl Finance BV	XS0094812814	EC1008225	EUR	1.725.000,00	3,750	23.02.99	23.02.04	A	Act/Act
44	Koninklijke KPN NV	XS0099230715	EC1514891	EUR	1.250.000,00	4,000	30.06.99	30.06.04	A	Act/Act
45	DaimlerChrysler Intl Fin	DE0002849809	EC0879261	EUR	200.000,00	3,500	29.01.99	29.01.04	A	Act/Act
46	Fiat Finance & Trade	XS0095927504	EC1146298	EUR	1.000.000,00	3,750	31.03.99	31.03.04	A	Act/Act
47	Lockheed Martin Corp	US539821AL25	DD5284532	USD	300.000,00	6,750	18.03.93	15.03.03	SA	30/360
48	Total Fina Elf S.A.	DE0001930402	TT3341738	DEM	250.000,00	5,250	07.07.97	23.12.03	A	ISMA 30/360
49	Vodafone Finance BV	DE0003516605	EC1745487	EUR	2.500.000,00	4,875	08.09.99	08.09.04	A	Act/Act
50	United Utilities Water plc	XS0119256427	EC3060984	EUR	120.000,00	6,000	18.10.00	01.12.05	A	ISMA 30/360
51	Cox Communications Inc	US22404QAE89	MM1313574	USD	100.000,00	6,690	19.09.97	20.09.04	SA	30/360
52	Bank One Corp	US06422NCN49	EC1023521	USD	500.000,00	5,625	17.02.99	17.02.04	SA	30/360
53	Deere & Co	US244199AX30	EC1596062	USD	250.000,00	6,550	19.07.99	15.07.04	SA	30/360
54	Hilton Hotels Corp	XS0044959855	TT3140056	GBP	125.000,00	8,875	11.08.93	11.08.03	A	ISMA 30/360
55	Ahold Finance USA Inc	XS0112351662	EC2610268	EUR	1.500.000,00	6,375	08.06.00	08.06.05	A	Act/Act
56	BAT Intl Finance PLC	XS0096054282	EC1160182	EUR	1.500.000,00	4,250	14.04.99	14.04.04	A	Act/Act
57	Lafarge	FR0000495483	EC1532208	EUR	500.000,00	4,375	15.07.99	15.07.04	A	Act/Act
58	Santander Intl (C.I.)	DE0002310307	MM1351533	DEM	500.000,00	5,000	21.04.98	21.04.05	A	ISMA 30/360

Appendix B (continued):

This table presents main characteristics of corporate bonds with a maturity of more than five years during the sampling period which were selected to construct the synthetic five year constant-maturity bond.

No.	Issuer	ISIN	Bloomberg no.	Currency	Notional	Coupon	Issue date	Maturity date	Payment frequency	Convention
1	Commerzbank	DE0001848083	EC0980572	EUR	1.500.000,00	4,250	16.02.99	25.10.09	A	Act/Act
2	Dresdner Finance B.V.	XS0087184312	TT3420722	EUR	758.678,25	5,250	20.05.98	04.01.09	A	Act/Act
3	Volkswagen Int Fin	XS0142019479	EC5077994	EUR	1.000.000,00	5,375	25.01.02	15.01.12	A	Act/Act
4	Deutsche Bank	DE0002312857	TT3368392	EUR	1.224.284,87	5,000	30.04.98	04.01.09	A	Act/Act
5	Iberdrola Intl.	XS0097762065	EC1350411	EUR	600.000,00	4,500	25.05.99	25.05.09	A	Act/Act
6	Societe Generale	FR0100113937	FF1028019	EUR	49.545,93	6,800	19.03.96	19.03.07	A	Act/Act
7	Renault SA	FR0000495699	EC1556298	EUR	500.000,00	5,125	21.07.99	21.07.06	A	Act/Act
7	Renault SA	FR0000483083	EC2976081	EUR	500.000,00	6,375	19.10.00	19.10.07	A	Act/Act
8	Tokyo Electric Power Co	XS0096998561	EC1263309	EUR	1.000.000,00	4,375	14.05.99	14.05.09	A	Act/Act
9	Toyota Motor Credit Corp	US892332AH00	EC0784057	USD	300.000,00	5,500	14.12.98	15.12.08	SA	30/360
10	Korea Development Bank	US500630AM01	TT3278757	USD	750.000,00	7,250	22.05.96	15.05.06	SA	ISMA 30/360
11	Kon. Philips Electronics N.V.	US718448AB95	DD5305659	USD	250.000,00	7,250	24.08.93	15.08.13	SA	30/360
12	Volvo Treasury	FR0000109647	TT3342033	EUR	152.449,00	6,125	11.06.97	11.06.09	A	ISMA 30/360
13	Merrill Lynch & Co.	US590188JP48	EC1008209	USD	2.000.000,00	6,000	17.02.99	17.02.09	SA	ISMA 30/360
14	Citigroup Inc	US172967AX90	EC1178168	USD	750.000,00	6,200	31.03.99	15.03.09	SA	ISMA 30/360
15	Philip Morris Comp Corp	XS0099837832	EC1568996	USD	500.000,00	7,500	16.07.99	16.07.09	A	ISMA 30/360
16	Morgan Stanley Dean Witter	US617446AB59	US617446AB59	USD	100.000,00	10,000	28.06.88	15.06.08	SA	30/360
17	Goldman Sachs Group	US38141MMP31	EC1046498	USD	220.000,00	6,500	23.02.99	25.02.09	SA	30/360
18	Telefonica S.A.	ES0278430931	EC1141273	EUR	500.000,00	4,500	14.04.99	14.04.09	A	Act/Act
19	France Telecom	FR0000583288	FF1036368	EUR	914.694,10	5,750	07.02.97	25.04.07	A	Act/Act
19	France Telecom	XS0126164812	EC3574349	EUR	3.500.000,00	6,750	14.03.01	14.03.08	A	Act/Act
20	BNP Paribas	XS0089305469	EC0090984	EUR	600.000,00	5,625	07.08.98	07.08.08	A	ISMA 30/360
21	British Telecom PLC	XS0052067583	TT3189525	GBP	300.000,00	8,625	23.08.94	26.03.20	A	ISMA 30/360
22	British Gas Intl Finance	XS0044417375	TT3155062	GBP	250.000,00	8,875	08.07.93	08.07.08	A	ISMA 30/360
23	J. Sainsbury PLC	XS0132125112	EC4118245	GBP	300.000,00	6,500	11.07.01	11.07.12	A	Act/Act
24	ICI Investments BV	XS0079094891	MM1260221	GBP	300.000,00	7,625	21.08.97	21.08.07	A	ISMA 30/360
25	Investor AB	XS0088607931	MM1210358	EUR	300.000,00	5,250	30.06.98	30.06.08	A	Act/Act
26	Ericsson AB	XS0097717358	EC1349611	USD	500.000,00	6,500	20.05.99	20.05.09	A	ISMA 30/360
27	Bank of America Corp	US066050CV50	EC0984251	USD	1.500.000,00	5,875	08.02.99	15.02.09	SA	ISMA 30/360
28	Ford Motor Credit Co.	US345397SM61	EC1921211	USD	5.000.000,00	7,375	28.10.99	28.10.09	SA	ISMA 30/360
29	San Paolo IMI	IT0001211496	II1061961	EUR	258.228,00	5,390	16.03.98	17.03.10	A	Act/Act
30	Wells Fargo Company	EC0967645	EC0967645	USD	200.000,00	5,625	03.02.99	03.02.09	SA	30/360
31	Walt Disney Company	US25469HBD44	DD5314966	USD	125.000,00	5,800	27.10.93	27.10.08	SA	30/360
32	Lehman Brothers Holdings Inc	US52490BQ27	DD1126778	USD	250.000,00	7,200	19.08.97	15.08.09	SA	30/360
33	Bear Stearns Co Inc	US073902BR87	EC2041472	USD	800.000,00	7,625	07.12.99	07.12.09	SA	30/360
34	General Motors Corp	US370442AY11	MM1365079	USD	500.000,00	6,375	29.04.98	01.05.08	SA	30/360
35	Pearson PLC	GB0006777725	TT2007348	GBP	100.000,00	10,500	13.06.88	13.06.08	A	ISMA 30/360
36	Marks & Spencer Finance	XS0138137285	EC4710371	GBP	375.000,00	6,375	07.11.01	07.11.11	A	Act/Act
37	International Endesa BV	XS0095981972	EC1152171	USD	350.000,00	6,000	07.04.99	07.04.09	A	ISMA 30/360
38	Deutsche Telekom Int Fin	DE0002317807	TT3435043	EUR	2.000.000,00	5,250	20.05.98	20.05.08	A	Act/Act
39	Household Finance Corp	US441812GA63	EC0127471	USD	500.000,00	6,375	28.07.98	01.08.10	SA	30/360
40	Boeing Corp	US09700WAK99	MM1339926	USD	15.000,00	6,580	29.12.97	15.01.09	SA	30/360
41	IBM Corp	US45920QBX16	EC0890441	USD	100.000,00	5,500	15.01.99	15.01.09	SA	30/360
42	Carrefour SA	FR0000492282	EC1090496	EUR	1.000.000,00	4,500	18.03.99	18.03.09	A	Act/Act
43	Repsol Intl Finance BV	XS0110487062	EC2479870	EUR	1.175.000,00	6,000	05.05.00	05.05.10	A	Act/Act
44	Koninklijke KPN NV	XS0091945419	EC0591007	EUR	1.500.000,00	4,750	05.11.98	05.11.08	A	Act/Act
45	DaimlerChrysler Intl Fin	XS0126467124	EC3583522	EUR	2.500.000,00	6,125	21.03.01	21.03.06	A	Act/Act
46	Fiat Finance & Trade	XS0107525403	EC2237518	EUR	1.000.000,00	6,250	24.02.00	24.02.10	A	Act/Act
47	Lockheed Martin Corp	US539830AL32	EC2005832	USD	1.000.000,00	8,200	23.11.99	01.12.09	SA	30/360
48	Total Fina Elf S.A.	FR0000207003	FF1031807	EUR	373.502,50	6,750	08.07.96	25.10.08	A	Act/Act
48	Total Fina Elf S.A.	FR0000186173	EC1215960	EUR	300.000,00	3,875	05.05.99	05.05.06	A	Act/Act
49	Vodafone Finance BV	DE0003084505	EC1375731	EUR	3.000.000,00	4,750	27.05.99	27.05.09	A	Act/Act
50	United Utilities Water plc	XS0095536909	EC1100253	EUR	600.000,00	4,875	18.03.99	18.03.09	A	Act/Act
51	Cox Communications Inc	US224044AG22	DD1022506	USD	150.000,00	7,625	27.06.95	15.06.25	SA	30/360
51	Cox Communications Inc	US22404QAD07	MM1225745	USD	60.000,00	7,030	06.11.96	06.11.06	SA	30/360
52	Bank One Corp	US06423AAD54	EC1599066	USD	1.000.000,00	6,875	22.07.99	01.08.06	SA	30/360
52	Bank One Corp	US06423AAN37	EC4322730	USD	1.250.000,00	6,000	08.08.01	01.08.08	SA	ISMA 30/360
53	John Deere Capital Corp	US244217BC81	EC1059582	USD	300.000,00	6,000	25.02.99	15.02.09	SA	30/360
54	Hilton Hotels Corp	XS0100088755	EC1597649	GBP	175.000,00	7,250	29.07.99	29.07.08	A	ISMA 30/360
55	Koninklijke Ahold NV	NL0000118560	EC3070249	EUR	200.000,00	6,375	30.11.00	30.11.07	A	Act/Act
56	BAT Intl Finance PLC	XS0094703799	EC0991710	EUR	1.700.000,00	4,875	25.02.99	25.02.09	A	Act/Act
57	Lafarge	FR0000208761	FF1032714	EUR	152.450,00	5,400	03.02.98	03.02.08	A	Act/Act
57	Lafarge SA	FR0000481665	EC2734035	EUR	700.000,00	6,375	26.07.00	26.07.07	A	Act/Act
58	Santander Intl (C.I.)	DE0002302353	TT3422868	DEM	500.000,00	5,375	11.03.98	12.02.08	A	ISMA 30/360

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Table 1: Firm and bond characteristics

Panel A: Firms by size and rating

Size (in millions of Euro) represents a firm's market capitalization in local currency converted with the daily Euro exchange rate. Rating is an aggregated rating obtained from a mapping of Moody's, Standard & Poor's and Fitch's credit ratings on a numerical 17 grade scale (AAA / Aaa= 1, AA+ / Aa1 = 2, ..., CCC /Caa1 and below = 17).

Size (mil. EUR)		10% quantile	50% quantile	90% quantile	Mean
	Jan 2000	4,739	24,156	134,225	44,378
	Jun 2001	4,981	30,038	113,404	47,546
	Dec 2002	3,414	20,322	79,635	32,121

Rating (in %)		1	2	3	4	5	6	7	8	9	10	11	12	Mean	St.D.
	Jan 2000	0	3.6	7.1	16.1	28.6	19.6	10.7	5.4	5.4	3.6	0	0	5.6	1.8
	Jun 2001	0	1.8	1.8	14.3	23.2	25.0	14.3	7.1	8.9	3.6	0	0	6.1	1.8
	Dec 2002	0	1.8	1.8	8.9	19.6	19.6	12.5	14.3	14.3	3.6	1.8	1.8	6.7	2.1

Panel B: Bonds by notional, coupon, maturity, and currency

Bond data consist of one synthetically created five-year constant maturity bond per firm if, at least, two actual bonds with a maturity below and above five years during the sampling period existed (n=58 firms). All numbers refer to the time period 2000-2002, notionals are converted in EUR with the daily exchange rate, percentages are weighted by the number of observations.

Notional (in '000 EUR)	Median of bonds with maturity ≤ 5 years	511,291
	Median of bonds with maturity > 5 years	539,432
Coupon (in %)	Median of bonds with maturity ≤ 5 years	6.160
	Median of bonds with maturity > 5 years	6.125
Maturity (in years)	Median of bonds with maturity ≤ 5 years	2.94
	Median of bonds with maturity > 5 year	7.53
Currency (in %)	EUR	46.5
	USD	41.4
	GBP	12.1

Table 2: Mean CDS and bond spreads by year and rating

CDS represents a five-year maturity CDS spread that refers to senior unsecured debt. BSS and BSG are the differences between a synthetic five-year constant maturity corporate bond yield and the equivalent currency five-year LIBOR interest swap rate or government bond yield. The table shows mean spreads per year and rating category. Spreads stem from 58 firms and are noted in basis points. In brackets, we report the underlying number of observations.

Variable	Year \ Rating	1 (AAA, Aaa)	2-4 (AA, Aa)	5-7 (A, A)	8-10 (BBB, Baa)	11-13 (BB, Ba)	Total
CDS	2000	-	24.51	43.05	65.97	-	41.53
			(2,940)	(7,162)	(1,605)		(11,707)
	2001	-	27.56	62.12	133.99	357.81	71.09
			(2,519)	(8,400)	(2,905)	(8)	(13,832)
	2002	-	36.88	76.49	189.00	647.76	118.95
			(2,157)	(6,616)	(4,091)	(324)	(13,188)
	Total	-	29.02	60.25	147.46	640.78	78.45
			(7,616)	(22,178)	(8,601)	(332)	(38,727)
BSS	2000	-	18.46	47.43	74.25	-	42.97
			(3,382)	(5,783)	(1,824)		(10,989)
	2001	-	20.60	56.94	111.90	136.89	61.78
			(2,594)	(7,940)	(2,886)	(9)	(13,429)
	2002	-	25.63	59.98	138.10	330.5	84.56
			(2,111)	(6,581)	(3,820)	(332)	(12,844)
	Total	-	21.02	55.22	115.58	325.39	64.08
			(8,087)	(20,304)	(8,530)	(341)	(37,262)
BSG	2000	-	66.34	121.80	153.08	-	109.91
			(3,275)	(5,587)	(1,767)		(10,629)
	2001	-	59.44	105.31	155.71	189.43	107.38
			(2,490)	(7,604)	(2,783)	(7)	(12,884)
	2002	-	52.80	92.96	166.38	370.51	115.40
			(2,034)	(6,336)	(3,685)	(320)	(12,375)
	Total	-	60.60	106.02	159.92	366.64	110.89
			(7,799)	(19,527)	(8,235)	(327)	(35,888)

Table 3: Stationarity and autocorrelation of firm-specific time series

Panel A reports the number of firms for which the null hypothesis of non-stationary data (stationary data) can be rejected by means of an Augmented Dickey-Fuller-test and a Phillips-Perron-test (Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test) with lags 1-8 for weekly data and lags 1-40 for daily data. Level (Change) refers to the stock price (log stock return), the CDS spread (first difference of CDS spreads) and the BSS spread (first difference of BSS spreads). All data come from 58 firms over the period 2000-2002. Panel B presents median autocorrelation coefficients of log stock returns, CDS spread changes and BSS spread changes for lags 1-5.

Panel A: Stationarity tests

	Stock price		CDS		BSS	
Weekly data (Wed-Wed)	Level	Change	Level	Change	Level	Change
Augmented Dickey-Fuller test	1	58	1	57	2	57
Phillips-Perron test	1	58	3	58	2	58
KPSS test	43	0	41	0	22	1
Daily data						
Augmented Dickey-Fuller test	1	58	5	58	0	58
Phillips-Perron test	1	58	14	58	7	58
KPSS test	43	0	38	0	29	0

Panel B: Median autocorrelation of stock returns and spread changes

Weekly data (Wed-Wed)	Lag 1	Lag 2	Lag 3	Lag 4	Lag 5
Stock returns	-0.08	-0.03	0.05	-0.08	0.00
CDS spread changes	0.07	0.01	-0.04	-0.10	0.02
BSS spread changes	-0.09	0.02	0.08	-0.04	-0.01
Daily data					
Stock returns	-0.01	-0.04	-0.02	-0.02	-0.01
CDS spread changes	0.02	0.02	0.01	0.02	0.01
BSS spread changes	-0.22	0.03	-0.04	0.05	-0.01

Table 4: Contemporaneous correlation of firm-specific time-series

Spearman's rank correlation coefficients ρ_S are calculated for a pair of firm-specific time series (daily and weekly log stock returns R, CDS spread changes ΔCDS, and bond spread changes ΔBSS). Data stem from 58 firms over the period 2000-2002 and the rating is as of January 2000. All correlation coefficients (except in the first rows) are medians.

		Weekly data			Daily data		
		ρ_S(R, ΔCDS)	ρ_S(R, ΔBSS)	ρ_S(ΔCDS,ΔBSS)	ρ_S(R, ΔCDS)	ρ_S(R, ΔBSS)	ρ_S(ΔCDS,ΔBSS)
Overall	Mean	-0.25	-0.13	0.25	-0.10	-0.02	0.09
	Median	-0.27	-0.09	0.22	-0.11	-0.01	0.05
	p < 0.01	35	15	28	31	11	15
	p < 0.05	42	18	34	39	14	23
	p < 0.10	44	21	39	43	17	25
Region	Europe	-0.27	-0.10	0.28	-0.09	-0.03	0.08
	USA	-0.31	-0.08	0.21	-0.12	0.01	0.03
	Asia	0.00	-0.07	0.09	-0.07	-0.01	0.04
Rating	2-4	-0.15	-0.04	0.18	-0.06	-0.01	0.03
	5-7	-0.31	-0.12	0.21	-0.11	0.00	0.03
	8-10	-0.25	-0.09	0.22	-0.12	-0.03	0.07
Industry	Telco	-0.36	-0.23	0.49	-0.16	-0.11	0.25
	Rest	-0.25	-0.08	0.20	-0.10	0.00	0.03
	Financ.	-0.35	-0.08	0.21	-0.13	0.00	0.03
	Rest	-0.26	-0.10	0.22	-0.11	-0.01	0.07

Table 5: VAR estimation results

Our VAR model consists of three-equations with the log stock return (R_t), the CDS spread change (ΔCDS_t), and the bond spread change (ΔBSS_t) as dependent variables respectively. Numbers represent median coefficients (columns 2, 5, and 8) and the absolute frequency of firms for which the coefficient of the explanatory variable is significantly different from zero at the 0.01-level (columns 3, 6, and 9). Columns 4, 7, 10 report the number of firms for which we can reject the null hypotheses at a 0.01-level (Wald test) that lags 1 to P have no joint explanatory power (the Wald test for p=5 corresponds to a Granger causality test). For each equation we additionally show the median R^2, median p-value from a standard F-Test and the number of firms which exhibit a F-test p-value below 0.01. The hypothesis that the residuals come from a white-noise process is tested with a Ljung-Box (LB) test (weekly data: lags 1-8, daily data: lags 1-40) and Bartlett's test (B) for each equation and firm separately. Data stem from 58 firms over the period 2000-2002.

Panel A: Estimation results for weekly data (Wed-Wed)

Column: (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dep. Var.	R_t			ΔCDS_t			ΔBSS_t		
R_{t-1}	-0.06	5		-15.62	19		-5.93	4	
R_{t-2}	-0.03	1		-5.25	2	13	-5.40	5	5
ΔCDS_{t-1}	0.00	3		0.01	9		0.16	23	
ΔCDS_{t-2}	0.00	0	2	0.01	9		0.09	8	24
ΔBSS_{t-1}	0.00	2		-0.01	3		-0.18	26	
ΔBSS_{t-2}	0.00	2	4	0.00	6	6	-0.08	10	
Const.	0.00	0		0.18	0		0.21	0	
Median R^2	0.0568			0.0952			0.1281		
Median p-val. F	0.1799			0.0189			0.0021		
No. F-test p<0.01	9			27			35		
Residuals:									
No. LB-p. <0.01	2			11			9		
No. B-p. <0.01	0			0			1		

Panel B: Estimation results for daily data

Column: (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dep. Var.	R_t			ΔCDS_t			ΔBSS_t		
R_{t-1}	-0.01	9		-14.67	32		-9.27	21	
R_{t-2}	-0.04	5		-7.09	20	36	-6.21	6	21
R_{t-3}	-0.02	4		-5.70	15	35	-1.44	0	20
R_{t-4}	-0.01	3		-4.25	12	37	-2.89	2	20
R_{t-5}	-0.02	1		-0.68	2	39	-1.19	1	19
ΔCDS_{t-1}	0.00	3		-0.02	23		0.08	20	
ΔCDS_{t-2}	0.00	2	4	-0.01	15		0.05	12	23
ΔCDS_{t-3}	0.00	1	5	-0.02	11		0.05	10	25
ΔCDS_{t-4}	0.00	0	5	0.02	12		0.04	8	30
ΔCDS_{t-5}	0.00	0	5	0.01	4		0.03	9	33
ΔBSS_{t-1}	0.00	2		0.03	16		-0.27	47	
ΔBSS_{t-2}	0.00	2	2	0.02	13	19	-0.09	28	
ΔBSS_{t-3}	0.00	6	6	0.00	6	18	-0.08	22	
ΔBSS_{t-4}	0.00	2	4	0.01	4	19	0.00	10	
ΔBSS_{t-5}	0.00	1	4	0.00	5	19	0.00	6	
Const.	0.00	0		0.04	0		0.04	0	
Median R^2	0.0323			0.0977			0.1479		
Median p-val. F	0.0991			0.0000			0.0000		
No. F-p. <0.01	12			54			57		
Residuals:									
No. LB-p. <0.01	4			27			16		
No. B-p. <0.01	0			0			0		

Table 6: Results from cointegration tests and VECM estimation

Pane A reports results from a Johansen test for cointegration (likelihood ratio or trace test) between the CDS spread level and the bond spread level above swap rates (BSS). The coefficients of the error correction term (lagged residuals from the cointegration equation) λ_1 and λ_2 are estimated in a two-equation vector error correction model (VECM) with ΔCDS_t and ΔBSS_t as endogenous variables and lags 1-5. GG is the Gonzalo-Granger measure of price discovery is calculated as $GG = \lambda_2 / (\lambda_2 - \lambda_1)$. For firms with a GG measure higher than one (0.10-level: 7 firms, 0.01-level: 2 firms) or lower than zero (0.10-level: 2 firms, 0.01-level: no firm) we replace the original values by one and zero for the calculation of means and medians. Panel B reports the frequency of significant and correctly signed coefficients λ_1 and λ_2 (at the 0.01-level) for firms at which cointegration is present at the 0.10-level (0.01-level in brackets).

Panel A: Cointegration tests and error correction coefficients

Cointegration between spreads at the 0.10-level							
	No. of firms	Mean λ_1	Median λ_1	Mean λ_2	Median λ_2	Mean GG	Median GG
Europe	20 / 35	-0.0299	-0.0204	0.0299	0.0292	0.55	0.58
USA	15 / 20	-0.0117	-0.0059	0.0678	0.0587	0.84	0.93
Asia	1 / 3	0.0076	-	0.0910	-	1.09	-
All firms	36 / 58	-0.0208	-0.0109	0.0474	0.0377	0.69	0.79
Cointegration between spreads at the 0.01-level							
	No. of firms	Mean λ_1	Median λ_1	Mean λ_2	Median λ_2	Mean GG	Median GG
Europe	11 /35	-0.0457	-0.0482	0.0357	0.0293	0.47	0.38
USA	10 / 20	-0.0103	-0.0045	0.0837	0.0680	0.91	0.95
Asia	0 / 3	-	-	-	-	-	-
All firms	21 /58	-0.0288	-0.0131	0.0586	0.0448	0.68	0.78

Panel B: Sign and significance of error correction coefficients

	Only bond market contributes	Only CDS market contributes $\lambda_2 > 0$	Both markets contribute $\lambda_1 < 0$ and $\lambda_2 > 0$	Unclear interpretation	Total
Europe	6 (4)	8 (3)	5 (4)	1 (0)	20 (11)
USA	2 (0)	10 (8)	3 (2)	0 (0)	15 (10)
Asia	0 (0)	1 (0)	0 (0)	0 (0)	1 (0)
All firms	8 (4)	19 (11)	8 (6)	1 (0)	36 (21)

Figure 1: Time-series of CDS and bond spreads

Fig. 1a (Fig. 1b) displays times series of daily cross-sectional mean (median) spreads. CDS spreads are indicated by a solid line, bond spreads by a dotted line.

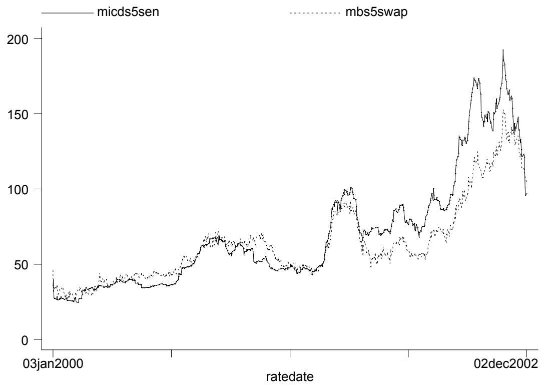

Fig. 1a: Mean spreads

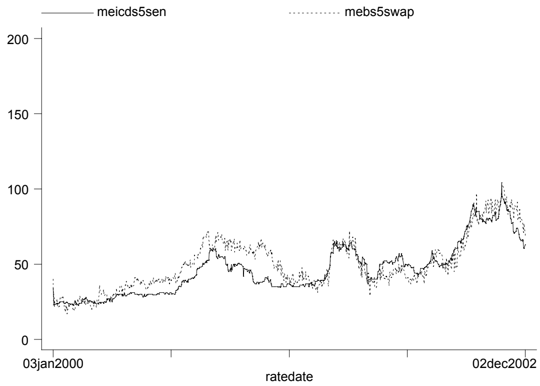

Fig. 1b: Median spreads

Figure 2: Sensitivity of ΔCDS and ΔBSS on lagged stock returns vs. rating

Fig. 2a displays the coefficient for stock return at lag 1 in equation 2 (with ΔCDS as left-hand variable) and Fig. 2b displays the coefficient for the stock return at lag 1 in equation 3 (with ΔBSS as left-hand variable). Spearman's rank correlation is -0.46*** for Fig. 2a and –0.09 for Fig. 2b.

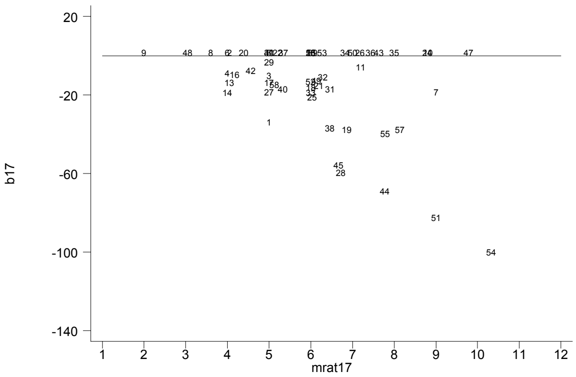

Fig. 2a: $\beta_{2, t-1}$ vs. rating

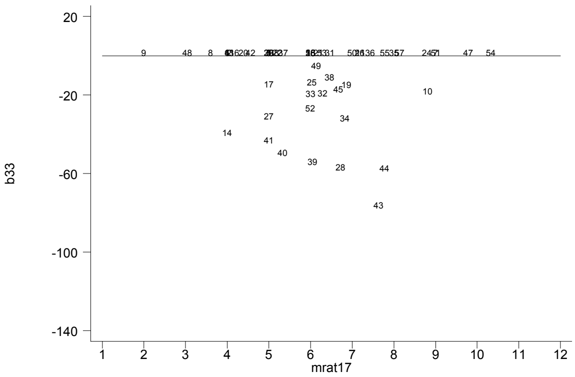

Fig. 2b: $\beta_{3, t-1}$ vs. rating

Figure 3: Error correction coefficients for European and US firms

Fig. 3a (Fig. 3b) displays the coefficients λ_1 and λ_2 from a two-equation vector error correction model for European (US) firms for which cointegration of CDS and bond spreads cannot be rejected at the 0.10-level.

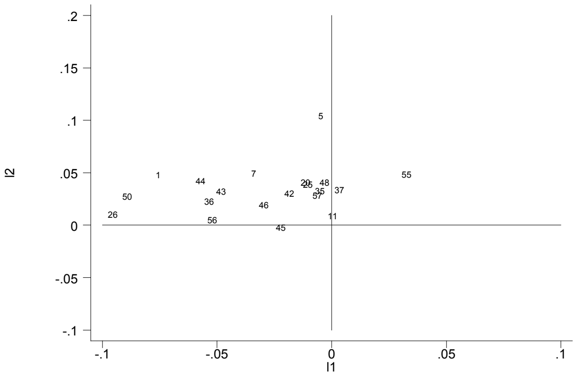

Fig. 3a: European firms

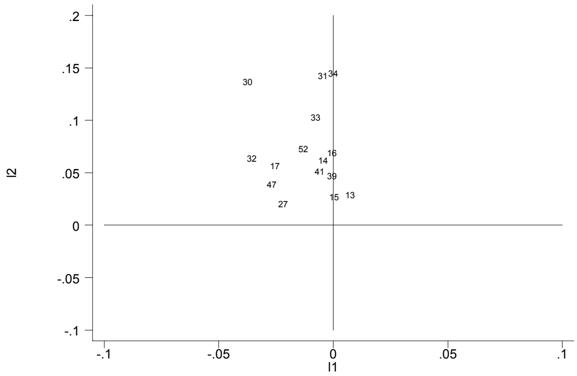

Fig. 3b: US firms

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