Counterparty risk and market maker monopoly during the 2007-2009 financial crisis *

Stefan Petry †

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†Address for correspondence: University of Melbourne, Department of Finance, 198 Berkeley Street, 3010 Victoria, Australia. Phone: +61 (3) 9035 8174; email: spetry@unimelb.edu.au.

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Abstract

This paper examines the pricing of counterparty risk in retail financial markets during the 2007-2009 financial crisis. I exploit the German Securities Law which treats retail structured products as unsecured bonds. Investors in those securities face the default risk of the underlying as well as the counterparty risk of the issuing bank. I focus on retail structured products that have an index as their underlying and analyze the margin between their actual quoted price and their theoretical value before and after the default of Lehman Brothers. My findings suggest that in the pre-Lehman period, counterparty risk was priced as evidenced by a significant negative relationship between the certificates' margin and the CDS spread of the issuing bank. In the post-Lehman period, the margin widens due to significantly lower bid quotes. However, the widening of the margin is unrelated to counterparty risk. Robustness checks rule out that the lower bid quotes are caused by higher selling pressure or hedging demands of the issuing bank. For example, I do not find a similar effect in a subsample of ETFs that are based on the same underlying indices. I hypothesize that the monopoly position of the issuing bank as a market maker could be one of the causes for the change in pricing retail structured products after the default of Lehman Brothers.

JEL classification: G01, G14, G15

Key words: Counterparty risk; Financial crisis; Structured products

1 Introduction

Counterparty risk is considered one of the propellants for the worsening of the financial crisis after the bankruptcy of Lehman Brothers in September 2008. However, a lack of publicly available data limits our understanding of whether and by how much counterparty risk is priced in financial markets. In this paper, I make use of a unique institutional setting, which allows me to back out counterparty risk pricing in retail financial markets. In particular, I analyze in how far the default of Lehman Brothers changed the pricing of counterparty risk during the 2007-2009 financial crisis.

Counterparty risk has become ubiquitous in financial markets because of an increased interconnectedness of financial institutions. One way through which banks have become more interconnected is by relying more on each other for short-term financing. This interbank lending market is susceptible to failure when fears of counterparty default arise, as it happened during the 2007-2009 financial crisis (Heider, Hoerova, and Holthausen 2010). Another development that has been fostering the interconnectedness of financial institutions is the growth in the use of derivatives. The design and issuance of derivatives has lead to a large network of trading partnerships. For example, in March 2008 Bear Stearns had more than 150 million outstanding trades across different counterparties. When rumors of possible liquidity problems came up, the Federal Reserve considered Bear Stearns too interconnected to be allowed to fail and supported its sale to J.P. Morgan (Brunnermeier 2009).[1]

Derivatives can be packaged together with other securities, such as bonds and stocks, to form structured products.[2] When they are issued on an exchange, they are referred to as retail structured products.[3] Retail structured products create specific payout forms tailored to the risk preferences of retail investors. They are designed and sold by banks who are also the counterparty that must provide the underlying in case of exercise or expiry. Accordingly,

[1] The following are three surveys on financial innovation and financial crises. Finnerty (1988) reviews all the forms of financial engineering performed by investment banks; Coval, Jurek, and Stafford (2009) survey structured finance in the U.S. but mainly aimed at the securitization process that lead to the recent financial crisis; and Allen, Babus, and Carletti (2009) review the theoretical and empirical literature on financial crises.

[2] Due to the financial crisis, the most well-known structured finance product has become the collateralized debt obligation (CDO). For a review of its functioning, see Coval, Jurek, and Stafford (2009).

[3] Alternative expressions may be (structured) warrants or certificates

investors in those products not only face the default risk of the underlying but also the default risk of the bank that has issued the structured product. In this paper, I refer to the default risk of the issuing bank as counterparty risk.

The regulatory framework in many countries protects retail investors from counterparty risk. When financial institutions offer their products on an exchange, they have to set aside a collateral. The collateral can be paid back to investors in case the issuer defaults. Only in over the counter (OTC) markets, when banks trade with other banks off the exchange, they are exposed to counterparty risk.[4] OTC data are not publicly available so that our understanding of the importance of counterparty risk in pricing financial assets is limited.[5]

In contrast to this standard regulatory framework for publicly trading derivatives contracts, the German Securities Law does not require the provision of a collateral for retail structured products. Retail structured products, or certificates as they are called in Germany, are legally considered as unsecured bonds of the bank. The investor becomes a creditor of the bank. Accordingly, investors in certificates are exposed to the counterparty risk of the issuing bank as well as to the default risk of the underlying. Germany is the biggest market for retail structured products in Europe, with around 512,000 securities trading by the end of 2010.[6]

In my analysis, I focus on stock index certificates. They are the simplest kind among the retail structured products. As their name implies, their underlying is a stock index. They are similar to index exchange traded funds (ETFs) with the major difference being their exposure to counterparty risk.[7] I make use of a unique dataset which covers all index certificates on the European Warrant Exchange (Euwax) at Stuttgart Stock Exchange, the most liquid warrant exchange in Germany. The advantage of using index certificates in my study is their simplicity. They do not contain embedded options whose prices would need to be modeled. Instead, they are based on a certificate-specific conversion ratio (usually 0.01) between the index and the certificate which allows me to accurately calculate the theoretical value of the certificates. A

[4] Duffie and Zhu (2011 (forthcoming)) examine whether a single or multiple central clearing counterparties can help mitigate the counterparty exposure in the OTC market.

[5] One exception is the paper by **?**, which I will discuss in the next section.

[6] Source: "Scoach leads the European market in 2010 as well", Exchange News Direct, 11 January 2011.

[7] In the robustness check section of this paper, I make use of this similarity between index certificates and ETFs and show that the post-Lehman pricing effect is not present in ETFs.

further advantage of analyzing the pricing of index certificates is that the default risk of the underlying, the index, is minimal. After controlling for other characteristics of the certificate and the underlying, the only remaining risk component will be the counterparty risk.

My empirical analysis consists of two parts. First, I examine whether the default of Lehman Brothers had a significant impact on the pricing of the index certificates. In the second part, I investigate in how far counterparty risk has been priced in index certificates before and after the default of Lehman Brothers. My measure for the pricing of the index certificates is their relative margin, i.e. the difference between their actual and theoretical price normalized by their theoretical price.[8] The relative margin can be interpreted as the percentage price premium (or discount) of the certificate over its intrinsic value. I use the default of Lehman Brothers as an exogenous shock to investors' perceptions about counterparty risk.

My findings suggest that the default of Lehman Brothers lead to a significant decrease in the relative margin of index certificates. This can be interpreted as a permanent wealth loss to all investors in those products at the time. The decline in the relative margin is robust to controls for idiosyncratic characteristics of the certificates and the underlying. I also rule out two other likely explanations, higher net selling pressure or higher hedging costs. In particular, I show that this price decline is not existent in a subsample of ETFs, which are not subject to counterparty risk, but that have the same index as an underlying. I find that counterparty risk was weakly priced before the default of Lehman but it loses its explanatory power after the default of Lehman. This indicates that the price decline of index certificates is not related to the credit risk of the issuer. I hypothesize that the monopoly position of the issuing bank as a market maker could be one of the determinants for the price decline.

The paper proceeds as follows. Section 2 describes the related literature. Section 3 explains the institutional setting for retail structured products in Germany. Section 4 describes the data sources, cleaning procedures and sample characteristics. Section 5 presents the empirical results, and section 6 concludes.

[8] Other empirical papers that look at spread measures to examine the pricing effects of the financial crisis are Kelly, Lustig, and Van Nieuwerburgh (2011) who look at the spread between out of the money (OTM) put options on a basket of securities and the index on the financial sector ("basket-index put spread for financial firms"). Gorton and Metrick (2011 (forthcoming)) use the LIB-OIS spread as a proxy for counterparty risk.

2 Related literature

Jorion and Zhang (2009) identify counterparty risk as an additional channel for credit contagion, i.e. the clustering of default, and argue that the fear of counterparty defaults explains the worsening of the credit crisis after the Lehman bankruptcy in September 2008. Counterparty (credit) risk represents another type of default risk. Several studies have analyzed counterparty risk from a theory perspective.[9] The empirical evidence is scarce because counterparty risk cannot be measured with U.S. public data. One recent exception is **?** who make use of a proprietary OTC dataset that contains U.S. credit default swaps (CDS) transaction prices and quotes. They identify that the pricing of counterparty risk becomes much more significant after the bankruptcy of Lehman Brothers. However, counterparty risk is only priced for non-financial firms, suggesting that the market expects "too big too fail" policies would prevail.

Instead of using not publicly available OTC credit default swaps, my study is based on structured products that trade in the German financial market. Although counterparty risk cannot be measured in U.S. financial markets, several previous studies have analyzed the determinants of the pricing differential between structured products and their underlyings. The main conclusion from these papers is that the issuing institutions price the structured products to their favor. Analyzing structured products in the U.S., Chen and Kensinger (1990), Chen and Sears (1990) and Benet, Giannetti, and Pissaris (2006) all find evidence that the prices of structured products are skewed in favor of the sponsoring financial institution. Chen and Kensinger (1990) examine Market Index certificates of Deposit (MICDs), which pay variable interested pegged to the performance of the S&P500 but also guarantee a minimum interest rate. Chen and Sears (1990) analyze the S&P500 indexed note called the SPIN and find evidence of overpricing at issuance and underpricing in the secondary market. Benet, Giannetti, and Pissaris (2006) use standard contingent claim analysis to analyze 31 reverse-exchangeable securities (RES) that were issued by ABN-AMRO bank and that are trading on AMEX. They find that the issuing terms of RES are positively skewed in favor of the sponsoring financial institution. Benet, Giannetti, and Pissaris (2006) also find evidence that the terminal payoffs

[9] See, for example, Jarrow and Yu (2001), Giesecke and Weber (2004), Vanden (2009), and Hentschel and Smith (1997).

of the RES are positively correlated with the issuer's financial performance, indicating some pricing of counterparty risk. However, Benet, Giannetti, and Pissaris (2006) are also cautious by acknowledging that factors like tax treatments or margins costs make it difficult to precisely replicate structured products. It may even be that RES complete the market so that their price premium indicates that they are efficiently priced.[10]

Similar analyses have been carried out for The Netherlands (Szymanowska, Horst, and Veld 2009) and Switzerland (Burth, Kraus, and Wohlwend 2001). Szymanowska, Horst, and Veld (2009) analyze 75 plain vanilla reverse convertible (RC) bonds and knock-in RC on the Amsterdam Stock Exchange. They find that plain vanilla RC bonds and knock-in RC bonds are, on average, overpriced by 5.92% and 5.50%, respectively, when using a model-based approach. Interestingly, overpricing lasts for approximately one-fourth of the lifetime of the RCs. To explain this phenomenon, the authors hypothesize that at issuance, the banks are sellers of the certificates but as they get closer to maturity, they become buyers. Burth, Kraus, and Wohlwend (2001) analyze whether concave structured products, called capital protected notes, issued by financial institutions are fairly priced. Their sample comprises 275 plain vanilla concave products on Swiss blue chips that were outstanding on August 1, 1999 and issued in Switzerland. Their descriptive statistics reveal that 16% of the initial offerings have an offering price that is cheaper than the replicated price of the underlying. However, the average pricing difference is 1.91% and therefore positive and significant. They find that the pricing difference varies substantially by the issuer. Focusing on products without a coupon, they find that the mispricing is less if a co-lead manager had been involved.

The country that has been examined the most is Germany. Similar to the U.S., the majority of the studies on retail structured products analyze potential price differences between the certificate and the value of its components. This type of analysis is motivated by the fact that the issuers of certificates also function as their market maker and may quote unfavorable prices. The majority of those studies have focused on Germany. A general finding similar to the one

[10] Gorton and Pennacchi (1993) investigate the reason for the existence of what they call composite securities. One common argument is that composite securities should be redundant because they are aggregates of already existing securities. However, Gorton and Pennacchi (1993) show in their model that less informed traders can minimize their losses to insiders by trading composite securities due to the lower return variance of structured products.

in the U.S. is that certificates are usually overpriced (Wilkens and Stoimenov 2007, Wilkens, Erner, and Röder 2003). More specifically, the main focus of the literature in Germany has become the so called life-cycle hypothesis and the evidence seems in support of it. That is, the overpricing is the highest in the primary market and higher for more complex products (Stoimenov and Wilkens 2005). The overpricing disappears over the life-cycle of the product and may even turn into a discount at maturity or close to maturity of the product (Stoimenov and Wilkens 2005). In fact, the evidence suggests that the majority of issuers anticipate the order flow in certificates and increase their margins when they expect net sales to be positive (Wilkens, Erner, and Röder 2003). The support of the order flow hypothesis is important as issuers are obliged to buy back certificates from investors at their quoted prices. If issuers quoted prices only above the theoretical value of the certificate, they would face the risk of having to buy them back at those high prices, too. Quoting prices above the theoretical value only makes sense if issuers anticipate more sales than buy-backs (Wilkens, Erner, and Röder 2003). As one of the exceptions, Muck (2006) does not find evidence supporting the life-cycle hypothesis. His findings add that exchange-traded leverage certificates exhibit a median surcharge of 2.3%, while OTC certificates are subject to a median overpricing of 13.0%. Also somewhat different from the mainstream is Rossetto and Bommel (2009) whose findings suggest that, on average, an ELC on a DAX stock is worth up to 0.3% more than its intrinsic value. Premiums increase in the volatility of the underlying. Their descriptive statistics show a median bid-ask spread of 0.68% of the mid-quote. Their conclusion is that the certificates analyzed complete the market so that one cannot generally speak of "overpricing". The types of certificates that have been analyzed in the German context are all equity-linked structured products (Stoimenov and Wilkens 2005), discount certificates on the DAX (Baule 2011 (forthcoming)), long and short index certificates on the German DAX index (Wilkens and Stoimenov 2007), discount certificates and reverse convertibles Wilkens, Erner, and Röder (2003), bonus certificates (Baule, Entrop, and Wilkens 2008), Turbo certificates also called Leverage certificates Muck (2006), endless leverage certificate (Rossetto and Bommel 2009), Discount Reverse Convertibles and reverse convertible bonds (Breuer and Perst 2007).

The only studies that have analyzed counterparty risk in Germany are Baule, Entrop,

and Wilkens (2008) and Entrop, Scholz, and Wilkens (2009). But their results are conflicting. Baule, Entrop, and Wilkens (2008) examine the price margin of discount certificates. They find that the issuer's credit risk makes up a large portion (up to 42%) of the issuers profit from certificates. Private investors also seem to ignore issuer's credit risk. However, the credit risk margin in the study is based on a calibrated model instead of truly observable counterparty risk. Contradicting these results, Entrop, Scholz, and Wilkens (2009) analyze open-end leverage certificates and find that counterparty risk does not play a role in the pricing of certificates. In addition to the necessity to rely on theoretical models to identify counterparty risk, Baule, Entrop, and Wilkens (2008) and Entrop, Scholz, and Wilkens (2009) use data from 2004 and 2006, respectively. However, the pricing of counterparty risk is most likely to become quantifiable after the start of the financial crisis in 2007.

This paper is different from the above mainly in two aspects. First, I focus on index-certificates, which do not require model assumptions to price them. In addition, most of the index certificates in my sample are without maturity date. Using endless index-certificates alleviates from the existence of an issuer pricing strategy as found in other studies (see, for example, Stoimenov and Wilkens (2005).[11] Second, my sample covers the period of the financial crisis between March 2007 until June 2009, which makes it more likely to identify changes in the pricing of counterparty risk.

3 The market for retail structured products

Germany is the largest market in the world for retail structured products. Colloquially, they are referred to as "certificates" (*Zertifikate*). Its two exchanges for structured products are Scoach at Frankfurt Stock Exchange and Euwax (European Warrant Exchange) at Stuttgart Stock Exchange. They had a combined market share of around 40% among all European exchanges in 2008 (Lammersdorf, Burghardt, and Wagener 2010). At the end of 2010, there were around 512,000 retail structured products listed in the German market, with around 3,000 securities

[11] An issuer pricing strategy is based on the order flow. Since the ratio of repurchases to sales is expected to increase over time, certificate price premia are expected to be highest at the initial sales and should continue to decline over the life cycle of the certificate.

being admitted for trading each day.[12]

In order to keep an overview of the different types of certificates, a first categorization differentiates into investment certificates with a long-term investment horizon, and leverage certificates, with a short-term (speculative) investment horizon. Investment certificates are the most important type of retail structured product with a market share of around 99% in January 2008. Based on the open interest, the following were the most popular investment certificates in January 2008: guarantee certificates had a market share of 33.4%, followed by bonus certificates (20.6%), express certificates (15.9%), discount certificates (14.4%), and index certificates (5.5%).[13] Without going into too much detail, the name categorization of the investment certificates is based on the their payoff profile and risk.

One reason why Germany has become an attractive marketplace to issue retail structured products is their legal status. According to the German Securities Law, retail structured products are unsecured bonds. They are not guaranteed by a third party in the event of the issuer's default and expose investors to counterparty risk. The counterparty risk is also the main difference between certificates and exchange traded funds (ETF).In the case of index ETFs, the securities bought to replicate the index become part of the "special assets" that serve as collateral in the case of the issuer's default.[14]

Another reason for Germany's leading position in retail structured products is its market structure and trading features (Grabbe 2010)[15] To provide trading liquidity for the certificates, issuers act as the market maker for their own products and provide quotes on the exchange. In addition, the certificates can be traded directly with the issuer over the counter (Wilkens and Stoimenov 2007). The exact legal requirements depend on the respective exchange. The two certificate exchanges in Germany, Frankfurt and Stuttgart, have very similar regulations so that issuers often decide to list their products on both exchanges. Both exchanges require that the

[12]Exchange News Direct: "Scoach leads the European market in 2010 as well", 11 January 2011.

[13]Source: German Derivatives Association (DDV), monthly statistic January 2008.

[14]Furthermore, dividends are always passed on to ETF investors but they are never passed on to certificate investors. Only if the underlying index is a performance index, certificate investors benefit from the reinvested dividends. Between 01 July 2008 and 31 December 2008, it was also more tax efficient to buy ETFs rather than certificates. If held longer than 12 months, gains from ETFs would have been tax free, whereas gains from certificates would have been taxed at the lower of 25% or the personal tax rate.

[15]Original text is in German.

issuers provide quotes continuously during the trading day. More importantly, and in contrast to other countries, the certificate exchanges have put in place a specialist as an intermediary. The specialist is responsible for an orderly trading process. More than 90 percent of the orders are executed electronically so that the specialist has mainly a supervisory role. At the peak, up to 500 million quotes will be checked by specialists. On the electronic trading segment Euwax, the "specialist" is called Quality Liquidity Provider (QLP) (Lammersdorf, Burghardt, and Wagener 2010). The QLP checks the quotes for their plausibility but can also step in if the market maker does not provide the necessary number of certificates to execute an order. The quotes of the QLP are not allowed to lie outside of those of the market maker. The number of outstanding certificates is usually small so that the counterparty of an investor is most likely the market maker.[16] Given the roles assigned to the market maker and to the specialist, the market framework is similar to the one described in Rust and Hall (2003) in which a monopolistic market maker has price setting power. However, the existence (or potential entry) of middlemen, in this case the QLP or retail investors, can limit the market power of the market maker.

Certificates grant issuers and investors certain rights, as specified in the offer documents (prospectus). These rights differ depending on the issuer and the type of the underlying. Most of these rights are relevant for open-end certificates. Most of the index certificates are open-end, and they are also the focus of this study. Because of the lack of a maturity date, open-end index certificates give the issuer an early termination right subject to a notice period. Similarly, in order to guarantee investors a fair price over the life of the open-end security, certificates usually contain the right to be resold to the issuer at a predefined formula at certain dates of the year. For example, a common specification is that certificates can be resold to the issuer on the last business day of the months March, June, September and December. (Doll 2009, p. 131).

Given the legal status of certificates as bonds, they represent financing mean for issuers. In addition, they represent three profit sources for the issuer. First, issuers make profits from

[16]Since 28 April 2008, Scoach has moved the trading of warrants and certificates off the floor into their electronic trading platform. Part of this change was also the introduction of a specialist who fulfils a similar function as the QLP on Euwax.

certificates by charging a premium at issuance. Second, they earn the bid-ask spread from their market-making activity. And third, they pocket the dividends in case of index certificates that are based on price indices. In order to make up for the forgone profits of certificates that are based on performance indices with reinvested dividends, the market maker usually charges higher bid-ask spreads for those certificates. (often between 0.25% and 1%) (Doll 2009, p. 136). Statistics on execution times that are available from the Scoach exchange suggest that the qualitative differences among the issuers are small (Grabbe 2010).

4 Data

4.1 Data sources

I obtain the dataset on retail structured products from Ariva. Ariva is a bank-independent provider of capital markets information, which sources its information about certificates directly from the exchanges and the issuers. The Ariva dataset consists of the daily open, high, low and last prices and the master data of certificates traded on the two certificates exchanges Frankfurt and Stuttgart. The Ariva master file contains identifier information of the certificates and the underlying such as the type, the ISIN and the currency of the underlying, the name issuing bank and the date and volume of the initial certificate listing. The data comprise active certificates and certificates that have expired during the sample period. I use the identifier information in Ariva to acquire the certificates' end of day bid-ask quotes from Thomson Reuters Tick History, and to retrieve the daily closing prices of the underlyings from Datastream and Bloomberg and a subsample with open, high, low and close prices from Thomson Reuters Tick History. My sample period ranges from January 2007 until June 2009. Exchange rate data are from Eurostat, the statistical office of the European Union.

4.2 Cleaning procedure

I only keep certificates that have a stock index as their underlying. Focusing on index certificates as the simplest type of retail structured product has the advantage that I do not need to price options that are embedded in other types of retail structured products. Replicating option

prices is always subject to measurement errors. Using index certificates has the additional advantage that the default risk of the underlying, i.e. a whole index, is negligible. Hence, counterparty risk should be the main cause for a change in the pricing of index certificates after the default of Lehman Brothers.

My sample consists of certificates that listed on Euwax. There are more bid-ask quotes available in Thomson Reuters Tick History for Euwax than for Frankfurt. In addition, the trading volume in index certificates in the Ariva dataset is higher on Euwax. I apply the following cleaning filter to the dataset. I only keep certificates in the sample whose underlying is an index and that do not have embedded options.[17] I only keep certificates that are open-end, i.e. that do not have a maturity date, to avoid that time to maturity may impact the pricing. I exclude short certificates, which gain in value when the underlying falls. I exclude trading days on which less than 10 certificates have prices. I exclude one certificate for which the underlying price was constant for most of the sample period (565 days).[18] I exclude certificates for which the relative margin is either in the upper or lower 5% tail of its sample distribution on more than 50% of their trading days. I also exclude observations for which the certificate's relative margin is either smaller than -25% or bigger than 25%.[19]. Because of the importance of the conversion ratio and the currency of the underlying, I compared the rawdata values with those that are reported on the exchange and amended when necessary.[20]

4.3 Sample characteristics

The final sample includes 389 long, open-end index certificates based on 203 different indices as underlying, issued by 23 different banks.[21] The overall number of daily observations is 172,532.

[17] There are a variety of names provided by the issuer that can refer to index certificates. The most commonly used expressions are index certificates, open-end certificates and tracker certificates.

[18] This must be due to an index that got discontinued and I was unable to identify the replacement index.

[19] Looking at the data suggests that 25% is a justifiable cut-off point.

[20] Among the sample certificates, I made 9 adjustments to the conversion ratio and 5 adjustments to the underlying currency. I used the websites http://www.finanzen.net and http://www.scoach.de for this cross-check. For those certificates that have ceased to exist now but were still active during the sample period, I used http://www.boersen-zeitung.de, checked issuer's website, or contacted the issuer directly. Open-end certificates can cease for a number of reasons. For example, Bear Stearns canceled its open-end index certificates due to the prospective acquisition through J.P. Morgan. Source: 13 May 2008: "Bear Stearns kuendigt Zertifikate vorzeitig". Zertifikate Anleger Nr 10/2008, 4 Jahrgang.

[21] In case a subsidiary appears as a separate issuer, I put it under the parent name.

Appendix 1 provides a list of the indices that are the underlying in at least five sample certificates. The four most popular indices with the number of certificates in parentheses are the DAX performance index (15), the Nikkei 225 (15), the S&P500 (14) and the TecDAX Performance index (13). Appendix 2 provides further characteristics for the sample certificates. For example, 102 certificates with non-Euro denominated underlying are not protected against foreign exchange risk (not quanto). For 367 of the sample certificates, Ariva provides information whether the index includes reinvested dividends. In 160 of those 367 certificates, the underlying is a performance index. And finally, 4 certificates are canceled during the sample period and 7 after the sample period.

Table 2 presents the summary statistics for the pre-Lehman (*Panel A*) and post-Lehman (*Panel B*) period. The variables definitions and sources are listed in Table 1. The margin is the difference between the actual price of the certificate and the theoretical price of the certificate. The relative margin is the margin divided by the theoretical price of the certificate and can be interpreted as the percentage cost of buying the certificate instead of the index. The mean (median) relative margin pre-Lehman is -0.0058 (-0.0034) and decreases to -0.011 (-0.0064) post-Lehman. The relative margin is negative because the prices received from Ariva are mostly bid quotes. The Ariva dataset does not indicate whether a price is at the bid or the ask. Because of this lack of reporting, I have downloaded additional end of day certificate bid-ask quotes from Thomson Reuters Tick History that I will use a robustness check in the analyses below. Another intriguing observation is that the daily cross-sectional standard deviation of the relative margin almost doubles from 0.0169 pre-Lehman to 0.0280 post-Lehman. Part of the empirical analysis below aims to identify whether this greater price heterogeneity is due to a more significant pricing of counterparty risk.

The average certificate volume, excluding observations with zero volume, increases from 2,442 to 2,670. The number of observations with positive trading volume is generally low. Between 1.3%-1.5% of the trading days in the sample are valuation/exercise days in case investors decide to exercise their right to sell back the index to the issuing bank.

5 Empirical analysis

My sample consists of two time periods, January 2007 to August 2008, which is the time before the fall of Lehman (*pre-Lehman*), and January 2009 to June 2009, which is the time period after the default of Lehman Brothers (*post-Lehman*). In order to examine the impact of Lehman's default on the pricing of counterparty risk, it is important to use the pricing of index certificates during the non-crisis period as the comparison group. This approach is justified by Figure 1. The figure includes the daily average of the certificates' relative margins (solid line) and their daily (cross-sectional) standard deviation (dashed line). The Figure highlights that the events that took place in the months between September and December 2008 had a significant on the pricing of securities and justifies their exclusion from the analysis.[22]

Two observations in Figure 1 are noteworthy. First, the mean relative margin is usually negative and turns positive only in certain periods. The reason is that when no exchange trades have occurred, the certificate exchange usually provides the market maker's bid quote from that day. The volatility of the relative margin is roughly in line with the volatility of the underlying index returns, as is confirmed by the descriptive statistics in Table 2. The cross-sectional standard deviation of the relative margin can be interpreted as a measure of certificate pricing heterogeneity.

The second more striking observation is the higher daily cross-sectional volatility of the relative margin and the more negative level of the average relative margin following the bankruptcy of Lehman Brothers. Given the simplicity of pricing index certificates, there must be some underlying factor that drive these changes in pricing. Since the relative margin is a ratio, its changes may be driven by changes in the underlying index. In the multiple regression setting that follows this discussion, I will control for characteristics of the underlying.

In all, Figure 1 indicates that September 2008 and the three months that follow, represent a major turning point in the financial crisis. It supports the hypothesis that the default of Lehman Brothers caused a change in the pricing of index certificates. In the following sections, I explore possible causes of the increased price heterogeneity. I start with a multiple regression

[22] "WaMu is seized, sold off to JP Morgan, in largest failure in US banking history ", Wall Street Journal, 26 September 2009.

to confirm that the relative margin post-Lehman is significantly different from time before the bankruptcy of Lehman. I then continue to see if issuer credit risk explains parts or all of the pricing changes.

5.1 Change in the pricing of index certificates

The following represents the baseline regression specification used throughout the paper.

$$\textit{Relative margin}_{i,j,t} = \alpha + \beta_1 \textit{Post Lehman dummy}_t + \gamma' X_{i,j,t} + \varepsilon_{i,j,t}$$

The dependent variable is the relative margin of certificate i, issued by bank j, trading on day t. The relative margin is the margin of the certificate, defined as the actual certificate price minus its theoretical price, divided by its theoretical price. The Post Lehman dummy equals one for the period January 2009 until June 2009 and zero for the period January 2007 until August 2008. X are individual control variables that represent possible other determinants of the relative margin. In all regressions, I use the following control variables. I control for the volatility of the underlying because Rossetto and van Bommel (2009) find that premia increase in the volatility of the underlying. I also control for whether the index is a performance index. Performance indices include reinvested dividends, which is beneficial for investors in those index certificates but it means less profit for the issuing banks and hence may lead to larger bid-ask spreads. Another control variable is whether the certificate is exchange rate protected (quanto) to prevent that exchange risk is driving the relative margin. The certificate's issue volume serve as a proxy for the liquidity of the product. The certificate's trading volume controls for the fact that days with higher trading volume on the exchange may have have significantly different relative margins. I also control for possible no-trade days. i.e. there are observations in my dataset for which the open, high ,low and last prices of the certificates are equal. It may indicate that the certificates had not been trading during the day. I mark these observations via a Notrade dummy. Important certificate-specific contract details to control for are the valuation and exercise days, and the investor notice period. Many of the index-certificates are

without maturity date. In addition to selling them on the exchange, investors are granted the right to sell them back to the issuer at certain "exercise dates" based on a pre-defined valuation formula. The valuation date may be different from the exercise date. If investors decide to exercise their certificates, they may need to adhere to a notice period. I have hand-collected these data from the prospectuses as one may expect that issuers provide different quotes on valuation/exercise days and depending on the length of the notice period. Finally, I control for the fact that some of the open-end index certificates got canceled by their issuing bank during or after the sample period. It will be interesting to see in how for those forced cancelation certificates differ in their pricing from the rest of the sample.

5.1.1 Pricing of index certificates before and after Lehman's default

I start by employing a pooled OLS model with certificate fixed effects to examine whether the default of Lehman Brothers changed the pricing of index certificates. The results in Table 3 show that the Post-Lehman dummy is significantly negative across all specifications. Since the Ariva prices are mainly bid quotes, the results indicate that bid quotes have decreased significantly after the default of Lehman Brothers, controlling for underlying-specific and certificate-specific factors. In regression model 1, I only regress the relative margin on the Post-Lehman dummy. In regression 2, I control for underlying-specific factors such as the monthly return volatility of the underlying index and if the index is a performance index. In addition to the underlying characteristics, I control for certificate characteristics in regression 3. Regression 4 includes additional controls for certificate-specific contract details such as the valuation date, the exercise date, and the investor notice period. The Post-Lehman dummy coefficient in regression 4 is -0.0046 and highly significant. Given a pre-Lehman mean relative margin of -0.0058, the default of Lehman causes the relative margin to decrease by almost 80%. While the return volatility of the underlying does not seem to play a role, a performance index leads to lower bid quotes in regressions 2 and 3. This confirms previous findings that market makers do compensate themselves for the loss of dividends by adjusting their bid-ask quotes. The positive coefficient in regression may be due to collinearity with the contract variables. For example, I include a dummy for the investor valuation and exercise dates in regression 4. The coefficient on the

exercise date is negative and significant, suggesting that investors obtain worse prices when they sell their shares on these contractually pre-defined return dates. Regressions 3 and 4 show that the certificate issue volume and the trading volume do have explanatory power, but is economically so small that the coefficients show up as 0 in the regression table. The forced cancelation dummy is negative and highly significant in regressions 3 and 4. It indicates that those certificates which are expected to be resold to the issuing bank are quoted significantly lower bid quotes. In fact, this behavior of the market maker to quote lower bid quotes for certificates that will be sold in the future can be a partial explanation for the price decline of the index certificates after the default of Lehman Brothers. I will discuss this issue in more detail at the end of this paper.

Figure 1 indicated that there may be considerable bounces between the bid and ask quotes for the certificates. Therefore, it is warranted to analyze bid and ask quotes separately.

5.1.2 Analysis of the bid-ask spreads

Where available, I obtain the end of day bid-ask spreads for the sample index certificates from Thomson Reuters Tick History. I employ the same regression model as before but use either the end of day bid or the end of day ask quotes to calculate the relative margins. The results are displayed in regression models 1 and 2 of Table 4. The Post-Lehman dummy is only significantly negative if the bid quotes are used to calculate the relative margin. It suggests that the default of Lehman caused a decline in the bid quotes but not the ask quotes. Another way to state this is that the bid-ask spread has widened asymmetrically through lower bid quotes. This intuition is confirmed by regression model 3, which uses the relative bid-ask spreads as the dependent variable. I follow Amihud and Mendelson (1986) and define the relative bid-ask spread as the Euro spread divided by the average of the end of day bid and ask quotes of the index-certificates. I use the logarithmic value of the relative bid-ask spread as the dependent variable. As expected, the default of Lehman Brothers has a positive effect on the relative bid-ask spread. So far, the findings suggest that after the default of Lehman Brothers, the relative margin of index certificates has declined significantly, which is caused by lower bid quotes. Before I am going to test the hypothesis that the credit risk of the issuer plays a role,

I will rule out two other possible explanations: net selling pressure and higher hedging costs.

5.1.3 Alternative explanations

The microstructure literature suggests that asymmetric information, trade size and underlying characteristics are the main determinants of the bid-ask spread (Copeland and Galai 1983, Glosten and Milgrom 1985, Easley and O'Hara 1987, Glosten and Harris 1988). While I have controlled for certificate trading volume and underlying return volatility, they may not be the perfect proxies for other hypotheses.

For example, while the trading volume of index certificates may not have changed much post-Lehman, a majority of the investors may sell back their index certificates to the market maker (the issuing bank). The market maker may have reacted to this higher net selling pressure through lower bid quotes. In order to test this supposition, I restrict the post-Lehman period to March 2009 until June 2009. The reason is that from March 2009 onwards, stock indices around the world started to rise again. It will be hard to reconcile higher net selling of index certificates while their underlyings rise in value. Table 5 confirms that the Post-Lehman dummy remains significantly negative when using March 2009 June 2009 as the post-Lehman period.

Another explanation for lower bid quotes can be higher hedging demands or hedging costs for the issuing banks. Since the market maker for the index certificates is the issuing bank, the lower bid quotes may simply represent the higher costs. To test this hypothesis, I collect pricing data on Exchange Traded Funds (ETFs) that share the same underlying as the index certificates in my sample. Since it is the bid quotes that matter for the index certificates, I use the end of day bid quotes for ETFs. I obtain the data from Thomson Reuters Tick History. I am able to identify 34 ETFs that are based on the same underlying as the index certificates in my sample. I construct the same relative margin for the ETFs and run a regression with the ETF relative margin as the dependent variable and control for the underlying characteristidcs. For the equivalent index certificates with the same index as underlying, I repeat the regression from above. The results in Table 6 show that the ETF relative margin is unaffected by the Post Lehman dummy. Index certificates with the same underlying, however, do have significantly

lower bid quotes. As argued above, there are only two main differences between ETFs and index certificates. First, index certificates are subject to counterparty risk. And second, the index certificate issuing bank is also its sole market maker and the main trading counterparty while ETFs are more frequently traded on the exchange. In the next section, I will analyze whether counterparty risk is responsible for the decline in the bid quotes.

5.2 Counterparty risk

This section tests the hypothesis whether issuer related risk has been causing the decline in the relative margin. I use the five year credit default swap (CDS) spreads of the issuing banks to proxy for issuer risk.[23] I form an interaction effect between the Post-Lehman dummy and the CDS spreads to examine in how far the CDS spreads explain the certificates' relative margins pre- and post-Lehman. If counterparty risk has been priced before the default of Lehman Brothers, the coefficient on the non-interacted CDS-Spread variable should be significant. The coefficient of this interaction term should be significant if the pricing of counterparty risk has changed post Lehman. Several of the issuers were taken over during the financial crisis. While the issuer name in my certificate dataset does not change, I have to take account of the new owner when I match them with their CDS spreads. For example, on 11 July 2008, the French cooperative bank Credit Mutual acquired the German retail structured product branch of Citigroup. From that point onwards, the CDS spreads of Citigroup must be replaced by the CDS spreads of Credit Mutuel. I conduct an extensive internet search to identify whether issuing banks or their German branches were taken over. I identify the new majority owner who I use to match the CDS spreads with. I then estimate the OLS regressions with the CDS-Post Lehman dummy interaction effect as described above. Table 7 shows that the CDS spreads are significant and economically small before the default of Lehman. However, post-Lehman the CDS spreads of the issuing banks have no explanatory power for the decline in the relative margin. In contrast, the Post Lehman dummy remains negative and highly significant. The results contradict the common belief that the default of Lehman Brothers lead to a more

[23] Jorion and Zhang (2007) explain that the 5-year CDS contracts are the most liquid and constitute over 85% of the CDS market.

significant pricing of counterparty risk. Instead, it may be that the monopoly position of the issuing bank as a market maker may be one explanation for the significant drop in the relative margin. In support of this explanation is the finding that market makers adjust their quotes based on the expected order flow. For example, the forced cancelation dummy in my regressions is negative and highly significant. The finding suggests that certificates that were canceled by the issuing bank and for which it is expected that investors will return them to the issuing bank before they cease, have significantly lower bid quotes.

6 Conclusion

I use the default of Lehman Brothers as an exogenous shock to investors' perceptions about counterparty risk to examine whether counterparty risk is priced and how it has changed over time. This study is unique in that it uses publicly available data from German retail financial markets. The German Securities Law treats retail structured products legally like unsecured bonds, which exposes the investor to the credit risk of the issuing bank. In this paper, I focus on one particular class of retail structured products, called index certificates. Their underlying is an index, which facilitates the calculation of the theoretical value of these certificates. To measure counterparty risk, I compare the relative margin of these certificates from before the crisis with those after the default of Lehman Brothers. The relative margin is the difference between the actual price of the certificates and their theoretical price, divided by the theoretical price. My findings suggest that the relative margin has decreased significantly after the default of Lehman. This decrease is robust to various regression specifications and is driven by lower bid quotes. More importantly, the decline in the relative margin is not observed in Exchange Traded Funds that are similar to index certificates but are not subject to counterparty risk. I find that counterparty risk was weakly priced before the default of Lehman. However, it loses its explanatory power post-Lehman, which suggests that the price decline is *not* driven by a more significantly priced counterparty risk component. I hypothesize that the monopoly position of the issuing bank as a market maker could play a role in explaining the pricing change after the default of Lehman.

Appendix

Appendix 1: List of most popular indices as underlying

This table shows indices that are used as an underlying in 5 or more index certificates.

Name of underlying index	Number of certificates
AMEX Biotechnology	6
DAX Performance	15
Dow Jones Industrial Average Excess Return	8
Dow Jones Stoxx 50 (Price, EUR)	6
HSCEI - Hang Seng China Enterprises Inde	6
MDAX (Performance)	6
NASDAQ 100	7
Nikkei 225	15
S&P 500	14
SMI - Swiss Market Excess Return Index	6
TecDAX (Performance)	13
190 other indices	287
Total	**389**

Appendix 2: Characteristics of index certificates

This table shows selected characteristics of the index certificates. *Quanto* indicates whether the certificate is protected against exchange rate risk. A *performance index* is an index that includes reinvested dividends. The *currency* codes are based on the ISO country codes.

Quanto		Underlying performance		Cancelled certificates	
Yes	No	Yes	No	During sample period	After sample period
49	450	171	304	1	34

Currency if quanto = No	
AUD	3
BRL	1
CHF	4
CZK	2
EUR	325
GBP	4
HKD	12
HUF	4
JPY	12
KRW	4
PLN	5
USD	74

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Table 1: Variable definitions

This table defines the variables and their data sources used in the paper.

Variable	Description	Data source
Underlying return	Continuously compounded return of underlying price.	Datastream
Underlying return vol.	Monthly (calendar month) standard deviation of underlying return.	Own calculation
Performance index dummy	Dummy equal to one if the underlying index is a performance index and zero otherwise. Performance indices include reinvested dividends.	Ariva
Issuer CDS spread	5-year credit default swap (CDS) spreads.	Markit
Certificate price	Price of the index certificate.	Ariva
Theoretical certificate price	Theoretical (true) price of the certificate absent of any fees, spreads, etc. Equals the index price multiplied by the conversion ratio as stated in the certificate's offer documents.	Own calculation (based on Ariva data and hand-checking of the certificates' offer documents)
Certificate margin (EUR)	Actual certificate price minus theoretical certificate price.	Own calculation
Certificate relative margin	(Actual certificate price minus theoretical certificate price)/theoretical certificate price.	Own calculation
Relative margin daily std.	Daily, cross-sectional standard deviation of the relative margin across all sample certificates.	Own calculation
Certificate relative bid-ask spread	Euro spread divided by the average of the end of day bid and ask quotes of the index-certificates (following Amihud and Mendelson (1986))	Thomson Reuters Tick History
Certificate issue volume	Number of certificates that were registered to be sold at the initial public offering.	Ariva
Certificate trading volume (excl. 0)	If a trade has taken place on the exchange, the trading volume will be positive. If no trade has taken place on the exchange, either because of inactivity or because trades have taken place OTC with the issuer, the trading volume is reported as zero.	Ariva
Certificate valuation date dummy	Dummy equal to one if the respective trading day is a valuation day and zero otherwise. The valuation day is the trading day used to determine the price of a certificate if the investor decides to return it to the issuer. In the majority of the cases, the valuation date equals the exercise date, but it can also be shortly before or after the exercise date.	Own research based on certificates' offer documents
Certificate exercise date dummy	Dummy equal to one if the respective trading day is an exercise day and zero otherwise. On exercise dates, as specified in the certificates' offer documents, investors have the right to return the certificates to the issuer at a defined valuation formula.	Own research based on certificates' offer documents
Certificate investor notice period (in days)	The offer documents of certificates may specify a notice period that the investor needs to adhere to if she decides to return the certificates to the issuer on the exercise date.	Own research based on certificates' offer documents
Quanto-certificate dummy	Dummy equal to one if the certificate is exchange rate protected (quanto) and zero otherwise. Exchange rate protection becomes important if the underlying index is not denominated in Euros.	Ariva and hand-checking of the certificates' offer documents
Certificate forced cancellation dummy	Dummy equal to one if the certificate cancelled and zero otherwise.	Ariva and hand-checking of the certificates' offer documents

Table 2: Descriptive sample statistics

Descriptive statistics for the sample of 389 index certificates based on 203 indices. The sample consists of two time periods: a time period before the default of Lehman Brothers (January 2007 to August 2008) and a time period after the default of Lehman Brothers (January to June 2009). Statistics for the pre-Lehman and post-Lehman period are presented in *Panel A* and *Panel B*, respectively. Variables are as defined in Table 1.

	Obs	Mean	Median	Std	Min	Max
Panel A: pre-Lehman (Jan 2007 - Aug 2008)						
Underlying return	132,434	-0.0003	0.0002	0.0150	-0.1293	0.1488
Underlying return vol.	136,282	0.0137	0.0125	0.0060	0.0000	0.0551
Performance index dummy	128,624	0.4112	0	0.4921	0	1
Issuer CDS spread	118,699	53	51	41	5	724
Certificate price	136,297	79	45	392	3	8,111
Theoretical certificate price	136,297	79	45	393	3	8,106
Certificate margin (EUR)	136,297	-0.3605	-0.1190	3	-186	203
Certificate relative margin	136,297	-0.0058	-0.0034	0.0185	-0.1913	0.1203
Relative margin daily (cross-sectional) std.	416	0.0169	0.0158	0.0042	0.0101	0.0326
Certificate relative bid-ask spread	131,180	0.0081	0.0080	0.0101	0	2
Certificate issue volume	135,893	1,966,144	700,000	5,918,857	1,000	100,000,000
Certificate trading volume (excl. 0)	24,233	2,442	400	10,217	1	822,952
Certificate valuation date dummy	136,297	0.0144	0	0.1192	0	1
Certificate exercise date dummy	136,297	0.0153	0	0.1226	0	1
Certificate investor notice period	123,235	4	5	5	0	20
Quanto-certificate dummy	136,297	0.0867	0	0.2814	0	1
Certificate forced cancellation dummy	136,297	0.0231	0	0.1501	0	1
Panel B: post-Lehman (Jan 2009 - Jun 2009)						
Underlying return	31,110	0.0004	0.0003	0.0243	-0.1297	0.3211
Underlying return vol.	35,828	0.0225	0.0209	0.0090	0.0000	0.0987
Performance index dummy	34,088	0.4550	0	0.4980	0	1
Issuer CDS spread	34,299	140	130	59	25	528
Certificate price	36,235	47	24	259	1	5,151
Theoretical certificate price	36,235	48	24	259	1	5,144
Certificate margin (EUR)	36,235	-0.3891	-0.1260	4	-136	151
Certificate relative margin	36,235	-0.0110	-0.0064	0.0297	-0.2477	0.1969
Relative margin daily (cross-sectional) std.	125	0.0280	0.0280	0.0032	0.0171	0.0393
Certificate relative bid-ask spread	35,599	0.0140	0.0091	0.0442	0	1
Certificate issue volume	36,147	2,067,003	800,000	6,198,422	1,000	100,000,000
Certificate trading volume (excl. 0)	2,730	2,670	390	9,088	1	151,467
Certificate valuation date dummy	36,235	0.0130	0	0.1133	0	1
Certificate exercise date dummy	36,235	0.0148	0	0.1206	0	1
Certificate investor notice period	35,022	5	5	5	0	20
Quanto-certificate dummy	36,235	0.0749	0	0.2632	0	1
Certificate forced cancellation dummy	36,235	0.0144	0	0.1192	0	1

Table 3: Certificate margin before and after Lehman's default

The dependent variable is the certificates' relative margins, defined as $\frac{actual\text{ - }theoretical\ certificate\ price}{theoretical\ certificate\ price}$. Independent variable of most interest is the Post Lehman dummy equal to one for the time period Jan-Jun'09 and zero for Jan'07-Aug'08. Coefficients are estimated via OLS. Variables are as defined in Table 1. Cluster robust standard errors are in parentheses. *, **, and *** denotes significance at the 10%, 5%, and 1% levels, respectively.

	Dependent variable: Certificate relative margin			
	(1)	(2)	(3)	(4)
Post Lehman dummy	-0.0052***	-0.0049***	-0.0048***	-0.0046***
	(0.001)	(0.0011)	(0.0011)	(0.0012)
Underlying return vol.		-0.0477	-0.0394	-0.0391
		(0.0351)	(0.0348)	(0.0374)
Performance index dummy		-0.0064***	-0.0063***	0.0505***
		(0.0004)	(0.0004)	(0.0092)
Notrade dummy			0.0009**	0.0009**
			(0.0003)	(0.0004)
Certificate issue volume			0.0000***	-0.0000***
			-	-
Certificate trading volume			0.0000**	0.0000*
			-	-
Quanto-certificate dummy			-0.0010***	0.0184***
			(0.0001)	(0.0039)
Forced cancellation dummy			-0.0133***	-0.0628***
			(0.0002)	(0.0083)
Valuation date dummy				-0.0005
				(0.0004)
Exercise date dummy				-0.0035***
				(0.0004)
Investor notice period				-0.0012***
				(0.0003)
Constant	0.0009***	0.0015***	0.0011**	0.0313***
	(0.0002)	(0.0005)	(0.0005)	(0.004)
Certificate fixed effects	Yes	Yes	Yes	Yes
Observations	172,532	162,327	162,327	148,543
adj. R-sq	0.4799	0.4838	0.484	0.4794

Table 4: Certificate margin and relative bid-ask spread

The dependent variables for the three regressions are the relative margin based on the bid quote, the relative margin based on the ask quote and the certificates' bid-ask spreads. The certificates' relative margins are defined as $\frac{\text{actual - theoretical certificate price}}{\text{theoretical certificate price}}$. The relative bid-ask spread is defined as the Euro spread divided by the average of the end of day bid and ask quotes of the index-certificates (following Amihud and Mendelson (1986)). Independent variable of most interest is the Post Lehman dummy equal to one for the time period Jan-Jun'09 and zero for Jan'07-Aug'08. The coefficients are estimated via an OLS model. Variables are as defined in Table 1. Cluster robust standard errors are in parentheses. *, **, and *** denotes significance at the 10%, 5%, and 1% levels, respectively.

Dependent variable	Relative margin (bid)	Relative margin (ask)	ln(b-a spread)
Post Lehman dummy	-0.0038***	-0.0001	0.2062***
	(0.0011)	(0.0012)	(0.0367)
Underlying return vol.	-0.0867***	0.0134	9.7540***
	(0.0323)	(0.0357)	(1.4164)
Performance index dummy	0.0313***	0.0019***	1.1941***
	(0.0084)	(0.0004)	(0.0139)
Notrade dummy	0.0013***	0.0010*	-0.0839***
	(0.0004)	(0.0006)	(0.0151)
Certificate issue volume	-0.0000***	-0.0000***	-0.0000***
	-	-	-
Certificate trading volume	0	-0.0000***	-0.0000**
	-	-	-
Quanto-certificate dummy	0.0117***	0.0484***	0.0482*
	(0.0036)	(0.0009)	(0.0255)
Forced cancellation dummy	-0.0464***	-0.0077***	0.7119***
	(0.0076)	(0.0006)	(0.0234)
Valuation date dummy	-0.0004	-0.0002	-0.0296*
	(0.0004)	(0.0004)	(0.0174)
Exercise date dummy	-0.0004	-0.0004	-0.0346**
	(0.0003)	(0.0004)	(0.0142)
Investor notice period	-0.0009***	0.0002***	0.0187***
	(0.0003)	(0.0001)	(0.0031)
Constant	0.0217***	-0.0001	-6.2823***
	(0.0036)	(0.0006)	(0.0152)
Certificate fixed effects	Yes	Yes	Yes
Observations	129,023	128,253	128,238
adj. R-sq	0.5486	0.002	0.2689

Table 5: Robustness check: margin before and after Lehman's default - net buying period

The dependent variable is the certificates' relative margins, defined as $\frac{actual\text{ - }theoretical\ certificate\ price}{theoretical\ certificate\ price}$. Independent variable of most interest is the Post Lehman dummy equal to one for the time period Mar-Jun'09 and zero for Jan'07-Aug'08. Coefficients are estimated via OLS. Variables are as defined in Table 1. Cluster robust standard errors are in parentheses. *, **, and *** denotes significance at the 10%, 5%, and 1% levels, respectively.

	Dependent variable: Certificate relative margin			
	(1)	(2)	(3)	(4)
Post Lehman dummy	-0.0058***	-0.0054***	-0.0053***	-0.0051***
	(0.001)	(0.0011)	(0.0011)	(0.0012)
Underlying return vol.		-0.0687*	-0.0588	-0.0594
		(0.037)	(0.0363)	(0.0392)
Performance index dummy		-0.0070***	-0.0069***	-0.0033***
		(0.0003)	(0.0003)	(0.0005)
Notrade dummy			0.0009***	0.0010**
			(0.0004)	(0.0004)
Certificate issue volume			0.0000***	-0.0000***
			-	-
Certificate trading volume			0.0000*	0
			-	-
Quanto-certificate dummy			-0.0005***	-0.0006
			(0.0002)	(0.0007)
Forced cancellation dummy			-0.0110***	-0.0141***
			(0.0002)	(0.0006)
Valuation date dummy				-0.0004
				(0.0004)
Exercise date dummy				-0.0033***
				(0.0004)
Investor notice period				0.0001
				(0.0001)
Constant	0.0005***	0.0014***	0.0010*	0.0041***
	(0.0001)	(0.0005)	(0.0005)	(0.0006)
Certificate fixed effects	Yes	Yes	Yes	Yes
Observations	160,553	151,254	151,254	137,774
adj. R-sq	0.4971	0.5012	0.5015	0.4973

Table 6: Robustness check: ETF relative margin vs. certificate relative margin

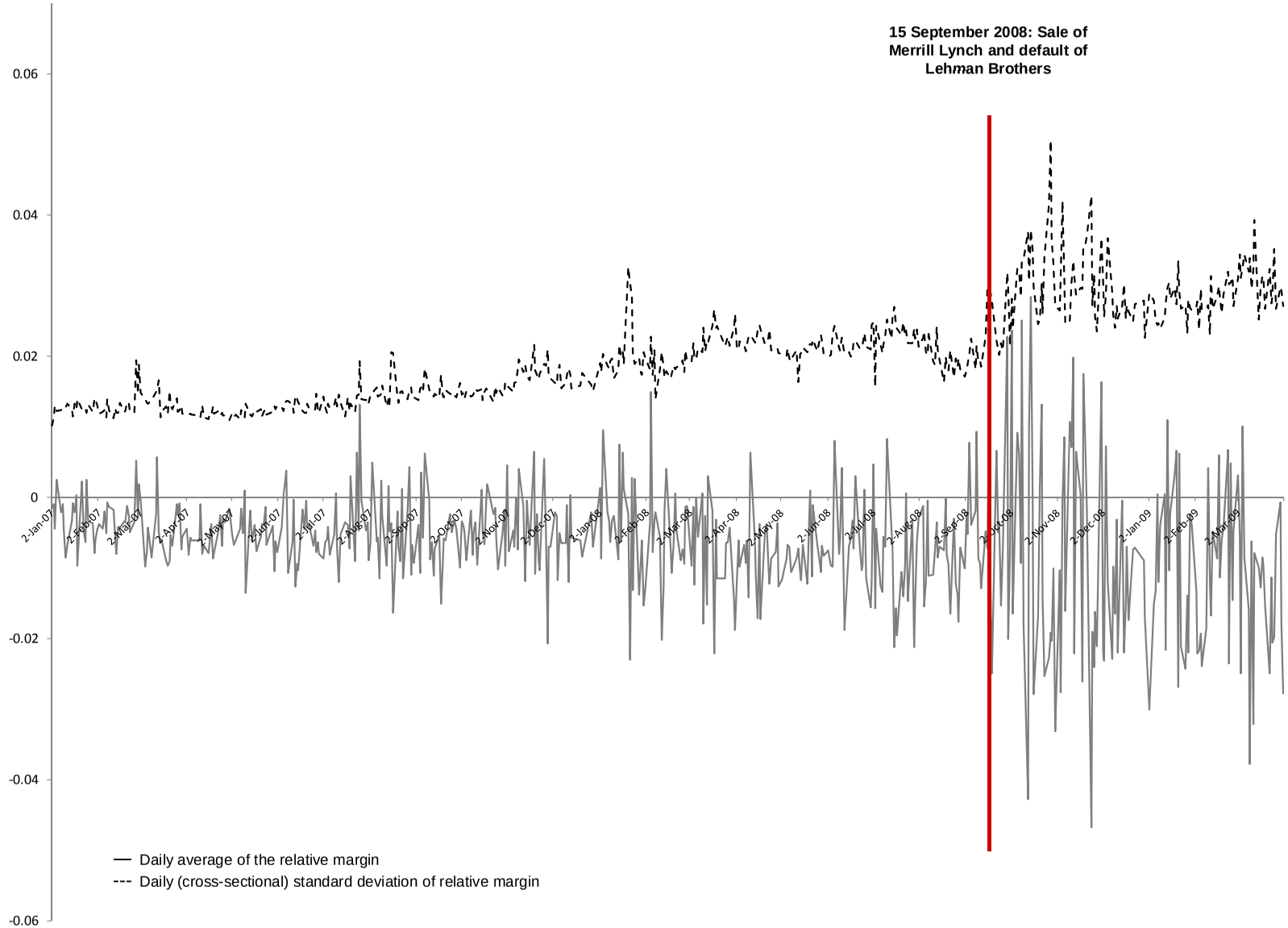
The dependent variable is the ETF relative margin based on end of day bid quotes in regression 1. In regression 2, the dependent variable is the certificate relative margin based on the end of day bid quotes, defined as $\frac{actual\text{ - }theoretical\ certificate\ price}{theoretical\ certificate\ price}$. Independent variable of most interest is the Post Lehman dummy equal to one for the time period Jan-Jun'09 and zero for Jan'07-Aug'08. Coefficients are estimated via OLS. Variables are as defined in Table 1. Cluster robust standard errors are in parentheses. *, **, and *** denotes significance at the 10%, 5%, and 1% levels, respectively.

Dependent variable	ETF relative margin (bid)	Certificate relative margin (bid)
Post Lehman dummy	-0.00004	-0.00097***
	(0.0009)	(0.0003)
Underlying return vol.	-0.10431***	-0.07588***
	(0.0292)	(0.0272)
Performance index dummy	-0.00900***	-0.00728***
	(0.0004)	(0.0001)
Notrade dummy		0.00506***
		(0.0002)
Certificate issue volume		-0.00002
		(0.0002)
Certificate trading volume		-0.00000***
		-
Quanto-certificate dummy		-0.00000**
		-
Forced cancelation dummy		0.00026
		(0.0004)
Valuation date dummy		0.00013
		(0.0003)
Exercise date dummy		-0.00033***
		-
Investor notice period		-0.00485***
		(0.0003)
Constant	0.00738***	0.01166***
	(0.0004)	(0.0007)
ETF fixed effects	Yes	
Certificate fixed effects		Yes
Observations	35,247	33,659
adj. R-sq	0.52097	0.6155

Table 7: Pricing of counterparty risk before and after Lehman's default

The dependent variable is the certificates' relative margins, defined as $\frac{actual\text{ - }theoretical\ certificate\ price}{theoretical\ certificate\ price}$. Independent variable of most interest is the Post Lehman dummy interacted with the issuing banks CDS spreads. The Post Lehman dummy is equal to one for the time period Jan-Jun'09 and zero for Jan'07-Aug'08. Coefficients are estimated via OLS. Variables are as defined in Table 1. Cluster robust standard errors are in parentheses. *, **, and *** denotes significance at the 10%, 5%, and 1% levels, respectively.

Dependent variable: Certificate relative margin		
	(1)	(2)
Post Lehman dummy	-0.004641***	-0.003902**
	(0.0015)	(0.0016)
CDS-Spread	-0.000026***	-0.000023*
	-	-
CDS-Spread*Post-Lehmen dummy	0.000017	0.00001
	-	-
Underlying return vol.		-0.002627
		(0.0392)
Performance index dummy		0.047484***
		(0.0106)
Notrade dummy		0.000939***
		(0.0003)
Certificate issue volume		-0.000000***
		-
Certificate trading volume		0
		-
Quanto-certificate dummy		0.017802***
		(0.0044)
Forced cancellation dummy		-0.061833***
		(0.0093)
Valuation date dummy		-0.000128
		(0.0004)
Exercise date dummy		-0.000599
		(0.0004)
Investor notice period		-0.001393***
		(0.0003)
Constant	0.003486***	0.031532***
	(0.0007)	(0.005)
Certificate fixed effects	Yes	Yes
Observations	148,413	126,151
adj. R-sq	0.503809	0.516085

Figure 1: Time series of relative margin and daily standard deviation of the relative margin of index certificates

This figure shows daily (cross-sectional) average of the certificates' relative margins (solid line) and their daily (cross-sectional) standard deviation (dashed line). The relative margin is the margin of the certificate, defined as the actual certificate price minus its theoretical price, divided by its theoretical price. Shown is the period January 2007 to June 2009. The figure highlights the structural break caused by the default of Lehman Brothers and other events during September 2008.