DEUTSCHE BUNDESBANK
EUROSYSTEM

Credit contagion between financial systems

Natalia Podlich
Michael Wedow

Discussion Paper
Series 2: Banking and Financial Studies
No 15/2011

Deutsche Bundesbank, Wilhelm-Epstein-Straße 14, 60431 Frankfurt am Main,
Postfach 10 06 02, 60006 Frankfurt am Main

Tel +49 69 9566-0
Telex within Germany 41227, telex from abroad 414431

Please address all orders in writing to: Deutsche Bundesbank,
Press and Public Relations Division, at the above address or via fax +49 69 9566-3077

Internet http://www.bundesbank.de

ISBN 978-3–86558–778–7 (Printversion)
ISBN 978-3–86558–779–4 (Internetversion)

Abstract:

We examine contagion from a number of financial systems to the German financial system using the information content of CDS prices in a GARCH model. After controlling for common factors which may cause comovement in security prices, we find evidence for contagion from the US and European financial systems. Our results additionally confirm that the set up of the financial rescue scheme in Germany partially shielded German banks but not insurance companies from contagion. Overall, our results suggest that contagion from dealer banks have the most prominent effect on the German financial system. While dealer banks impact on German banks and insurance companies in a similar way, a deterioration in the CDS spreads of dealer banks has a particularly pronounced effect on German dealer banks.

Keywords:

Systemic Risk, CDS Spreads, Contagion, OTC Dealer

JEL-Classification:

G14, G21, G28

Non-technical summary

The global financial crises has led to a marked rise in the awareness of the importance of systemic risk. More specifically, the crisis has demonstrated that systemic events can rapidly spill over across borders and to markets, gathering strength and augmenting systemic risk. The vulnerability of financial institutions to contagious effects has placed this issue on top of the agenda of financial stability regulation.

In this paper, we examine contagion effects emanating from the financial systems of the US, Europe, Asia-Pacific region and emerging markets to the German financial system using the information content of CDS prices. The structure of OTC markets makes this market and the dealer banks particularly vulnerable to contagion. This is largely due to the high concentration of trading among a few dealers and to the opaqueness of the market. For this reason, we specifically examine the strength of contagion from dealer banks to the German financial system, distinguishing between banks and insurance companies. In addition we explore the magnitude of contagion over time. The relevance of the dynamic nature of contagion was demonstrated during the financial crisis, which started in the US housing market but peaked when a number of individual institutions became distressed. We thus investigate changes in the strength of these financial systems' interdependence. To achieve this we consider, inter alia, the impact of the default of Lehman Brothers and the financial stabilization scheme set up in Germany. To address all these objectives, we use weighted CDS spread indices for each financial system. Our reliance on broad indices allows us to obtain a comprehensive view of the risk to the German financial system.

Our findings suggest that there are strong contagious effects from the US and Europe and no effects from the Asia-Pacific region and emerging markets on the the German financial system. While the magnitude of contagion from the US and Europe to the German financial system is comparable, contagion

from the US only affects the level of risk in the German financial system, while contagion from the European financial system also leads to an increase in the volatility of the German index. Furthermore, our results suggest that introducing public support schemes partially shielded German banks but not insurance companies from contagious effects. More importantly, our results highlight asymmetries in the contagion effects with regard to different sectors of the German financial system. German insurance companies experience contagion effects from European and US financial intermediaries while German banks are by and large immune to contagion effects from non-dealer intermediaries headquartered in the US and Europe. German dealer banks experience the largest impact from other dealers but are immune to other financial intermediaries. This evidence confirms that the close and highly concentrated network formed by these banks poses a potential threat to the stability of the financial system.

Nichttechnische Zusammenfassung

Die globale Finanzkrise hat die Bedeutung von systemischen Risiken eindringlich in das Bewusstsein gerückt. Die Krise hat gezeigt, dass systemische Ereignisse sich schnell über Grenzen und Märkte hinweg ausbreiten und dabei an Intensität gewinnen können. Damit können systemische Ereignisse zu einer Gefahr für die Finanzstabilität werden. Mit der Verwundbarkeit von Finanzinstituten für Ansteckungsrisiken ist das Thema an die erste Stelle in der Agenda für Finanzstabilität gerückt.

Im vorliegenden Papier werden Ansteckungseffekte aus dem internationalen Umfeld - insbesondere aus Europa (außerhalb Deutschlands), den USA, der Region Asien-Pazifik und den Entwicklungsländern - auf das deutsche Finanzsystem empirisch ermittelt. Die besondere Struktur der OTC-Märkte, bei der ein überwiegender Anteil des Handelsvolumens auf eine geringe Anzahl an OTC Dealer-Banken entfällt, macht das Finanzsystem besonders anfällig für Ansteckungsrisiken durch diese Banken. Die Analyse stützt sich dabei auf Indizes, die auf den gewichteten CDS-Prämien der Finanzintermediäre der jeweiligen Region basieren. Dabei werden die Ansteckungsrisiken von den OTC-Dealer-Banken auf das deutsche Finanzsystem analysiert, wobei der deutsche Banken- und Versicherungssektor separat betrachtet wird.

Empirisch lässt sich gut dokumentieren, dass sich die Interdependenzen zwischen den Finanzsystemen im Zeitablauf ändern können. Dies bestätigt auch die aktuelle Finanzkrise, die ihren Ursprung in dem US-amerikanischen Immobilienmarkt fand und ihren Höhepunkt erreichte, als viele Finanzinstitute weltweit in Schwierigkeiten gerieten. Um die Dynamik der Ansteckungseffekte zu berücksichtigen, wird die Stärke der Abhängigkeit zwischen den Finanzsystemen über die Zeit untersucht. Insbesondere werden Ereignisse wie die Insolvenz von Lehman und die Einführung von Stützungsprogrammen für das Finanzsystem wie der Sonderfonds der Finanzmarktstabilisierung (SoFFin) in Deutschland berücksichtigt.

Die Analyse zeigt, dass Europa und die USA einen starken Einfluss auf das deutsche Finanzsystem ausüben. Für die Region Asien-Pazifik und die Entwicklungsländer konnte hingegen kein statistisch signifikanter Einfluss nachgewiesen werden. Während die Höhe des von Europa und USA ausgehenden Ansteckungseffektes im Risikoniveau vergleichbar ist, lassen sich Unterschiede in der Übertragung der Volatilität der Indizes feststellen. Ein Anstieg der Volatilität in Europa führt zu einem Anstieg der Volatilität im deutschen Finanzsystem. Dagegen ist keine Übertragung der Volatilität aus den USA festzustellen. Die Ergebnisse der Studie bestätigen darüber hinaus, dass die Einführung des Stützungsprogrammes in Deutschland den deutschen Bankensektor, aber nicht den Versicherungssektor, vor Ansteckungseffekten abgeschirmt hat. Zudem wirken sich Ansteckungseffekte auf den deutschen Banken- und Versicherungssektor unterschiedlich aus. Deutsche Versicherungsunternehmen sind Ansteckungseffekten von Finanzintermediären aus Europa und den USA ausgesetzt. Für deutsche Banken und besonders für die deutschen OTC Händler lässt sich lediglich ein signifikanter Effekt ausgehend von OTC Dealer Banken feststellen. Diese Beobachtung verdeutlicht, dass die starke Konzentration der OTC Märkte Finanzsysteme besonders anfällig für Ansteckungseffekte machen kann.

Contents

List of Figures

Credit Contagion between Financial Systems [1]

1 Introduction

Contagion between financial institutions is a major contributing element for the emergence of systemic risk. [2] As the global financial crisis unfolded, one particularly noteworthy feature was the strong comovement of financial institutions' credit spreads. The magnitude and speed of these comovements caught many observers off guard and highlighted the fact that contagion can be an important amplifier of systemic risk. Moreover, comovements were not limited to national financial systems but quickly spread across borders, affecting single institutions and entire financial systems (Moshirian, 2011). The global financial crisis thus signaled the need to develop a framework for the surveillance of systemic risks (International Monetary Fund, 2009).

More generally, the negative repercussions of the distress of one or several financial intermediaries on others has been termed contagion (Kaufman (1994) and De Bandt et al. (2010)). Along this line of thought, contagion involves an initially idiosyncratic event spreading horizontally across the financial system. Kaufman (1994) provides an extended review of the theory and the empirical evidence on bank contagion. He compares the characteristics of bank failure contagion with contagious effects in other industries. The literature he reviews shows that contagion following the failure of a bank spreads faster and more broadly within the banking industry than in other industries. In addition, con-

[1] We are grateful to Jörg Breitung, Frank Heid, Isabel Schnabel, Christoph Memmel and the participants of the research seminar of the Deutsche Bundesbank for their helpful comments and suggestions. The paper represents the authors' personal opinions and not necessarily those of the Deutsche Bundesbank. All remaining errors are of course our own. Natalia Podlich, Wilhelm-Epstein-Str. 14, 60431 Frankfurt am Main, natalia.podlich@bundesbank.de.

[2] From a broader perspective, contagion is one dimension of systemic risk, alongside macroeconomic shocks and the unraveling of imbalances.

tagion leads to a larger number of failures in the banking sector. The evidence presented in Kaufman (1994) thus suggests a more potent role for contagion in the banking sector than in other industries.[3] In line with the literature, contagion can be conceptually classified into two broad categories (Claessens and Forbes (2001), Forbes and Rigobon (2002), Chapter 2). The first category relates to spillover effects which result from the interdependence of markets and financial intermediaries. Under this notion, contagion is transmitted via financial or real linkages between the different entities. In addition, Jorion and Zhang (2009) further identify a credit contagion channel within this category which arises due to counterparty and competitive effects. The second category refers to the transmission of shocks which are unrelated to observed changes in the macroeconomic environment or other fundamentals. This form of contagion instead results from the behavior of investors or other financial agents.[4]

In our analysis, we control for changes in the macroeconomic environment to examine the credit contagion channel between financial intermediaries. However, we do not distinguish between the two categories of contagion and instead define contagion broadly as a comovement in asset prices after conditioning on country-specific risk factors. Several theoretical papers discuss the reasons for this sort of contagion. Acharya (2009) describes systemic risk as an endogenous consequence when banks lend to similar industries. The correlation of banks' asset returns subsequently leads to the emergence of stress events in the financial system. Wagner (2010) argues that banks' portfolio diversification can increase systemic risk when banks hold similar assets, thus exposing them to the same sources of risk. Hence, while diversification may be optimal from the perspective of the individual bank it can also be detrimental to the

[3] Nevertheless, Kaufman (1994) also cites evidence that bank runs do not appear to drive solvent bank into insolvency and that the losses to depositors (creditors) of failed banks are smaller on average than in other industries.

[4] A more comprehensive definition of contagion and transmission channels can be found in Chapter 2, Claessens and Forbes (2001).

stability of the financial system. In addition, Goldstein and Pauzner (2004) show that even when the fundamentals of two countries are independent, the fact that they share the same group of investors may generate contagion when they treat both countries in a similar fashion. Allen and Carletti (2006) argue that credit risk transfer, which became possible with the introduction of new financial instruments and the creation of new markets, can lead to contagion.

In this paper, we aim to contribute to the empirical literature on contagion between financial institutions in two ways. First, the literature on contagion has so far primarily focused on contagious effects between individual institutions within the same financial system. We study contagion effects from a broader perspective by focusing on the interlinkages between different financial systems instead of between individual institutions. More specifically, our first contribution is to provide an empirical framework to measure the strength of contagion effects emanating from the financial systems of the US and Europe on the German financial system. A more thorough understanding of the significance of contagion between financial systems is important from a financial stability perspective to obtain a measure of how systemic risk is transmitted internationally and to adopt adequate policy measures. In this context, we also assess the impact of financial stabilization schemes set up by the authorities during the financial crisis as a potential policy measure for limiting contagion effects.

Second, in our empirical analysis, we study contagion between different sectors of the financial system. More specifically, we study contagion effects for banks and insurance companies separately. Furthermore, as we rely on data from the over-the-counter (OTC) market for credit default swaps a natural extension of our paper is to assess contagion between dealer banks. The role of OTC markets in the transmission of shocks through the global financial system has been highlighted by a number of spectacular defaults during the crisis (European Central Bank, 2010). The structure of OTC markets makes these markets and the dealer banks particularly vulnerable to contagion. This is largely due to the high concentration of trading among a few dealers and to the opaqueness of the market. Stulz (2010) argues that CDS contracts create a web of exposures between financial institutions whereby a default of one financial institution can lead to the failure of other institutions. This web is particularly pronounced for the dealers in this market. Based on data published by the Depository Trust and Clearing Corporation (DTCC), dealers in the CDS market trade more than 88% of all credit products amongst themselves. This figure is even higher for single name contracts where the underlying entity is a financial institution.[5] As a result, the failure of an important counterparty in CDS contracts can lead to large losses for other institutions, causing contagion that can ultimately destabilize the financial system. Duffie (2010) discusses the mechanism that can lead to the failure of dealer banks, arguing that they differ markedly from conventional commercial banks. He argues that the business model of dealers in the securities and derivative markets make them susceptible to new types of runs which can spread to other dealers and, inter alia, due to fire sales of securities to other financial intermediaries. Our second contribution thus consists in providing evidence for contagion between different financial sectors and particularly dealer banks.

To address these objectives, we use weighted CDS spread indices for each financial system. Each individual index is based on a large number of banks and insurance companies for which data are available. Our reliance on broad indices allows us to obtain a comprehensive view of the risk of the respective financial system. Methodologically, we rely on a GARCH model proposed by Engle (1982) and generalized by Bollerslev (1986) in our analysis. In particular, we apply an AR-GARCH model with multiplicative heteroscedasticity to analyze the contagious effects. Therefore, the set up of the model allows us to

[5] About 90% of all single name contracts where the underlying entity is a financial firm are bought and sold by dealers.

study contagion effects in the level as well as the variance of our indices.

Our findings suggest that there are strong contagious effects from the US and Europe on the German financial system. Not surprisingly, the impact emanating from US is higher in the crisis period. Moreover, our results suggest that introducing public support schemes partially shielded German banks but not insurance companies from contagious effects. More importantly, our results highlight differences in the contagion effects between the different sectors of the German financial system. Banks and insurance companies are equally affected by contagion from dealer banks. German dealer banks experience the economically largest impact from other CDS dealers but appear immune to changes in the credit spreads of intermediaries that are not active as dealers in the CDS market. This evidence confirms that the close and highly concentrated network formed by these banks pose a potential threat to the stability of the financial system.

In the next section, we briefly place our paper in the context of the related literature. This is followed by a discussion of the empirical set up and the selection of the data. More specifically, we discuss the calculation of the weighted CDS indices for the different financial systems. In the fourth section, we present the results of our GARCH model and the final section provides some concluding remarks.

2 Literature Review

The substantial body of literature on contagion can be broadly classified into studies on contagious effects between markets and between individual firms. The papers in these two broad strands differ in their empirical approach and the type of data used. The papers taking a market perspective study the international transmission of contagion during financial crises and market-specific shocks using broad market indices for securities' prices. As an early example, Solnik (1974) examines the price generating process for stocks from eight European countries, the US and Japan using an international asset pricing model. He shows that while domestic factors matter most for stock price movements, they are also affected by foreign events. This evidence suggests that international systemic risk is priced into stock prices. A particularly well studied event is the October 1987 stock market crash. Among the papers analyzing this event, King and Wadhwani (1990) develop a model in which contagion occurs when investors infer information from price changes in other markets. They use high frequency data for the stock markets in London, New York and Tokyo showing that price changes in one market spill over to other markets. Moreover, they find that a surge in volatility leads to an increase in contagion between markets. Hamao et al. (1990) also examine contagion between these three stock markets during the period of the October crash by means of a GARCH model. Similarly to King and Wadhwani (1990), they find that price changes in foreign stock markets significantly impact on the domestic market in the conditional mean and variance, though not in all bilateral directions. Malliaris and Urrutia (1992) conduct Granger causality tests for stock market indices in six countries around the October 1987 crash. Their results suggest that before and after the crisis there were no lead-lag relationships between the markets, while during the month of the crash the spillovers increased in both directions for the majority of markets. They interpret these findings to mean that the crash was not caused by any particular stock market but had its origins in all of them simultaneously. Forbes and Rigobon (2002) suggest an adjustment to the correlation coefficient frequently used to measure the extent of contagion. They take account of the fact that the variance of market returns fluctuates over time, leading to a bias in this measure for contagion. They also apply this adjustment to the US stock market crash in 1987 and find no evidence for contagion. Besides the stock market crash in 1987, a number of other extreme events have received widespread attention in the contagion literature. Among these events, the emerging market crises during the 1990s have received particular attention.[6] Besides contagious effects between financial sectors, Baur (2011) examines the transmission of distress from the financial sector to real economy during the recent financial crisis. The evidence presented in Baur (2011) document the role of the financial sector in transmitting shocks between countries and to different sectors. More specifically, none of the sectors considered was completely immune to the crisis. However some of sectors suffered less indicating the ability of investors to differentiate between sectors and therefore to maintain the effectiveness of diversification.

In view of the mixed evidence for the existence of contagion, alternative methods have been suggested that take into account the potential non-normality of asset returns and possible non-linear interlinkages between stock returns. Bae et al. (2003) studied the extreme comovements using exceedance correlations for stock prices. Hartmann et al. (2004) employ a non-parametric measure, using extreme value theory to gauge contagion effects between stock and bond markets. Beine et al. (2010) measure stock market coexceedance using quantile regression, showing that financial liberalization leads to a rise in tail comovemement. Fry et al. (2010) propose a new test of contagion focusing on the coskewness of market returns. They apply their new test to study contagion effects between the real estate and equity market within and between countries for the Hong Kong crisis in 1997 and the subprime crisis in 2007. Generally, these papers point to the existence of contagious effects between markets and across national borders. This strand in the literature underlines the importance of the methodology used to gauge contagion and to take into account the non-normality of asset returns.

With regard to contagion studies for financial intermediaries, the literature has studied the effects of adverse events such as a bank's failure on the equity returns of other banks within an event study framework (see Aharony and

[6] See Claessens and Forbes (2001) for a review of this literature.

Swary (1983), Swary (1986) and Pozdena (1991)). Generally, these papers conclude that while there is evidence for contagious effects, they can be largely attributed to fundamentals rather than irrational investor behavior. Slovin et al. (1999) examine the effect of adverse events for US banks. They find that dividend reductions at money center banks have a negative impact on other money center banks and on regional banks. Regional banks, in turn, do not affect money center banks but instead lead to positive abnormal returns for rival banks in the same geographic area, indicating competitive effects. De Nicolo and Kwast (2002) study the stock return correlation for a sample of large US banks. They measure contagion using pairwise correlation coefficients with a GARCH constant conditional correlation model and find an upward trend in the inter-dependency among banks. They argue that the consolidation process in the banking sector is behind this trend and that this increase may lead to more systemic risk. The majority of this literature has focused on US banks. Schroeder and Schueller (2003) presents one of the few studies for the European banking system. They estimate bivariate correlations in a GARCH framework for national bank stock indices of the EU countries. In line with De Nicolo and Kwast (2002), they find that the conditional correlation trended upwards, with structural breaks following the implementation of the second banking directive and the introduction of the euro. Fenn and Cole (1994) and Polonchek and Miller (1999) present two of the few studies that exist on contagion effects for the insurance industry. Polonchek and Miller (1999) argue that contagion effects between insurance firms arise because of monitoring costs. Rationally uninformed investors draw inferences for the entire industry based on adverse information from some firms. Their results reveal that contagion effects within the insurance sector pose an important risk. As pointed out by Stulz (2010) and Duffie (2010), contagion might be particularly prevalent among dealers in the OTC market. One of the few papers which empirically tests for contagion in the OTC market is Clark and Perfect (1996). Using the stock returns of the largest U.S. banks active in the derivative markets they show that large derivatives losses made by four clients of one bank led to negative abnormal returns for other dealers in the derivatives market. While some of these abnormal returns can be explained by fundamentals, the result highlights the importance of contagion effects within this industry.

In sum, the findings in the literature provide support for the claim that contagion between markets and across borders can be important for the transmission of international shocks. However, evidence on the international transmission of shocks between financial institutions is limited so far despite the recent experience during the global financial crisis. The bulk of the literature on contagion between financial intermediaries focused on contagion within the US to detect evidence for contagion. In addition, some of the findings in this research indicate an increase in the role of contagion and thus of systemic risk over the recent years. Finally, the findings by Forbes and Rigobon (2002) highlight that a careful interpretation of the results is needed given that the definition of contagion is ambiguous and any correlation may also reflect interlinkages rather than contagion.

3 Data and Empirical Specification

3.1 Data and Financial System Indices

CDS spreads offer a number of advantages over alternative market prices used in the literature. First, CDS spreads directly reflect the risk of failure of the underlying entity (Jorion and Zhang, 2009). The majority of the literature relies on stock returns to measure contagion effects. While stock returns are a viable source of information, stock prices reflect the discounted future stream of income from holding stock and thus do not reflect credit risk to the same extent as CDSs (Jorion and Zhang (2007)). In addition, Blanco et al. (2005)

have shown that CDS prices have an informational lead over bond prices and are thus a better asset for assessing credit risk. Second, we are particularly interested in studying the risk of contagion to the German financial system. Since a number of significant players in the German financial system are unlisted, CDS spreads allow a more comprehensive assessment.

In order to capture contagious effects in the CDS market, we use daily spreads of single name 5-year senior CDS contracts where the underlying entity was either a bank or an insurer. These contracts are more frequently traded and thus more liquid (British Bankers' Association, 2006). For each underlying entity, we choose the CDS contract in the currency with the potentially highest liquidity. [7]

We obtain CDS spread data from the Markit Group for the period January 2004 through January 2011. The sample consists of quotes contributed by more than 30 dealers for all trading days during the period. Once the quotes are delivered by the dealers, Markit screens the quotes, removes outliers and stale observations. Only when more than two contributors remain, does Markit calculate a daily composite spread. CDS spread quotes are the most widely used source of CDS data in the literature (Mayordomo et al., 2010).

A final consideration for the selection of CDS spreads are the restructuring clauses, given that different restructuring clauses are applicable for financial institutions in the US, Europe and Asia. We selected the CDS spread based on the ex-restructuring clause for institutions from North America, modified-modified restructuring for Western Europe and old restructuring for Asia.

In selecting financial institutions, we follow Mayordomo et al. (2010), who argue that the information content of CDS spreads is related to firm size. Therefore, we use the weekly list of the 1000 single reference entities with the

[7] According to DTCC, the majority of CDS contracts are denominated in USD (62%) and EUR (35%).

largest notional amounts of CDS contracts outstanding published by DTCC.[8] We identify more than 360 financial institutions; we were able to obtain CDS spreads for 234 and total assets for 194 of these entities, which we ultimately use to calculate our weighted indices (see Table 1). From a regional perspective, Europe dominates the sample with 96 institutions, followed by banks headquartered in emerging markets and the US with 38 institutions. The composition with regard to the sector contains mostly banks but also the largest insurance companies. All of the 28 dealers identified are banks.

Table 1
No. of Banks and Insurers by region

Region/Country	No. of Banks	No. of Insurers	No. of Dealers
US	20	18	8
Europe	83	13	12
Asia-Pacific	22	3	5
Emerging	43	0	0
Germany	26	6	3
Total	*194*	*40*	*28*

Note: Europe includes Portugal, Italy, Ireland, Greece, Spain, Switzerland, Sweden, Norway, UK, Denmark, Iceland, France, Austria, Belgium and the Netherlands; ; Asia-Pacific contains Singapore, Japan and Australia; Emerging includes Argentina, Brazil, Chine, India, Indonesia, Kazakhstan, Korea, Malaysia, Russia, Thailand, Turkey, Ukraine. The sample is based on 1837 observations.

For each of the five regions, i.e. countries, we calculate a representative index of the financial system. This index is based on the weighted CDS spread of the financial institutions, which are part of the respective financial system. For the weights, we use the total assets of each institution over total assets for all the institutions for which we have CDS spreads and total assets available.[9]

We also considered a number of alternative methods and avenues for obtaining a suitable index, such as using principal component analysis (PCA), simple means or market capitalization as the basis for calculating weights. However,

[8] See http://www.dtcc.com/products/derivserv/data/index.php.

[9] We normalize the weights when there are missing observations for individual institutions to avoid breaks in the time series.

each of these alternatives have serious shortcomings. The components from the PCA cannot be calculated appropriately due to missing observations for the CDS spreads. Furthermore, the components are less convenient for interpretation purposes. Simple means are less representative of the financial system given the considerable differences in the size of firms. While market capitalization could potentially serve as an adequate weighting factor, it would considerably reduce the number of financial institutions, particularly for Germany, where a number of significant players are not listed on the stock market.

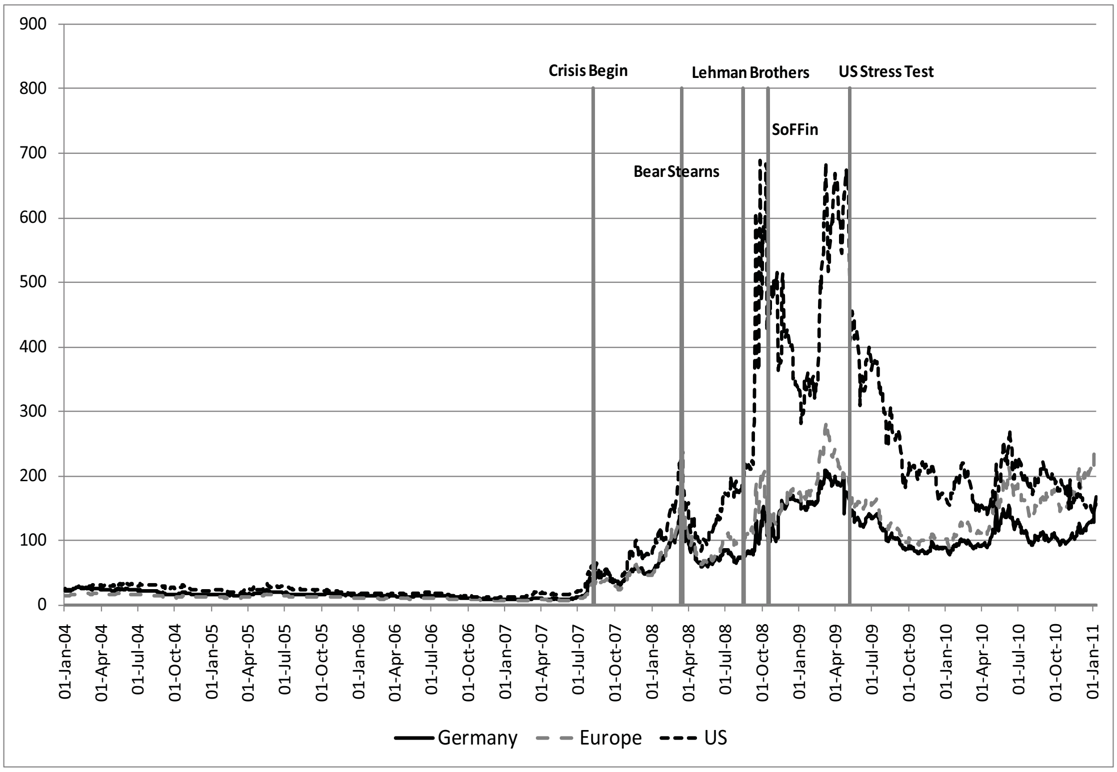
We show the indices for the institutions from Europe, Germany and the US in Figure 1. CDS spreads remained relatively flat prior to the financial crisis and surged upwards around June 2007, with the US institutions' spreads starting to rise already around January 2007. The starting date of the crisis is defined by the first intervention of central banks in the financial markets on the 9th of August 2007, when CDS spreads hiked upwards.[10] Further hikes occurred in March 2008 when Bear Stearns was taken over by J.P. Morgan and, in particular, in September 2008 when Lehman Brothers defaulted. CDS spreads declined markedly after the establishment of the rescue schemes in the US and Europe in October 2008 and again after the US stress-test, which allowed some US banks to repay the capital rejections they had received.

3.2 Empirical Specification

In our empirical analysis, we investigate the transmission of credit risk from the Asia-Pacific region (AP), the Emerging Market countries (EM), Europe (EU) and the US to the German financial system. In order to estimate contagion effects, we analyze the conditional mean and the variance of the index for the German financial system using an GARCH regression with AR distur-

[10] For the official statement, see http://www.federalreserve.gov/newsevents/press/monetary/20070810a.htm

Figure 1. CDS Spread Indices for the Financial Systems of Europe, Germany and the US in bp., from January 2004 to January 2011



bances and multiplicative heteroscedasticity.[11] One advantage of the GARCH model is that it explicitly allows testing for contagion in the first and second moment of price changes. Furthermore, the conditional variance can be modeled as a time variant variable, which offers a more efficient and realistic estimation approach. More specifically, we employ an AR(1)-GARCH(1,1) model to estimate contagion effects, which has the following form:

$$\Delta y_t^{GE} = \alpha_0 + \alpha_1 \Delta y_{t-1}^{EU} + \alpha_2 \Delta y_{t-1}^{US} + \alpha_3 \Delta y_{t-1}^{AP} + \alpha_4 \Delta y_{t-1}^{EM} + \beta' \Xi_t + \mu_t \qquad (1)$$

$$\sigma_t^2 = \gamma_0 + \gamma_1 \epsilon_{t-1}^2 + \lambda_1 \sigma_{t-1}^2 \qquad (2)$$

$$\mu_t = \rho \mu_{t-1} + \epsilon_t \qquad (3)$$

[11] Alexander and Kaeck (2008) used a Markov switching model of the determinants of changes in the iTraxx Europe indices. Their tests for regime shifts show strong evidence of switching for all indices apart from the Financial Senior index. Partly for this reason we rely on a GARCH model but test for asymmetries and structural breaks in the subsections 4.1 and 4.2.

with $\epsilon_t \sim t(0, \sigma^2)$. Here, y represents one of the four regional indices on day t with GE for Germany and for Europe (EU), the US, the Asia-Pacific region (AP) and the Emerging Market countries (EM). We condition the German index on the CDS indices of other financial systems. The indices of the four regions are lagged by one day to reduce the endogeneity problem and to control for a reverse causality. Ξ stands for a vector of control variables. The inclusion of control variables should allow us to capture comovements between the financial system indices instead of effects which result from changes in fundamental factors. In our choice of control variables, we rely on the variables that have been identified in the literature but also consider additional variables that have received less attention so far. We use the current yield of German government bonds with a remaining maturity of 15 to 30 years to capture the level of the risk free interest rates. We also considered using alternative variables for the risk free rate such as the swap rate but prefer the rate of government bonds given that swaps rates are indexed to the Libor and thus contain a credit risk premium which experienced large swings during the financial crisis (Houweling and Vorst, 2005). Our second control variable is the yield curve as the difference between government bonds with a maturity of 0.5 and 10 years.[12] A steeper yield curve reflects higher expected future interest rates and facilitates the term transformation of financial intermediaries, thus supporting their profitability. Furthermore, the steepness of the yield curve provides an indication of future economic activity (see Fama (1984)) and the yield curve should thus be negatively associated with credit spreads. We also include the volatility index for the German stock market (VDAX) as a measure of firm value volatility as in Alexander and Kaeck (2008) and expect a positive coefficient. In order to control for credit risk developments in the real economy, we additionally include the iTraxx index for non-financial firms.[13]

[12] The interest rates for these bonds are derived on the basis of the method suggested by Svensson (1994).
[13] We also test a number of further control variables such as the interbank interest rate Libor. It emerged that the Libor rate was always insignificant in our estimation.

σ_t^2 is the conditional variance of the index for the German financial system at time t. Equation 3 contains an AR process, which is a part of the mean equation.[14] Table 2 contains the four indicators for each region and four control variables.

Table 2
Summary Statistics for Financial System CDS Indicators and Control Variables

Variable	No. of Obs.	Mean	Std. Dev.	Min	Max
Germany	1832	59.1	51.6	8.5	209.5
Europe	1832	68.7	69.1	7.0	279.4
USA	1832	125.8	148.1	11.2	688.9
Asia-Pacific Region	1832	59.3	56.1	6.4	242.1
Emerging Markets	1832	117.3	113.9	24.9	715.7
Control Variables					
iTraxx non-financials	1717	76.5	55.4	24.4	282.3
VDAX	1795	22.7	9.7	11.7	83.2
Yield Curve	1794	1.7	1.1	0.0	3.6
Treasury Rate	1794	4.1	0.5	2.6	5.0

The conditional variance is modeled as a function of its own past values and squared errors from the recent period. We also include a vector of four squared residuals, which we obtain by applying AR-GARCH models to each of the four other financial system indices i.e. AP, EMs, EU and the US. Since tests confirmed that all variables contain a unit root, we include them as log-differences in our estimations. This is in line with Acharya et al. (2010) who argue that log changes provide a better approximation of a change in a firm's value.

We chose to omit these variables given that they are only available for a shorter observation period but results can be obtained upon request.

[14] To avoid the risk of misspecification, we test the residuals after each estimation with the alternative Durbin test. We specified this test to be robust to an unknown form of heteroskedasticity. The test did not reveal any indication of serial correlation of the residuals.

4 Results

Forbes and Rigobon (2002) argue that contagion measures such as correlation coefficients are conditional on market volatility. After adjusting for this bias, the spurious contagion measured in the increased correlation between international stock markets should disappear. In line with this argument, the first step in our empirical analysis is to implement the test suggested by Forbes and Rigobon (2002) to assess if there is evidence for contagion between the German financial system index and the four indices for Europe, the US, the Asia-Pacific region and Emerging market countries after adjustment for increased volatility of these CDS indices. The test shown in Table 3 suggests that the increase in the correlation between the German financial system and the system in other regions during the financial crisis constitutes first evidence of contagion. All four tests show evidence for a significant rise in the correlation between corresponding financial systems at the 1 percent level.

Table 3
Forbes-Rigobon Test for Contagion between Germany and the US, Europe, Asia-Pacific and Emerging Markets during the Global Financial Crisis

	US	Asia-Pacific	Europe	Emerging Markets
Germany	13.07	40.49	8.51	124.12

Note: The test compares the correlation between two indices before and after a market shock. The starting date for the financial crisis is set on the 9th of August 2007, when central banks intervened in the markets for the first time to facilitate the orderly functioning of the financial markets. If the correlation adjusted value > critical value then the null hypothesis "no change in the co-movement between CDS spreads during a crisis period" can be rejected. Chi2 (1) at 5 % is equal to 3.84 and at 1% equal to 6.64.

To further investigate the direction of causality between our indicators, we use Granger-Causality tests. These tests, shown in Panel I of Table A 1 of the appendix, confirm a bi-directional relationship between the German, the European and the US financial system. For the Asia-Pacific region and the emerging markets, the direction of causality goes unilaterally from the German financial system to the Asia-Pacific region and to the emerging markets. In Panel II, we perform additional causality tests for the role of dealer banks. For this purpose, we exclude all dealer banks from the regional indices to obtain dealer free regional indices and a separate index for the dealers. The tests show that with the exception of the US financial system, there is a significant and positive effect from the dealers to the regional indices, which is particularly pronounced for Europe.

In line with the evidence from the causality tests, we include the financial system indices in the GARCH model with a lag of one time period to reduce possible endogeneity problems. We examined the distribution of the changes in the CDS spreads and the residuals from the GARCH model graphically and using the Shapiro-Wilk test. The graph shows a symmetric distribution with heavier tails, and the test rejected the normality of the variables. We thus specify our GARCH model with the errors, following a Student-t distribution with heavier tails. In Table 4, column 1 contains the results for the GARCH model for the four macroeconomic variables, the baseline specification, and column 2 also includes the four financial system indices. The four macroeconomic variables have the expected signs and are individually significant. A higher stock market volatility as a proxy of market uncertainty is positively related to the overall credit risk of the German financial system. Similarly, an increase in credit risk in the non-financial sector also causes credit risk in the financial sector to rise. The yield curve and the treasury rate both exhibit a negative coefficient, highlighting the beneficial effect of term transformation and the positive effect of an improving macroeconomic outlook. The ARCH and GARCH terms are positive and significant, validating our decision to choose a GARCH model.[15] More importantly, column 2 highlights that there are significant contagion effects emanating from the European and the US financial system to the German financial system after controlling for exogenous factors.

[15] In a first step, we applied a Lagrange multiplier (LM) test for autoregressive conditional heteroskedasticity (ARCH) to residuals obtained from OLS regression and found evidence that the errors are autoregressive conditional heteroskedastic. We also used higher order GARCH and ARCH terms in our model but they turned out to be insignificant in most specifications.

Next, we introduce a number of variables based on the financial system indices in the equation for the conditional variance to test for volatility contagion effects between the foreign financial systems and the German financial system. Interpreting the squared residual as a "volatility surprise", we take the squared residual derived from a GARCH model as specified in equations 1 to 3, which we estimate separately for each of the four indices for the EU, US, AP and EM. In the estimation of each volatility surprise, we control for fundamental region specific factors and effects from the remaining regions to avoid a spurious relationship.[16] For example, when we estimate the model for Europe, we control for the US, Asia-Pacific region and the Emerging Market countries. Once we have obtained the squared residuals from GARCH model for each of the four financial indices, and assuming multiplicative heteroscedasticity,[17] the full specification of the conditional variance equation for the German index is given by

$$\sigma_t^2 = exp(\varrho_0 + \varrho_1 \epsilon^2_{EU,t-1} + \varrho_2 \epsilon^2_{US,t-1} + \varrho_3 \epsilon^2_{AP,t-1} + \varrho_4 \epsilon^2_{EM,t-1})$$

$$+\gamma_1 \epsilon^2_{t-1} + \lambda_1 \sigma^2_{t-1} \tag{4}$$

Our results in column 3 suggest that volatility surprises from the financial system of the USA lead to a positive contagious volatility effect on the German system. However, this effect vanishes in column 4 when we include the full set of indicators in the conditional mean specification and , instead, volatility contagion emanating from Europe becomes statistically significant. Column 4 confirms the results in column 1 and 2. Given the lack of significance for

[16] The region specific factors are the corresponding volatility indices for the respective stock markets and yield curves.

[17] Harvey (1976) shows the advantages of modeling multiplicative heteroscedasticity in comparison to additive heteroscedasticity.

the Asia-Pacific region or the Emerging Markets, we drop these regions from the conditional mean and variance equation in column 5. This is supported by a Log Likelihood test of the models in column 4 and 5, which shows that excluding these four variables does not significantly alter the Log Likelihood and does not reduce the predictive power of the model.

4.1 Asymmetric effects

As our primary concern in this paper is contagion as a major contributory element to systemic risk, an important issue is how extreme movements in markets contribute to the spreading of risk between financial systems. In this section, we examine the relevance of asymmetric contagion effects on both extreme positive and negative movements in regional CDS indices using a difference-in-difference approach. More specifically, our aim is to investigate whether the German financial system responds differently to positive and negative shocks from other financial systems. To achieve this, we create two dummies that are equal to one for the largest positive and largest negative spread movements in the CDS indices for Europe and separately for the US. We denote these dummies as *Extreme Mov.* and interact these dummies with each of the two CDS indices. We show the results for the specifications including the dummies jointly with the interaction terms for the 10 percent largest positive and negative movements in the two indices in columns 1 to 2 and for the 5 percent largest positive and negative movements in columns 3 to 4 of Table 5. There is no evidence for asymmetric contagion effects from the European financial system. For the 10 percent largest positive changes in column 1, only the interaction term for the US is positive and significant, suggesting that extreme movements in the index for the US financial system have an asymmetric impact on the German index. However, this effect disappears for the 5 percent

Table 4

Contagion Effects on the German Financial System

$Germany_t$	(1)	(2)	(3)	(4)	(5)
			Conditional Mean		
$Europe_{t-1}$		0.14***		0.14***	0.15***
		(6.117)		(4.875)	(5.528)
US_{t-1}		0.10***		0.10***	0.10***
		(6.494)		(5.442)	(5.920)
$Asia\text{-}Pacific_{t-1}$		0.00		0.00	
		(0.254)		(0.180)	
$Emerging_{t-1}$		0.01		0.00	
		(0.694)		(0.016)	
$VDAX_t$	0.04***	0.04***	0.04***	0.04***	0.05***
	(4.616)	(4.796)	(4.606)	(4.879)	(5.298)
Yield $Curve_t$	-0.01***	-0.02***	-0.01***	-0.02***	-0.02***
	(-5.763)	(-6.548)	(-5.323)	(-5.318)	(-5.395)
iTraxx $non\text{-}fin_t$	0.32***	0.30***	0.33***	0.32***	0.30***
	(23.311)	(23.262)	(21.741)	(21.417)	(21.298)
Treasury $Rate_t$	-0.24***	-0.20***	-0.21***	-0.15***	-0.16***
	(-6.521)	(-5.453)	(-5.226)	(-3.516)	(-4.043)
Constant	-0.00	0.00	0.00	0.00*	0.00
	(-0.079)	(0.234)	(1.191)	(1.811)	(1.444)
			Conditional Variance		
ϵ^{EU}_{t-1}			0.13	0.48***	0.48***
			(1.285)	(4.564)	(4.937)
ϵ^{US}_{t-1}			0.51***	0.11	0.03
			(4.337)	(1.276)	(0.356)
ϵ^{AP}_{t-1}			0.08	0.06	
			(0.879)	(0.815)	
ϵ^{EM}_{t-1}			0.06	-0.01	
			(0.650)	(-0.145)	
$ARCH_{t-1}$	0.28***	0.28***	0.32***	0.32***	0.30***
	(7.766)	(7.639)	(6.353)	(5.893)	(3.011)
$GARCH_{t-1}$	0.71***	0.71***	0.67***	0.67***	0.68***
	(19.573)	(19.599)	(13.575)	(12.522)	(13.653)
Constant	0.00***	0.00***	-2.44**	-3.11***	-4.39***
	(3.997)	(3.986)	(-2.211)	(-3.156)	(-5.911)
No. of Obs.	1647	1647	1289	1289	1409
Log Likelihood	4042.05	4096.2	3134.7	3176.56	3486.34
Wald-Test	966.93***	1275.45***	821.25***	999.01***	1082.96***
LR - Test		108.31***		83.72***	-619.55
LR compared to		(1)		(3)	(4)

Note: z-statistics in parentheses.*** p<0.01, ** p<0.05, * p<0.1

largest spread movements shown in column 3. [18]

Table 5
Asymmetric Contagion Effects to the German Financial System

$Germany_t$	(1)	(2)	(3)	(4)	(5)
	90th Percentile	10th Percentile	95th Percentile	5th Percentile	Asymmetric GARCH
			Conditional Mean		
$Europe_{t-1}$	0.14***	0.16***	0.14***	0.15***	0.13***
	(4.305)	(4.953)	(4.721)	(5.161)	(5.117)
US_{t-1}	0.10***	0.11***	0.09***	0.11***	0.11***
	(4.446)	(5.250)	(4.204)	(5.355)	(6.112)
Extreme Mov. EU_{t-1}	-0.00	0.00	-0.01	0.01	
	(-0.034)	(0.409)	(-1.154)	(1.185)	
Extreme Mov. US_{t-1}	-0.01**	0.00	0.00	0.00	
	(-2.526)	(0.328)	(0.808)	(0.443)	
Extreme Mov.*$Europe_{t-1}$	0.00	-0.04	0.13	0.06	
	(0.017)	(-0.398)	(0.966)	(0.497)	
Extreme Mov.*US_{t-1}	0.13**	-0.01	0.02	0.01	
	(2.420)	(-0.252)	(0.251)	(0.097)	
Constant	0.00	0.00	0.00	0.00	0.00*
	(1.440)	(0.654)	(1.155)	(1.021)	(1.717)
			Conditional Variance		
ϵ_{t-1}^{EU}	0.48***	0.47***	0.49***	0.47***	0.09***
	(4.992)	(4.897)	(5.050)	(4.917)	(6.496)
ϵ_{t-1}^{US}	0.05	0.04	0.03	0.04	0.02
	(0.574)	(0.438)	(0.391)	(0.452)	(1.445)
$ARCH_{t-1}$	0.31***	0.31***	0.31***	0.31***	
	(6.226)	(6.177)	(6.092)	(6.179)	
$GARCH_{t-1}$	0.68***	0.68***	0.68***	0.68***	
	(13.697)	(13.347)	(13.580)	(13.375)	
$EARCHA_{t-1}$					0.07*
					(1.771)
$EARCH_{t-1}$					0.20***
					(5.707)
$EGARCH_{t-1}$					0.79***
					(23.266)
Constant	-4.21***	-4.34***	-4.28***	-4.33***	-0.47***
	(-5.707)	(-5.848)	(-5.840)	(-5.865)	(-2.675)
No of Obs.	1409	1409	1409	1409	1409

Note: Exogenous variables for stock volatility, the yield curve, iTraxx non-financials and the government bond rate are included but not shown. z-statistics in parentheses.*** $p<0.01$, ** $p<0.05$, * $p<0.1$

[18] We also specified a model containing the extreme positive and negative spread movements jointly. The results are largely identical but we refrain from showing them here due to the size of the table. However, the results can be obtained upon request from the authors.

In column 5 of Table 5 we also show the results for the asymmetric GARCH model suggested by Nelson (1991). In essence, the model allows us to test whether the index for the German financial system reacts differently to unanticipated positive increases than it does to unanticipated decreases. The significant coefficient of the EARCHA_{t-1} term suggests that the German index reacts to unanticipated increases and decreases in a different fashion. The positive coefficient implies that positive innovations (unanticipated increases in CDS) are more destabilizing than negative innovations. The effect appears weak (0.07) and is substantially smaller than the symmetric effect (0.20). In fact, the relative scales of the two coefficients imply that the symmetric effect dominates the asymmetric effect. This finding supports our decision to prefer an symmetric GARCH model in the remainder of our analysis.

4.2 Structural breaks

The literature provides evidence that contagion is a dynamic concept that changes particularly during crisis periods or after large shocks. Valdés (1996) and Calvo (1999) develop theoretical models of endogenous liquidity. Both authors argue that liquidity shocks lead to an increased correlation in asset prices. Masson (1998) shows how a crisis in one country can shift investors' expectations from a good to a bad equilibrium in another country evoking a downturn. As mentioned in the literature review, Hamao et al. (1990), King and Wadhwani (1990) and Malliaris and Urrutia (1992) find empirical evidence for increased contagion following the October crash in 1987. As suggested by Figure 1, during the financial crisis credit risk in the European, the German and the US financial system increased from around 10 basis points to several hundred basis points. This heightened risk of distress in the financial system may have led to a change in contagion effects during the crisis period. In order to analyze whether there was indeed a structural shift in the contagious effects that we have so far identified, we condition the mean and variance on a set of dummies. The first dummy (Crisis) is equal to one for the period from the 9th of August 2007 to the end of 2010. On this day, central banks intervened in the markets, providing liquidity for the first time.[19] The second dummy is equal to one starting on the 17th of October 2008, which is when the German parliament enacted the Financial Market Stabilization Fund (SoFFin) to restore confidence in the financial system.[20] Given that the deadline for applying for financial support elapsed at the end of 2010, the dummy is set to zero from that point onwards. We expect the crisis to have led to a surge in contagion between the financial systems given the information on common exposures of different financial institutions to distressed assets and distressed financial institutions. In contrast, through its provision of different support measures to the German financial system, SoFFin is likely to have reduced contagion to the German financial system (Stolz and Wedow, 2010).[21]

In order to further assess structural breaks in the contagion effects, we again interact the dummies with the indices for Europe and the US. We show the results for this difference-in-difference estimation in columns 1 to 3 of Table 6. With regard to the conditional mean equation, column 1 reports the results for the interaction terms with the crisis dummy, column 2 those for the interaction terms with the SoFFin dummy and in column 3 all the interaction terms are

[19] The United States Federal Reserve (Fed) injected a combined 43 billion USD, the European Central Bank (ECB) 156 billion euros (214.6 billion USD), and the Bank of Japan 1 trillion Yen (8.4 billion USD). Smaller amounts came from the central banks of Australia and Canada. We also used the publication date of the US stress-tests on the 7th of May 2009 as the end date for the crisis without materially changing the results.

[20] The enactment of the German support scheme was briefly preceded by the Troubled Asset Relief Program in the US on the 3rd of October. For this reason, it is difficult to disentangle the effects of the two schemes. However, as we are examining the contagion effects on the German system, we expect the effects from SoFFin to be relatively more important.

[21] The Chow-Test supports our expectations referring to the crisis and the creation of SoFFin. The test results confirm the existence of two structural breaks at the beginning of the crisis and around the creation of SoFFin.

jointly included. While the interaction terms Crisis*US_{t-1} and SoFFin*US_{t-1} are significant in columns 1 and 3, the interaction term for $Europe_{t-1}$ and the Crisis dummy only becomes significant when specified jointly with its interaction with the SoFFin dummy. This is not surprising, given the large overlap between the two dummies. The interaction terms confirm that there are statistically significant structural breaks in the contagion effects. During the crisis, contagion from the US financial system had a larger impact on the German financial system, while contagion did not occur during the pre-crisis period. In contrast, contagion from the European system seems to have been a factor even before the financial crisis, whereas during the crisis contagion from the European financial system was economically insignificant.[22] This evidence highlights the changing importance of contagion effects for the German financial system during the global financial crisis. Turning to the interaction terms with SoFFin, we observe that the establishment of SoFFin appears to have attenuated the contagion effect from the US financial system.

With regard to the dummies in the equation for the conditional variance, we also find that in the crisis period the volatility of the German index is higher in comparison to the non-crisis period, while the introduction of SoFFin appears to have lowered the volatility of German index.[23]

The bankruptcy of Lehman Brothers on the 15th of September 2008 clearly constitutes the peak of the financial crisis given its impact on other banks and the concern over possible losses resulting from its default. In our view, this event thus merits further investigation. We do this by creating a dummy equal to one for the days from the 9th of September 2008 when the merger talks with the Korea Development Bank were put on hold, until the 15th of

[22] Adding the coefficient of the crisis period (-0.17) and the coefficient for the non-crisis period (0.19) yields an overall effect of about 0.02.

[23] We included interaction terms with the indices for Europe and the US in the equation for the conditional variance but the maximum likelihood fails to converge to a maximum due to the number of variables included.

September. We again interact this dummy with the indices for Europe and the US and include them in our GARCH model. As shown in column 4 of Table 6, the interaction terms as well as the dummy in the volatility equation are insignificant.

In the light of the structural breaks in the contagion effects from the European and US financial system, we also run our empirical model in column 5 of Table 4 with a rolling regression analysis. This approach also allows more timely insights in the comovements of prices and may serve to inform macro-prudential supervisors about the development of systemic risk. Due to the need for a sufficiently large number of observations to estimate the GARCH model, the estimation window spans a period of two years. As a result of many missing observations in 2004, our first estimation window starts on the 22nd of November 2004 and ends on the 22nd November 2006. We then move the estimation window in daily steps to obtain coefficients for the EU and the US indices in the conditional mean and variance equation.[24] We show the results for the four coefficients in Figure A 1 of the appendix. For the EU, the coefficient rose in the middle of 2007 up to 0.2 before falling back to around 0.1. The confidence level indicates that the coefficient remained significant throughout the period. The coefficient of the US financial system index rose in the second half of 2007 and became statistically insignificant at the end of 2007. The coefficient reached its peak of about 0.15 late in 2008 around the collapse of Lehman Brothers. Regarding the coefficients in the conditional variance equation, the lower two figures confirm the evidence presented in Table 4 that only the EU index had a positive and significant impact. The effect remained largely constant over the crisis period.

[24] The estimates are obtained by shifting the estimation window by a single day and are subsequently collapsed to obtain weekly averages.

Table 6
Structural Breaks in Contagion

$Germany_t$	(1)	(2)	(3)	(4)
		Conditional Mean		
$Europe_{t-1}$	0.19***	0.15***	0.19***	0.19***
	(3.869)	(4.106)	(3.895)	(3.898)
US_{t-1}	0.05	0.14***	0.05	0.05
	(1.484)	(5.475)	(1.524)	(1.521)
$Crisis_t$	0.00*		0.00*	0.00*
	(1.769)		(1.885)	(1.906)
$SoFFin_t$		0.00	-0.00	-0.00
		(0.165)	(-1.282)	(-1.299)
$Lehman_t$				0.01
				(0.323)
$Crisis*Europe_{t-1}$	-0.09		-0.17**	-0.15**
	(-1.532)		(-2.436)	(-2.148)
$Crisis*US_{t-1}$	0.08**		0.21***	0.20***
	(2.145)		(4.048)	(3.612)
$SoFFin*Europe_{t-1}$		-0.03	0.09	0.08
		(-0.648)	(1.480)	(1.169)
$SoFFin*US_{t-1}$		-0.08**	-0.20***	-0.18***
		(-2.144)	(-4.096)	(-3.608)
$Lehman*Europe_{t-1}$				-0.48
				(-0.693)
$Lehman*US_{t-1}$				0.26
				(0.451)
		Conditional Variance		
ϵ^{EU}_{t-1}	0.38***	0.47***	0.30***	0.30***
	(3.435)	(5.255)	(3.009)	(2.925)
ϵ^{US}_{t-1}	0.01	0.06	0.02	0.01
	(0.144)	(0.830)	(0.269)	(0.107)
$Crisis_t$	0.47*		0.94***	0.94***
	(1.700)		(2.776)	(2.736)
$SoFFin_t$		-0.23	-0.67**	-0.65**
		(-1.079)	(-2.445)	(-2.361)
$Lehman_t$				1.62
				(0.917)
No of Obs	1409	1409	1409	1409

Note: Exogenous variables for stock volatility, the yield curve, iTraxx non-financials and the government bond rate as well as ARCH, GARCH and constants are included but not shown. z-statistics in parentheses.*** $p<0.01$, ** $p<0.05$, * $p<0.1$

4.3 The role of OTC dealers in spreading contagion

As discussed in the introduction, the highly concentrated market structure of OTC markets and particularly the CDS markets may give rise to contagion due to the sizeable derivative exposures and the lack of transparency regarding exposures between dealer banks. In this subsection, we thus make an attempt to disentangle the contagion effects emanating from dealer banks. In line with our previous approach, we calculate a total asset weighted index for the 28 dealer banks. Table 1 shows the geographical distribution of dealers. In addition, we drop dealer banks from the previously used indices for Europe and the US to obtain indices containing only financial that are not active OTC dealers. We include all three indices in our baseline specification.

Table 7 contains the results when we introduce an index for dealer banks (Dealers) separately. In column 1, we add the dealer index alongside the indices for the US and Europe, which now exclude the dealers. The results highlight that dealer banks are a particularly important source of contagion. The dealer index is significantly positive and the magnitude of its coefficient exceeds those of the indices for Europe and the US for non-dealer institutions. The contagion impact from the latter two indicators in the mean equation is insignificant. We continue to find evidence for contagion in the variance equation emanating from both regions. In column 2 we additionally consider the structural breaks discussed earlier. While the contagious effects emanating from the US non-dealer and dealer banks in general increases during the crisis period, the impact from European non-dealer banks is significant even prior to the start of the crisis. During the crisis the overall impact becomes negative. This finding supports the notion of negative contagion suggested by Jorion and Zhang (2007). They argue that negative contagion indicates competitive effects when the failure of a competitor improves the position of the remaining market participants. The finding of a negative effect implies that an improvement in the credit risk of European competitors leads to an increase in CDS spreads of the German financial system. We repeat the specifications in columns 3 and 4 but distinguish between dealers in the US and Europe. Overall, the evidence points to the dealers as a major source of contagion. During the crisis dealer and non-dealer financial institutions appear to have mattered most.

Table 7
Are dealer banks a source of contagion?

$Germany_t$	(1)	(2)	(3)	(4)
		Conditional Mean		
Europe excl. $Dealer_{t-1}$	0.04	0.10**	0.04	0.08*
	(1.305)	(2.111)	(1.166)	(1.824)
US excl. $Dealer_{t-1}$	0.03	0.00	0.03*	0.02
	(1.630)	(0.096)	(1.765)	(0.642)
$Dealer_{t-1}$	0.15***	0.11***		
	(5.468)	(2.645)		
US $Dealer_{t-1}$			0.06***	0.02
			(4.172)	(0.837)
European $Dealer_{t-1}$			0.08***	0.09***
			(3.230)	(2.987)
$Crisis_t$		0.00**		0.00**
		(2.113)		(2.176)
$SoFFin_t$		-0.00		-0.00
		(-1.533)		(-1.578)
Crisis*Europe excl. $Dealer_{t-1}$		-0.25***		-0.23**
		(-2.824)		(-2.159)
Crisis*US excl. $Dealer_{t-1}$		0.14***		0.12**
		(2.782)		(2.287)
Crisis*$Dealer_{t-1}$		0.15**		
		(2.009)		
Crisis*US $Dealer_{t-1}$				0.10**
				(2.175)
Crisis*European $Dealer_{t-1}$				0.02
				(0.327)
SoFFin*Europe excl. $Dealer_{t-1}$		0.15		0.12
		(1.563)		(0.952)
SoFFin*US excl. $Dealer_{t-1}$		-0.14***		-0.13***
		(-3.116)		(-3.025)
SoFFin*$Dealer_{t-1}$		-0.10		
		(-1.321)		
SoFFin*European $Dealer_{t-1}$				-0.01
				(-0.108)
SoFFin*US $Dealer_{t-1}$				-0.07
				(-1.584)

	Conditional Variance			
ϵ^{EU}_{t-1}	0.34***	0.19*	0.35***	0.18*
	(3.114)	(1.830)	(3.200)	(1.743)
ϵ^{US}_{t-1}	0.22**	0.10	0.20**	0.09
	(2.444)	(1.213)	(2.346)	(1.178)
ϵ^{Dealer}_{t}	-0.07	-0.03	-0.08	-0.02
	(-0.974)	(-0.344)	(-1.018)	(-0.206)
Crisis_t		1.16***		1.17***
		(3.189)		(3.265)
SoFFin_t		-0.76**		-0.76**
		(-2.546)		(-2.557)
No of Obs.	1409	1409	1409	1409

Note: Exogenous variables for stock volatility, the yield curve, iTraxx non-financials and the government bond rate as well as ARCH, GARCH and constants are included but not shown. z-statistics in parentheses.*** p<0.01, ** p<0.05, * p<0.1

4.4 Sectorial Contagion Effects : German Banks, Insurance Companies and Dealer Banks

Against the evidence that dealer banks are the group of financial institutions which account for most of the contagion to the German financial system, we next examine how different sectors of the German financial system are affected by contagion. For this purpose, we create separate indices for German banks, insurance companies and dealers and use each index as a dependent variable in our GARCH model. Table 8 shows the results for banks in column 1 to 2, insurers in columns 3 to 4 and the three dealers within the German financial system. The results mark important asymmetries across the three groups with regard to the sources of contagion from different regions and CDS dealers, which are masked when looking at a more aggregate index of the financial system. First, leaving dealers aside, the results in columns 1 and 3 suggest similar contagion effects from the European and the US financial system to German banks and insurers. However, controlling for dealers in column 2 and 4 highlights that these financials emerge as the most important source of contagion for both banks and insurance companies. Non-dealer banks in Europe and the US matter significantly less for German banks both economically and statistically. Interestingly, contagion effects from US banks to German insurers are of a higher magnitude than for German banks, potentially highlighting the interconnectedness of German insurers in the global financial system. With regard to the German dealer banks, column 5 and 6 confirm that the interconnectedness suggested by Duffie (2010) and Stulz (2010) can give rise to important contagion effects for this group of institutions. For this subgroup of banks, the only statistically relevant contagion effect stems from other dealer banks. The effect is statistically and economically significant. A rise by one percent in the CDS spreads of dealer banks leads to an increase of around 0.16 percent in the CDS spread of German dealer banks. This evidence is all the more important given that the German dealer banks are particularly relevant for the stability of the German financial system. We also differentiated between dealer banks headquartered in Europe and the US for the German dealer banks. The results in column 7 reveal contagion effects primarily from US dealer banks but not from European dealers. The evidence presented here suggests that the most relevant institutions for the spreading of risk across borders are OTC dealer banks. The evidence in Table 8 also sheds some more light on the effectiveness of SoFFin in respect to shielding the financial system from contagion. The dummy for SoFFin in the conditional variance equation is significant and positive only banks while remaining insignificant for insurance companies. This asymmetry may be related to the fact that SoFFin was primarily intended to support banks while insurance companies were not explicitly targeted.

We additionally investigate the contagious effects emanating from different sectors of the global financial system. For this purpose we divided the sample of all financial institutions located in Europe and USA into the three sectors non-dealer banks, insurance companies and dealer banks. The results shown in Table A 2 of the appendix confirm that the most relevant source of contagion for German banks in general and particularly the German dealer banks remain the global OTC dealers.

Table 8
Do Contagion Effects differ across Financial Sectors?

German Financials	(1) Banks	(2) Banks	(3) Insurer	(4) Insurer	(5) Dealer	(6) Dealer	(7) Dealer
				Conditional Mean			
Europe_{t-1}	0.13***		0.15***		0.06		
	(5.037)		(3.929)		(1.597)		
US_{t-1}	0.08***		0.21***		0.14***		
	(4.804)		(8.325)		(5.817)		
Europe excl. Dealer_{t-1}		0.04		0.08		0.02	0.03
		(1.283)		(1.608)		(0.435)	(0.850)
US excl. Dealer_{t-1}		0.02		0.13***		0.04*	0.04*
		(0.949)		(5.500)		(1.924)	(1.740)
Dealer_{t-1}		0.14***		0.16***		0.16***	
		(5.282)		(3.989)		(4.718)	
Europ. Dealer_{t-1}							0.02
							(0.702)
US Dealer_{t-1}							0.10***
							(4.873)
Constant	0.00	0.00	0.00	0.00	-0.00	-0.00	-0.00
	(0.881)	(0.836)	(0.057)	(0.042)	(-0.472)	(-0.559)	(-0.605)
				Conditional Variance			
ϵ_{t-1}^{EU}	0.33***	0.32***	0.20***	0.20***	-0.01	-0.02	-0.03
	(3.141)	(3.148)	(3.959)	(4.102)	(-0.237)	(-0.338)	(-0.395)
ϵ_{t-1}^{US}	0.09	0.09	0.04	0.04	0.20***	0.23***	0.23***
	(1.113)	(1.164)	(0.962)	(1.079)	(2.779)	(2.827)	(2.767)
Crisis_t	0.94***	0.94***	1.04***	1.03***	2.66***	2.71***	2.75***
	(2.802)	(2.840)	(4.858)	(4.832)	(8.551)	(7.977)	(8.020)
SoFFin_t	-0.85***	-0.88***	-0.22	-0.22	-0.75***	-0.76***	-0.75***
	(-3.090)	(-3.246)	(-1.154)	(-1.111)	(-2.980)	(-2.807)	(-2.747)
ARCH_{t-1}	0.33***	0.32***	0.60***	0.61***	0.37***	0.47***	0.46***
	(3.088)	(3.218)	(7.973)	(8.105)	(4.410)	(8.126)	(8.171)
GARCH_{t-1}	0.63***	0.61***	0.39***	0.38***	0.50***	0.52***	0.53***
	(11.614)	(11.288)	(5.165)	(5.110)	(8.811)	(9.052)	(9.333)
Constant	-5.26***	-5.34***	-3.11***	-2.97***	-7.94***	-7.73***	-7.86***
	(-5.458)	(-5.619)	(-5.263)	(-5.056)	(-9.161)	(-8.092)	(-8.127)
No. of Obs.	1409	1409	1409	1409	1409	1409	1409

Note: Exogenous variables for stock volatility, the yield curve, iTraxx non-financials and the government bond rate are included but not shown. z-statistics in parentheses.*** p<0.01, ** p<0.05, * p<0.1

4.5 Robustness: Additional Control Variables

A potential concern for the robustness of our analysis is that we may have missed potentially important variables which were at the root of the global crisis and which, through their omission, give rise to the results presented so far. Among the potential variables that immediately come to mind are the subprime mortgage securities that led to the sizeable writedowns by banks. We thus also include the ABX and CMBX price indices for AAA rated residential and commercial mortgage backed securities in the specifications in Table 9 and repeat the estimations. [25] While each of the two indices is significant and - as expected - negative, the results in Table 9 confirm our previous results. Dealer banks from the US and from Europe are the most relevant source of contagion for German banks and, in particular, for the German dealer banks. In contrast, for German insurance companies, US financial intermediaries are relatively more important, while European financial intermediaries are not statistically significant.

5 Conclusion

In this paper, we have examined international contagion effects on the German financial system within a GARCH model. We find that contagion from the US and the European financial system matter most for banks and insurance companies in Germany. While the magnitude of contagion from the two regions is comparable, contagion from the US affects the German financial system only in terms of the level of credit risk, whereas the European financial system also leads to an increase in the conditional variance. Furthermore, our results suggest that introducing public support schemes partially shielded German banks but not insurance companies from contagious effects. More importantly, our results highlight differences in the contagion effects between the different sectors of the German financial system. Banks and insurance companies are equally affected by dealer banks but German insurance companies

[25] The estimation period differs with the other Tables in this paper as we could only obtain data on the ABX and CMBX starting in 2006. The results are thus not fully comparable.

Table 9

Additional Control Variables: ABX and CMBX Indices

German Financials	(1) Dealer	(2) Insurance	(3) Banks	(4) Dealer	(5) Insurance	(6) Banks
			Conditional Mean			
Europe excl. Dealer_{t-1}	-0.09	0.04	-0.03	0.00	0.06	-0.00
	(-1.302)	(0.540)	(-0.673)	(0.010)	(0.886)	(-0.102)
US excl. Dealer_{t-1}	0.06**	0.13***	0.02	0.07**	0.13***	0.02
	(1.992)	(5.381)	(1.297)	(2.400)	(5.512)	(1.281)
Europ. Dealer_{t-1}	0.12**	0.06	0.11***	0.04	0.05	0.09***
	(2.162)	(1.127)	(3.240)	(0.949)	(1.117)	(2.996)
US Dealer_{t-1}	0.10***	0.11***	0.06***	0.09***	0.09***	0.05***
	(4.096)	(4.363)	(3.758)	(3.871)	(3.747)	(3.455)
CMBX-AAA_t	-0.39***	-0.35***	-0.14***			
	(-4.197)	(-3.528)	(-2.971)			
ABX-AAA_t				-0.76***	-0.58***	-0.26***
				(-7.195)	(-5.361)	(-4.925)
Treasury Rate_t	-0.48***	-0.63***	-0.23***	-0.42***	-0.52***	-0.23***
	(-6.741)	(-8.414)	(-5.182)	(-6.536)	(-7.239)	(-5.369)
VDAX_t	0.10***	0.10***	0.08***	0.08***	0.08***	0.06***
	(6.518)	(6.301)	(7.297)	(6.111)	(5.255)	(6.096)
Yield Curve_t	-0.02***	-0.01*	-0.01***	-0.02***	-0.01*	-0.02***
	(-3.919)	(-1.753)	(-4.896)	(-4.222)	(-1.781)	(-4.846)
iTraxx non-fin_t	0.41***	0.34***	0.24***	0.35***	0.32***	0.23***
	(17.725)	(15.673)	(16.215)	(16.412)	(15.219)	(15.538)
Constant	0.00	0.00	0.00**	0.00	0.00	0.00*
	(0.844)	(0.031)	(2.102)	(0.368)	(0.202)	(1.776)
			Conditional Variance			
ϵ_{t-1}^{EU}	0.36**	0.30***	0.51***	0.10	0.24***	0.34***
	(2.267)	(3.759)	(4.647)	(0.904)	(4.273)	(3.150)
ϵ_{t-1}^{US}	0.17	0.04	0.09	0.21*	0.02	0.15*
	(1.462)	(0.681)	(1.177)	(1.875)	(0.533)	(1.809)
Crisis_t	0.81*	0.68**	-0.09	1.82***	0.89***	0.49
	(1.713)	(2.381)	(-0.274)	(4.152)	(3.877)	(1.413)
SoFFin_t	-0.54	-0.19	-0.71***	-0.65**	-0.25	-0.84***
	(-1.574)	(-0.852)	(-2.673)	(-2.102)	(-1.301)	(-3.021)
ARCH_{t-1}	0.32***	0.41***	0.35***	0.41***	0.56***	0.39***
	(5.825)	(5.694)	(5.724)	(6.672)	(6.079)	(6.436)
GARCH_{t-1}	0.66***	0.58***	0.64***	0.52***	0.40***	0.60***
	(12.195)	(8.167)	(10.595)	(9.507)	(4.739)	(9.758)
Constant	-4.15***	-2.95***	-2.56***	-6.60***	-1.91***	-4.10***
	(-3.121)	(-3.669)	(-2.829)	(-5.446)	(-2.735)	(-4.348)
No. of Obs.	1058	1058	1058	1142	1142	1142

Note: z-statistics in parentheses.*** p<0.01, ** p<0.05, * p<0.1

experience contagion effects from both European and US financial intermediaries that are not active as dealers, while German banks are not affected. More importantly, German dealer banks, which are arguably the systemically most important financial institutions in the German financial system, experience the economically largest impact from other dealers but appear largely immune with regard to contagion from other financial intermediaries. This evidence confirms the notion that the close and highly concentrated network formed by dealer banks poses a potential threat to the stability of the financial system.

More generally, the evidence found in this paper implies a number of relevant policy insights. First, contagion not only within a financial system but also internationally is an important risk factor that should be monitored by macroprudential supervisors. Second, contagion matters not only for the banking sector but can be at least equally important for other parts of the financial system such as the insurance sector. Third, the finding that OTC dealer banks are the most important source of contagion effects for the German financial system highlights the need for more intensive monitoring and regulation of these banks. The monitoring of their interlinkages should not be limited to exposures within the OTC derivative market but should encompass all exposure across different markets. Furthermore, the recent initiatives from the Financial Stability Board on the regulation of the OTC market may alleviate contagion effects in this market. More specifically, the FSB aims to mitigate systemic risk by enhancing transparency in the market through the trading of all standardized derivative contracts on exchanges or electronic platforms. Finally, the empirical approach presented here may serve as a monitoring tool for the continuous supervision of systemic risk. For this purpose, the model needs to be continually adapted to the emerging risks to the German financial system.

References

Acharya, V. (2009). A Theory of Systemic Risk and Design of Prudential Bank Regulation. *Working Paper*.

Acharya, V., L. H. Pedersen, T. Philippon, and M. Richardson (2010). Measuring Systemic Risk. *Working Paper*.

Aharony, J. and I. Swary (1983). Effects of bank failures: Evidence from capital markets. *Journal of Business 56*(3), 305–322.

Alexander, C. and A. Kaeck (2008). Regime dependent determinants of credit default swap spreads. *Journal of Banking and Finance 32*(6), 1008–1021.

Allen, F. and E. Carletti (2006). Credit risk transfer and contagion. *Journal of Monetary Economics 53*, 89–111.

Bae, K.-H., G. A. Karolyi, and R. M. Stulz (2003). A new approach to measuring financial contagion. *Review of Financial Studies 16*(3), 717–799.

Baur, D. G. (2011). Financial contagion and the real economy. *Journal of Banking and Finance*.

Beine, M., A. Cosma, and R. Vermeulen (2010). The dark side of global integration: Increasing tail dependence. *Journal of Banking and Finance 34*(1), 184–192.

Blanco, R., S. Brennan, and I. W. Marsh (2005). An empirical analysis of the dynamic relation between investment-grade bonds and credit default swaps. *Journal of Finance 60*(5).

Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics 31*.

British Bankers' Association (2006). Credit Derivatives Report 2006. *BBA Report*, 1–6.

Calvo, G. (1999). Contagion in emerging markets:when wall street is a carrier. *University of Maryland Mimeo*.

Claessens, S. and K. J. Forbes (Eds.) (2001). *International Financial Contagion*. Kluwer Academic Publishers, Norwell, MA.

Clark, J. A. and S. B. Perfect (1996). The economic effects of client losses on otc bank derivative dealers: Evidence from the capital market. *Journal of Money, Credit and Banking 28*(3).

De Bandt, O., P. Hartmann, and J. L. Peydró (2010). *The Oxford Handbook of Banking*, Chapter 25, pp. 633–672. Oxford University Press.

De Nicolo, G. and M. L. Kwast (2002). Systemic Risk and Financial Consolidation: Are they related? *Journal of Banking and Finance 26*, 861–880.

Duffie, D. (2010). The failure mechanics of dealer banks. *Journal of Political Perspectives 24*(1).

Engle, R. (1982). Autoregressive conditional heteroscedasticity with estimates of variance of united kingdom inflation. *Econometrica 50*.

European Central Bank (2010, April). Report on the lessons learned from the financial crisis with regard to the functioning of European financial market infrastructures. Technical report.

Fama, E. (1984). The information in the term structure. *Journal of Financial Economics 13*(4), 509–528.

Fenn, G. W. and R. A. Cole (1994). Announcements of asset-quality problems and contagion in the life insurance industry. *Journal of Financial Economics 35*(2), 181–198.

Forbes, K. and R. Rigobon (2002). No Contagion, Only Interdependence. Measuring Stock Market Comovements. *The Journal of Finance 57*(5).

Fry, R., V. L. Martin, and C. Tang (2010). A new class of tests of contagion with applications. *Journal of Business and Economic Statistics 28*(3), 423–437.

Goldstein, I. and A. Pauzner (2004). Contagion of self-fulfilling financial crises due to diversification of investment portfolios. *Journal of Economic Theory 119*, 151–183.

Hamao, Y., R. Masulis, and V. K. Ng (1990). Correlations in price changes and volatility across international stock markets. *Review of Financial Studies 3*(1), 281–307.

Hartmann, P., S. Straetmans, and C. G. de Vries (2004). Asset market linkages in crisis periods. *The Review of Economics and Statistics 86*(1), 313–326.

Harvey, A. C. (1976). Estimating regression models with multiplicative heteroscedasticity. *Econometrica 44*(3), 461–465.

Houweling, P. and T. Vorst (2005). Pricing default swaps: Empirical evidence. *Journal of International Money and Finance 24*, 1220–1225.

International Monetary Fund (2009). Lessons from the global crisis for macroeconomic policy. Technical report.

Jorion, P. and G. Zhang (2007). Good and bad credit contagion: Evidence from credit default swaps. *Journal of Financial Economics 84*(3).

Jorion, P. and G. Zhang (2009). Credit contagion from counterparty risk. *Journal of Finance 64*(5).

Kaufman, G. (1994). Bank Contagion: A Review of the Theory and Evidence. *Journal of Financial Services Research*, 123–150.

King, M. A. and S. Wadhwani (1990). Transmission of volatility between stock markets. *The Review of Financial Studies 3*(1), 5–33.

Malliaris, A. G. and J. L. Urrutia (1992). The International Crash of October 1987: Causality Tests. *Journal of Financial and Quantitative Analysis 27*(3).

Masson, P. (1998). Contagion:monsoonal effects, spillovers, and jumps between multiple equilibria. *IMF Working Paper* (142).

Mayordomo, S., Pena, and E. S. Schwartz (2010). Are all credit default swap databases equal? *NBER Working Paper* (16590).

Moshirian, F. (2011). The global financial crisis and the evolution of markets, institutions and regulation. *Journal of Banking and Finance 35*(3), 502–511.

Nelson, D. B. (1991). Conditional heteroskedasticity in asset returns: A new approach. *Econometrica 59*(2), 347–370.

Polonchek, J. and R. K. Miller (1999). Contagion effects in the insurance industry. *The Journal of Risk and Insurance 66*(3), 459–475.

Pozdena, R. (1991, October). Is Banking Really Prone to Panics? *FRBSF Weekly Letter, Federal Reserve Bank of San Francisco*.

Schroeder, M. and M. Schueller (2003). Systemic Risk in European Banking - evidence from Bivariate GARCH Models. *ZEW Discussion Paper 03*(11).

Slovin, M. B., M. E. Sushka, and J. Polonchek (1999). An analysis of contagion and competitive effects at commercial banks. *Journal of Financial Economics 54*(2), 197–225.

Solnik, B. (1974). The international pricing of risk: An empirical investigation of the world capital market structure. *Journal of Finance 29*(2).

Stolz, S. and M. Wedow (2010). Extraordinary measures in extraordinary times: Public measures in support of the financial sector in the EU and the United States. *European Central Bank Occasional Paper 117*.

Stulz, R. M. (2010). Credit default swaps and the credit crisis. *Journal of Political Perspectives 24*(1).

Svensson, L. E. O. (1994). Estimating and interpreting forward rates: Sweden 1992 -1994. *IMF Working Paper* (114).

Swary, I. (1986). Stock Market Reaction to Regulatory Action in the Continental Illinois Crisis. *Journal of Business 59*(3), 451–473.

Valdés, R. (1996). Emerging market contagion: Evidence and theory. *Central Bank of Chile Mimeo*.

Wagner, W. (2010). Diversification at financial institutions and systemic crises. *Journal of Financial Intermediation 19*, 373–386.

6 Appendix

Table A 1
Granger Causality Tests

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable	Germany	Germany	Germany	Germany	Europe	US	Asia-Pacific	Emerging Mkt.
				Panel I: Indicators incl. CDS dealers				
Germany_{t-1}	0.05	0.09***	0.17***	0.17***	0.19***	-0.12***	0.31***	0.21***
	(1.478)	(3.789)	(7.995)	(7.542)	(6.076)	(-3.818)	(9.992)	(7.488)
Europe_{t-1}	0.15***				0.08***			
	(4.681)				(2.590)			
US_{t-1}		0.13***				0.20***		
		(6.900)				(7.934)		
$\text{Asia-Pacific}_{t-1}$			-0.02				-0.07***	
			(-1.346)				(-2.837)	
$\text{Emerging Mkt.}_{t-1}$				-0.01				-0.04
				(-0.596)				(-1.466)
No. of Obs.	1,647	1,647	1,647	1,645	1,647	1,463	1,426	1,461
R^2	0.330	0.340	0.322	0.321	0.337	0.313	0.239	0.155
				Panel II: Indicators excl. CDS dealers				
Dealer_{t-1}	0.18***				0.44***	0.04	0.30***	0.22***
	(8.011)				(15.667)	(1.056)	(8.833)	(9.440)
Germany_{t-1}	-0.02							
	(-0.595)							
Europe_{t-1}					-0.29***			
					(-8.317)			
US_{t-1}						0.05*		
						(1.870)		
$\text{Asia-Pacific}_{t-1}$							-0.13***	
							(-5.251)	
$\text{Emerging Mkt.}_{t-1}$								-0.05**
								(-2.074)
No. of Obs.	1,647				1,647	1,463	1,426	1,461
R^2	0.201				0.340	0.166	0.175	0.173

Note: For each column, we only present results for the country or regional financial system indicators while exogenous variables for the CDS index of non-financial firms, the yield curve and a stock market volatility index specific to each country or region are also included but not shown. Panel I shows the financial system indicators based on all financial entities in the system. In Panel II dealer banks were excluded from the financial system indicators used as right hand side variables. As a result, the country or region specific indicators only contain non-dealer financial entities and dealer banks are included in a separated index. All variables are specified as log differences.

Figure A 1. Contagion Effects from Europe and the US to the German Financial System, Rolling GARCH Model

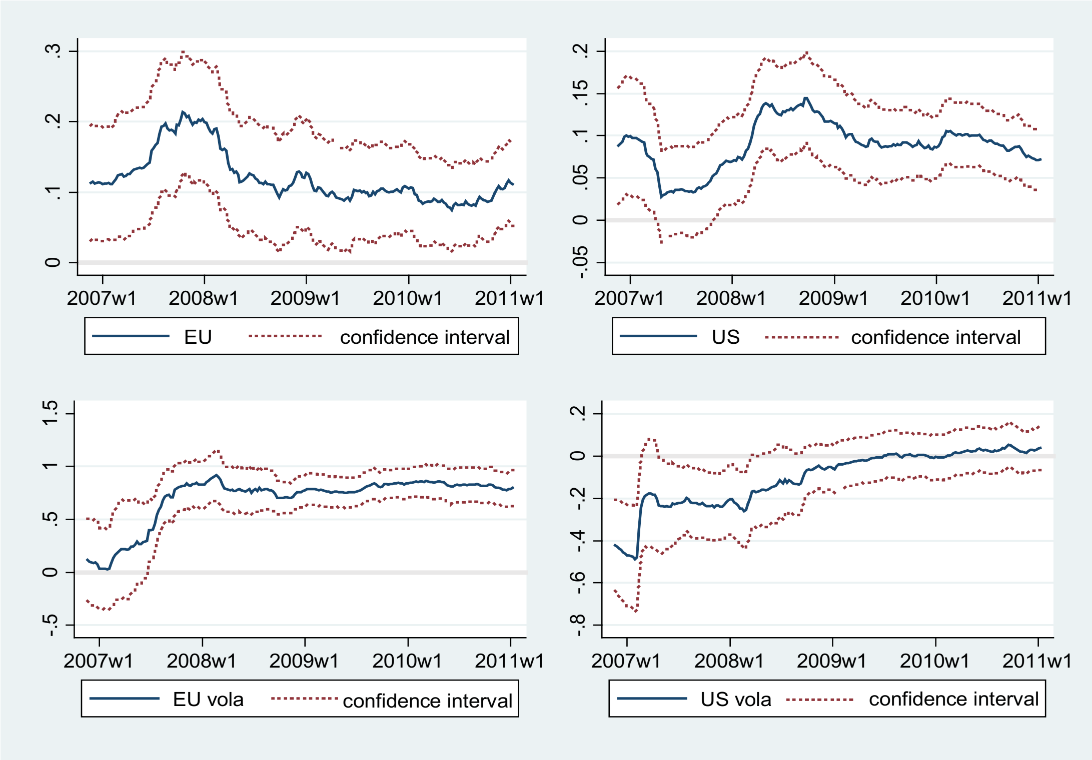


Table A 2

Contagion Effects from different Financial Sectors

	(1)	(2)	(3)	(4)
Dependent Variable	Banks	Insurers	Dealer	Banks excl. Dealer
	Conditional Mean			
$Banks_{t-1}$	-0.01	0.13***	-0.02	0.06**
	(-0.231)	(3.224)	(-0.655)	(2.479)
$Insurers_{t-1}$	0.04*	0.11***	0.07***	0.05***
	(1.742)	(3.125)	(2.715)	(3.040)
$Dealer_{t-1}$	0.15***	0.24***	0.16***	0.11***
	(6.400)	(5.164)	(4.806)	(5.606)
$VDAX_t$	0.05***	0.21***	0.06***	0.05***
	(5.630)	(9.339)	(5.941)	(5.901)
Yield $Curve_t$	-0.01***	-0.02**	-0.02***	-0.01***
	(-5.000)	(-2.355)	(-4.872)	(-3.539)
iTraxx non-fin_t	0.24***	0.30***	0.33***	0.20***
	(18.414)	(13.061)	(18.819)	(16.463)
Treasury $Rate_t$	-0.17***	-0.72***	-0.17***	-0.18***
	(-4.489)	(-7.855)	(-3.791)	(-5.138)
Constant	0.00	0.00	-0.00	0.00
	(0.856)	(0.205)	(-0.492)	(1.304)
	Conditional Variance			
ϵ_{t-1}^{EU}	0.30***	0.37***	-0.02	0.45***
	(2.999)	(9.336)	(-0.296)	(4.031)
ϵ_{t-1}^{US}	0.11	-0.30***	0.22***	-0.04
	(1.417)	(-19.958)	(3.057)	(-0.577)
$Crisis_t$	0.94***	-2.73***	2.69***	0.11
	(2.825)	(-8.811)	(8.553)	(0.339)
$SoFFin_t$	-0.88***	0.27	-0.77***	-0.77***
	(-3.210)	(0.883)	(-3.055)	(-2.669)
$ARCH_{t-1}$	0.33***	0.21***	0.38***	0.40**
	(3.240)	(11.905)	(4.420)	(2.379)
$GARCH_{t-1}$	0.62***	0.69***	0.50***	0.71***
	(11.406)	(41.727)	(8.965)	(13.831)
Constant	-5.27***	-6.08***	-7.77***	-4.72***
	(-5.529)	(-18.129)	(-8.949)	(-4.859)
No of Obs.	1409	1409	1409	1409

Note: The exogenous variable "Banks" includes all banks in the sample that are not headquartered in Germany and that are not active dealers. The exogenous variable "Insurers" includes all insurance companies in the sample that are not headquartered in Germany. The variable dealer contains all dealers except German dealers. z-statistics in parentheses.*** p<0.01, ** p<0.05, * p<0.1

The following Discussion Papers have been published since 2010:

Series 1: Economic Studies

01	2010	Optimal monetary policy in a small open economy with financial frictions	Rossana Merola
02	2010	Price, wage and employment response to shocks: evidence from the WDN survey	Bertola, Dabusinskas Hoeberichts, Izquierdo, Kwapil Montornès, Radowski
03	2010	Exports versus FDI revisited: Does finance matter?	C. M. Buch, I. Kesternich A. Lipponer, M. Schnitzer
04	2010	Heterogeneity in money holdings across euro area countries: the role of housing	Ralph Setzer Paul van den Noord Guntram Wolff
05	2010	Loan supply in Germany during the financial crises	U. Busch M. Scharnagl, J. Scheithauer
06	2010	Empirical simultaneous confidence regions for path-forecasts	Òscar Jordà, Malte Knüppel Massimiliano Marcellino
07	2010	Monetary policy, housing booms and financial (im)balances	Sandra Eickmeier Boris Hofmann
08	2010	On the nonlinear influence of Reserve Bank of Australia interventions on exchange rates	Stefan Reitz Jan C. Ruelke Mark P. Taylor
09	2010	Banking and sovereign risk in the euro area	S. Gerlach A. Schulz, G. B. Wolff
10	2010	Trend and cycle features in German residential investment before and after reunification	Thomas A. Knetsch

11	2010	What can EMU countries' sovereign bond spreads tell us about market perceptions of default probabilities during the recent financial crisis?	Niko Dötz Christoph Fischer
12	2010	User costs of housing when households face a credit constraint – evidence for Germany	Tobias Dümmler Stephan Kienle
13	2010	Extraordinary measures in extraordinary times – public measures in support of the financial sector in the EU and the United States	Stéphanie Marie Stolz Michael Wedow
14	2010	The discontinuous integration of Western Europe's heterogeneous market for corporate control from 1995 to 2007	Rainer Frey
15	2010	Bubbles and incentives: a post-mortem of the Neuer Markt in Germany	Ulf von Kalckreuth Leonid Silbermann
16	2010	Rapid demographic change and the allocation of public education resources: evidence from East Germany	Gerhard Kempkes
17	2010	The determinants of cross-border bank flows to emerging markets – new empirical evidence on the spread of financial crisis	Sabine Herrmann Dubravko Mihaljek
18	2010	Government expenditures and unemployment: a DSGE perspective	Eric Mayer, Stéphane Moyen Nikolai Stähler
19	2010	NAIRU estimates for Germany: new evidence on the inflation-unemployment trade-off	Florian Kajuth
20	2010	Macroeconomic factors and micro-level bank risk	Claudia M. Buch Sandra Eickmeier, Esteban Prieto

21	2010	How useful is the carry-over effect for short-term economic forecasting?	Karl-Heinz Tödter
22	2010	Deep habits and the macroeconomic effects of government debt	Rym Aloui
23	2010	Price-level targeting when there is price-level drift	C. Gerberding R. Gerke, F. Hammermann
24	2010	The home bias in equities and distribution costs	P. Harms M. Hoffmann, C. Ortseifer
25	2010	Instability and indeterminacy in a simple search and matching model	Michael Krause Thomas Lubik
26	2010	Toward a Taylor rule for fiscal policy	M. Kliem, A. Kriwoluzky
27	2010	Forecast uncertainty and the Bank of England interest rate decisions	Guido Schultefrankenfeld
01	2011	Long-run growth expectations and "global imbalances"	M. Hoffmann M. Krause, T. Laubach
02	2011	Robust monetary policy in a New Keynesian model with imperfect interest rate pass-through	Rafael Gerke Felix Hammermann
03	2011	The impact of fiscal policy on economic activity over the business cycle – evidence from a threshold VAR analysis	Anja Baum Gerrit B. Koester
04	2011	Classical time-varying FAVAR models – estimation, forecasting and structural analysis	S. Eickmeier W. Lemke, M. Marcellino

05	2011	The changing international transmission of financial shocks: evidence from a classical time-varying FAVAR	Sandra Eickmeier Wolfgang Lemke Massimiliano Marcellino
06	2011	FiMod – a DSGE model for fiscal policy simulations	Nikolai Stähler Carlos Thomas
07	2011	Portfolio holdings in the euro area – home bias and the role of international, domestic and sector-specific factors	Axel Jochem Ute Volz
08	2011	Seasonality in house prices	F. Kajuth, T. Schmidt
09	2011	The third pillar in Europe: institutional factors and individual decisions	Julia Le Blanc
10	2011	In search for yield? Survey-based evidence on bank risk taking	C. M. Buch S. Eickmeier, E. Prieto
11	2011	Fatigue in payment diaries – empirical evidence from Germany	Tobias Schmidt
12	2011	Currency blocs in the 21st century	Christoph Fischer
13	2011	How informative are central bank assessments of macroeconomic risks?	Malte Knüppel Guido Schultefrankenfeld
14	2011	Evaluating macroeconomic risk forecasts	Malte Knüppel Guido Schultefrankenfeld
15	2011	Crises, rescues, and policy transmission through international banks	Claudia M. Buch Cathérine Tahmee Koch Michael Koetter
16	2011	Substitution between net and gross settlement systems – A concern for financial stability?	Ben Craig Falko Fecht

17	2011	Recent developments in quantitative models of sovereign default	Nikolai Stähler
18	2011	Exchange rate dynamics, expectations, and monetary policy	Qianying Chen
19	2011	An information economics perspective on main bank relationships and firm R&D	D. Hoewer T. Schmidt, W. Sofka
20	2011	Foreign demand for euro banknotes issued in Germany: estimation using direct approaches	Nikolaus Bartzsch Gerhard Rösl Franz Seitz
21	2011	Foreign demand for euro banknotes issued in Germany: estimation using indirect approaches	Nikolaus Bartzsch Gerhard Rösl Franz Seitz
22	2011	Using cash to monitor liquidity – implications for payments, currency demand and withdrawal behavior	Ulf von Kalckreuth Tobias Schmidt Helmut Stix
23	2011	Home-field advantage or a matter of ambiguity aversion? Local bias among German individual investors	Markus Baltzer Oscar Stolper Andreas Walter
24	2011	Monetary transmission right from the start: on the information content of the eurosystem's main refinancing operations	Puriya Abbassi Dieter Nautz
25	2011	Output sensitivity of inflation in the euro area: indirect evidence from disaggregated consumer prices	Annette Fröhling Kirsten Lommatzsch
26	2011	Detecting multiple breaks in long memory: the case of U.S. inflation	Uwe Hassler Barbara Meller

27	2011	How do credit supply shocks propagate internationally? A GVAR approach	Sandra Eickmeier Tim Ng
28	2011	Reforming the labor market and improving competitiveness: an analysis for Spain using FiMod	Tim Schwarzmüller Nikolai Stähler
29	2011	Cross-border bank lending, risk aversion and the financial crisis	Cornelia Düwel, Rainer Frey Alexander Lipponer
30	2011	The use of tax havens in exemption regimes	Anna Gumpert James R. Hines, Jr. Monika Schnitzer
31	2011	Bank-related loan supply factors during the crisis: an analysis based on the German bank lending survey	Barno Blaes
32	2011	Evaluating the calibration of multi-step-ahead density forecasts using raw moments	Malte Knüppel
33	2011	Optimal savings for retirement: the role of individual accounts and disaster expectations	Julia Le Blanc Almuth Scholl
34	2011	Transitions in the German labor market: structure and crisis	Michael U. Krause Harald Uhlig

Series 2: Banking and Financial Studies

01	2010	Deriving the term structure of banking crisis risk with a compound option approach: the case of Kazakhstan	Stefan Eichler Alexander Karmann Dominik Maltritz
02	2010	Recovery determinants of distressed banks: Regulators, market discipline, or the environment?	Thomas Kick Michael Koetter Tigran Poghosyan
03	2010	Purchase and redemption decisions of mutual fund investors and the role of fund families	Stephan Jank Michael Wedow
04	2010	What drives portfolio investments of German banks in emerging capital markets?	Christian Wildmann
05	2010	Bank liquidity creation and risk taking during distress	Berger, Bouwman Kick, Schaeck
06	2010	Performance and regulatory effects of non-compliant loans in German synthetic mortgage-backed securities transactions	Gaby Trinkaus
07	2010	Banks' exposure to interest rate risk, their earnings from term transformation, and the dynamics of the term structure	Christoph Memmel
08	2010	Completeness, interconnectedness and distribution of interbank exposures – a parameterized analysis of the stability of financial networks	Angelika Sachs
09	2010	Do banks benefit from internationalization? Revisiting the market power-risk nexus	C. M. Buch C. Tahmee Koch, M. Koetter

10	2010	Do specialization benefits outweigh concentration risks in credit portfolios of German banks?	Rolf Böve Klaus Düllmann Andreas Pfingsten
11	2010	Are there disadvantaged clienteles in mutual funds?	Stephan Jank
12	2010	Interbank tiering and money center banks	Ben Craig, Goetz von Peter
13	2010	Are banks using hidden reserves to beat earnings benchmarks? Evidence from Germany	Sven Bornemann, Thomas Kick Christoph Memmel Andreas Pfingsten
14	2010	How correlated are changes in banks' net interest income and in their present value?	Christoph Memmel
01	2011	Contingent capital to strengthen the private safety net for financial institutions: Cocos to the rescue?	George M. von Furstenberg
02	2011	Gauging the impact of a low-interest rate environment on German life insurers	Anke Kablau Michael Wedow
03	2011	Do capital buffers mitigate volatility of bank lending? A simulation study	Frank Heid Ulrich Krüger
04	2011	The price impact of lending relationships	Ingrid Stein
05	2011	Does modeling framework matter? A comparative study of structural and reduced-form models	Yalin Gündüz Marliese Uhrig-Homburg
06	2011	Contagion at the interbank market with stochastic LGD	Christoph Memmel Angelika Sachs, Ingrid Stein

07	2011	The two-sided effect of financial globalization on output volatility	Barbara Meller
08	2011	Systemic risk contributions: a credit portfolio approach	Klaus Düllmann Natalia Puzanova
09	2011	The importance of qualitative risk assessment in banking supervision before and during the crisis	Thomas Kick Andreas Pfingsten
10	2011	Bank bailouts, interventions, and moral hazard	Lammertjan Dam Michael Koetter
11	2011	Improvements in rating models for the German corporate sector	Till Förstemann
12	2011	The effect of the interbank network structure on contagion and common shocks	Co-Pierre Georg
13	2011	Banks' management of the net interest margin: evidence from Germany	Christoph Memmel Andrea Schertler
14	2011	A hierarchical Archimedean copula for portfolio credit risk modelling	Natalia Puzanova
15	2011	Credit contagion between financial systems	Natalia Podlich Michael Wedow

Visiting researcher at the Deutsche Bundesbank

The Deutsche Bundesbank in Frankfurt is looking for a visiting researcher. Among others under certain conditions visiting researchers have access to a wide range of data in the Bundesbank. They include micro data on firms and banks not available in the public. Visitors should prepare a research project during their stay at the Bundesbank. Candidates must hold a PhD and be engaged in the field of either macroeconomics and monetary economics, financial markets or international economics. Proposed research projects should be from these fields. The visiting term will be from 3 to 6 months. Salary is commensurate with experience.

Applicants are requested to send a CV, copies of recent papers, letters of reference and a proposal for a research project to:

Deutsche Bundesbank
Personalabteilung
Wilhelm-Epstein-Str. 14

60431 Frankfurt
GERMANY