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How does pricing affect investors' product choice? Evidence from the market for discount certificates

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ABSTRACT

This paper examines the choices of retail investors in the market for structured financial products with a focus on implicit and explicit pricing components. We evaluate more than 72,000 single stock discount certificates on a daily basis from 2004 through 2008. The certificates are quoted an average of 0.58% above their fair value before the financial crisis, increasing to 1.24% during 2008. Although credit risk explains a major part (39%) of the certificates' overpricing, we find that issuer default risk does not have any influence on investors' product choices. Instead, retail investors are strongly influenced by irrational factors such as issuer and product familiarity. Finally, investors are found to make poor product choices (in terms of bid/ask spreads and markups over fair value), resulting in significant losses.

1. Introduction

The market for retail structured financial products is fundamentally different from most other financial markets in that the issuing banks also act as market makers. This exclusive arrangement means that the counterparty for all transactions in a given certificate is the product originator themselves. This means that the issuer possesses a degree of market power, which in this case manifests itself as the ability to charge a premium over the theoretical fair product value. Note that arbitrageurs can only play a limited role in ensuring fair prices in this setting as short-selling is banned. Empirical evidence on this premium may be found in Wilkens et al. (2003) and Baule (2011) for German discount certificates, Baule and Tallau (2011) for German bonus certificates, Benet et al. (2006) and Henderson and Pearson (2011) for U.S. structured equity products, and Burth et al. (2001) for the Swiss market.

The size of the price premium in structured products is known to vary substantially across close substitutes (see Dorn, 2012). This means that investors will have to search for the most attractively priced certificate from a range of similar alternatives, in terms of finding a certificate with a small bid/ask spread, a low implicit margin, and an issuer of low default risk. This represents a considerable[5], albeit not theoretically impossible, undertaking. Recall that issuers are obliged to provide binding bid and ask quotes throughout the trading day. As such, retail investors could observe and compare prices among close substitutes using the search tools provided by exchanges, internet platforms, and their own bank.

The available evidence, however, suggests that investors do not cope well with this search problem. More specifically, empirical research suggests that investors' poor choices in this market result in substantial losses caused by a range of reasons including: greed

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[5] On the European Warrant Exchange, more than one million different products can be traded at the same time. (Source: Website of the German Derivatives Association, available at www.deutscher-derivate-verband.de).

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and a low level of experience (Entrop et al., 2012), poor timing and overtrading (Bauer et al., 2009), search costs (Dorn, 2012), and poor selection abilities among complex products (Entrop et al., 2016). In addition, Dougherty (2008) states that the 2008 bankruptcy of Lehman Brothers and the subsequent default of their certificates suggest that many structured product investors do not fully appreciate the risk of issuer default.

It is worth noting that, in addition to this premium, a number of other stylized facts have been established about the prices of structured financial products. For example, prices are known to possess a 'lifecycle effect', whereby issuers often lower the markups over the certificates' lifetime (e.g., Wilkens et al., 2003, and Stoimenov and Wilkens, 2005). Further, issuing banks are also known to anticipate investor behavior by increasing markups in phases of positive net expected sales. Evidence of this 'order-flow hypothesis' may be found in Baule (2011). Finally, as structured products are unsecured securities, issuer default risk is relevant to pricing and Baule et al. (2008) demonstrates that credit risk plays a substantial role in explaining the overpricing of discount certificates.

The goal of this paper is to provide further evidence on the premiums of retail structured financial products and their impact on investors' decisions. To this end, we assemble a unique dataset from the largest structured financial product market in the world, and use it to answer the following research questions: How do product premiums develop before and during the turmoil of the financial crisis, and which factors are the key determinants of these markups? Do implicit margins, bid/ask spreads and issuer credit risk affect the individual investors' choice of structured products? Further, what are other determinants of investors' buy decisions? How far is their actual choice from the best alternative and how much do retail investors lose due to their suboptimal choice?

Our study is based on a unique data set that includes daily quotes of *all* outstanding discount certificates on DAX stocks at the European Warrant Exchange[6] (Euwax) from April 2004 through December 2008. We calculate each certificate's fair theoretical value on a daily basis, resulting in more than 10 million valuation points, which is by far more than in any other study. We then compare that fair value to the market value to identify the total price premium, which we divide into a default-free and a credit risk component. We use issuer-specific credit spreads, while most other studies do not allow for inter-issuer default risk variations. As such, this study is the first to provide profound insights into the pricing of discount certificates on single stocks, which represent the most popular type of structured products.

In addition to market quote data, our study also has actual trade data for 3997 retail investors from a large German direct bank. Using this trade data, we are able to measure the impact of various elements on investors' buy decisions in the market for structured financial products. We are also able to quantify the losses that result from investors making suboptimal product choices. Further, we are also able to identify the impact of issuer-specific default risk on the pricing of structured products. This latter issue is important as banks can sell structured products at par value where investors ignore default risk. Yet, as the events of 2008 have proven, default risk is very real and investors ignore it at their peril (see Dougherty, 2008).

The empirical analysis of this paper focuses on a Logit regression specification to analyze the individual effects of implicit margins, bid/ask spreads, and issuer credit risk on the decision to buy one discount certificate over other similar certificates. To control for irrational choice determinants, we also include visibility and familiarity variables in the analysis. We also study investors' quality of choice by benchmarking the purchased certificate against the 'best' (defined in terms of the size of the premium) possible choice from a range of similar products. We measure the losses to the investors caused by their suboptimal choices by comparing the roundtrip return of the actually chosen product with a hypothetical roundtrip return of the cheapest available alternative. Finally, we analyze how investors' personal and trading characteristics affect their losses from suboptimal product choice, the purchase quality and the decision to continue trading.

Our results may be summarized as follows. We find evidence in support of the lifecycle effect, in that the premiums generally fall as their maturity draws near. Further, our results suggest that competition among issuers lowers margins, whereas higher expected dividends and higher implied volatilities of underlying stocks increase product markups. We find that discount certificates on DAX stocks trade at an average premium of 0.58% during the first four years of our sample and this premium increases markedly in 2008 (averaging 1.24%). Most importantly, issuer credit risk accounts for 39% of the total margin on average, and even more during 2008, i.e. for up to 80% for specific banks.

When it comes to the decision to purchase a certificate, however, investors do not take into account issuer credit risk. Leaving aside default risk, investors prefer to buy certificates with lower-than-average default-free margins and bid/ask spreads, but their choices are far from optimal. Instead, familiarity is a very important influence on the purchase decision. As a result, we find that retail investors suffer from significant losses as a result of choosing inferior certificates from a subset of very close substitutes. These losses and the purchase quality are not affected by experience or trading activity, but are linked to search costs and search incentives. However, these relations vanished in the crisis year 2008.

The remainder of the paper is organized as follows. Section 2 gives an overview of the data used in this study. Section 3 describes the certificate valuation procedure and provides insights into the structure of product premiums. Section 4 examines the determinants of product choice while Section 5 compares the actual product choice with the optimal choice. Section 6 focuses more closely on the personal and trading characteristics of investors that determine their suboptimal choices and purchase decisions. Finally, Section 7 provides some concluding comments.

2. Data

In this study, we focus on discount certificates written against stocks that were included in the German DAX30 index between 2004 and 2008. A discount certificate promises a payoff equal to the cap in the event that the underlying share price is above the cap at maturity, or, in the event that the underlying price is below the cap level at maturity, the payoff is the share price (Fig. 1 presents a payoff function for a hypothetical certificate). As the investor's upside benefits are limited, discount certificates will trade at a lower price compared to the underlying. These securitized covered call positions are bought by investors who expect prices to move sideways or slightly downwards. Discount certificates are the most popular types of investment certificates in Germany, with a total trading volume of almost EUR 8bn on the Euwax and Scoach exchanges during 2013, which accounts for 30% of all investment certificates, and a volume of outstanding certificates of EUR 3.5bn as at December 2013.[7]

Our dataset consists of both trade and quote information. The quote file contains daily bid and ask quotes of all 72,200 discount

[6] The Euwax is the leading structured retail product exchange in Germany.

[7] See the website of the German Derivatives Association, available at www.deutscher-derivate-verband.de.

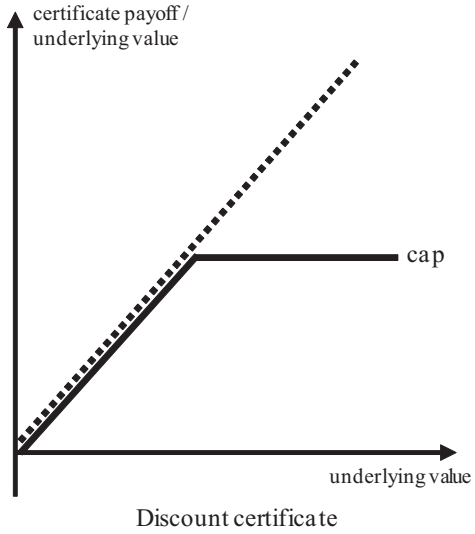

Fig. 1. Payoff profile of a discount certificate. This figure shows the payoff profile of a discount certificate dependent on the price of its underlying at the maturity date. The payoff of the certificate is indicated by the solid line, the value of the underlying is indicated by the dotted line.

certificates on DAX stocks that were tradable on the Euwax between April 2004 and December 2008.[8] Based on the quote data, we calculate each certificate's daily bid/ask spread as:

$$spr_t = \frac{P_t^{ask} - P_t^{bid}}{0.5\left(P_t^{ask} + P_t^{bid}\right)}, \tag{1}$$

where P_t^{bid} and P_t^{ask} are the certificate's quoted bid and ask price at trading day t, respectively. Fig. 2 summarizes the average spread across the sample period and, while spreads progressively fell from 2004 through 2007, in 2008 they jumped from about 0.20% to more than 0.80%.

We also have information on each certificate's issue and maturity date, underlying, issuer, and cap level. We define the moneyness of a discount certificate as

$$MONEY_t = \frac{S_t - X}{X}, \tag{2}$$

where X is the certificate's cap and S_t is the underlying's stock price. Statistics on the certificates' moneyness and time to maturity at issuance, as well as the number of issuances per year are presented in Table 1. The majority of discount certificates are issued with a cap below the underlying price at the time of issuance (on average, 11.32% below) and an average time to maturity of around 1.5 years. Fig. 3 summarizes the number of available discount certificates on DAX stocks each quarter and clearly highlights the steady growth in this sector over the sample period, reaching its peak during the last quarter of 2008 with almost 50,000 outstanding certificates. Table 1 reinforces this growth, as the number of issuances increased from less than 4000 during the last nine months of 2004 to more than 35,000 in 2008.

The trade file captures information on 26,328 discount certificate purchase transactions on DAX stocks by 3997 retail customers from a large German direct bank during our sample period. Table 2 summarizes this information and we note that the average moneyness at the dates of purchase is similar to the distribution moneyness at issuance (see Table 1). The remaining time to maturity at purchase is more than one year for the majority of trades until 2007, whereas most of the certificates bought in 2008 mature less than one year after the purchase. The volume per trade is right skewed with a mean of EUR 8920 and a median of only EUR 3074. Interestingly, we observe a significantly higher number of buy trades during 2008 compared to the years before.

[8] This data was sourced from the SIRCA Thomson Reuters Tick History (TRTH) database. For more information, see www.sirca.org.au/products/.

3. Valuation of discount certificates

3.1. Valuation framework

To measure the margin of a discount certificate on a trading day t, its theoretical fair value has to be determined. This fair value equals the sum of the underlying value, S_t, adjusted for intertemporal dividend payments, and a short European call position with a strike equal to X. This covered call position is often multiplied by a cover ratio, α, implying that the certificate refers to a fraction or a multiple of the underlying. Thus, the payoff of a discount certificate at maturity T is given by

$$DC_T = \alpha \min\{S_\tau; X\}, \tag{3}$$

where τ is the reference date on which the repayment is fixed (usually a few days before maturity, thus $\tau \leqslant T$).

We apply the Black–Scholes formula to estimate the theoretical default-free value of a discount certificate:

$$\begin{aligned} DC_t^{df} &= \alpha e^{-r(T-\tau)}(S_t - Div_t - C_t) \\ &= \alpha e^{-r(T-\tau)}\left((S_t - Div_t)N(-d_1) + Xe^{-r(\tau-t)}N\left(d_1 - \sigma\sqrt{\tau - t}\right)\right), \end{aligned} \tag{4}$$

with

$$d_1 = \frac{ln((S_t - Div_t)/X) + (r + \sigma^2/2)(\tau - t)}{\sigma\sqrt{\tau - t}}, \tag{5}$$

where Div_t denotes the aggregate discounted dividend payment estimates for between t and τ. C_t stands for the value of a European call option written on the certificate's underlying, with maturity τ and strike price X, at time t.

We calculate DC_t^{df} for every discount certificate on every trading day between its issuance and maturity. For S_t, we use the day t closing price of the certificates' underlying stock which we obtained from the SIRCA Thomson Reuters Tick History (TRTH) database. To proxy for the default-free spot rate (r), we use the government spot rate curve, estimated by Deutsche Bundesbank, using the Svensson (1994) function as an extension of the Nelson and Siegel (1987) approach (Bundesbank time series BBK01. WT3201). For periods of less than one year, linearly interpolated EUREPO rates are used. Dividend estimates are provided by Thomson Reuters on a monthly basis for the two payments following each estimation date and dividends are assumed to be paid on the day after the expected meeting dates of shareholders, which is common practice.

In order to estimate the volatility σ of the underlying stocks, we extract the implied volatilities from daily settlement prices of stock options traded at Eurex, also sourced from the SIRCA Thomson Reuters Tick History (TRTH) database. As Eurex stock options are American style, we apply a finite difference method, which allows for two discrete dividend payments. To avoid any bias caused by the volatility smile or the term structure of volatilities, the appropriate option should match the discount certificate with respect to underlying, strike (=cap), and maturity. In many cases, however, a perfect matching Eurex option cannot be found on the valuation day. Thus, we follow Baule (2011) and ter Horst and Veld (2008) and interpolate the estimated implied volatilities linearly across two dimensions, using the four options with the same underlying

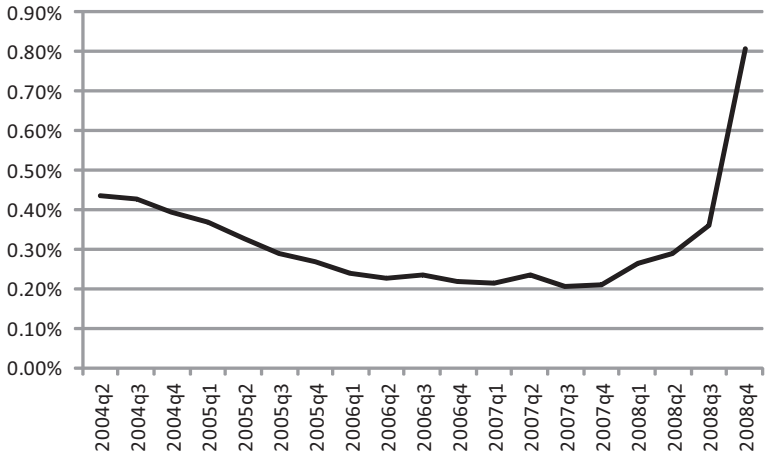

Fig. 2. Average bid/ask spreads. This figure shows the average quoted bid/ask spread, based on the daily bid and ask quotes of all outstanding discount certificates on DAX stocks on the Euwax.

Table 1
Moneyness and time to maturity at issuance. This table presents means, medians and quartiles of the moneyness and the time to maturity in years of discount certificates at the issue date. Moneyness is defined as the underlying's stock price minus the certificate's cap level, divided by the cap.

Year	Moneyness at issuance				Time to maturity (in years) at issuance				# of issuances
	25%	Mean	Median	75%	25%	Mean	Median	75%	
2004	−12.64%	1.36%	−1.56%	10.36%	1.25	1.73	1.54	1.78	3969
2005	−9.33%	3.92%	−0.87%	9.40%	1.27	1.68	1.54	1.87	6166
2006	−9.56%	6.93%	1.00%	15.01%	1.30	1.87	1.65	2.14	10,749
2007	−10.13%	8.89%	3.46%	22.18%	1.22	1.62	1.47	1.88	15,712
2008	−11.04%	16.14%	10.03%	36.07%	0.96	1.33	1.24	1.61	35,421
All years	−10.31%	11.32%	4.11%	25.33%	1.14	1.53	1.39	1.82	72,017

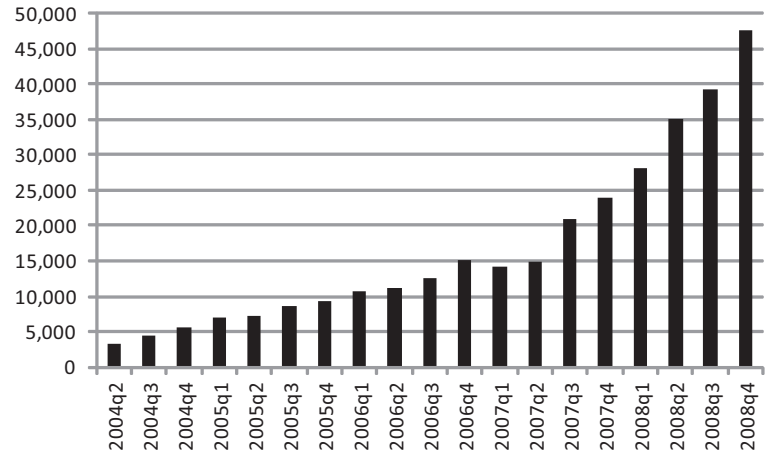

Fig. 3. Number of outstanding discount certificates. This figure shows the number of tradable discount certificates on DAX stocks on the Euwax in each quarter over the sample period of the data.

and the closest maturities and strikes to the discount certificate.[9] As stock options with a time to maturity of more than 2 years are rare during our sample period and dividend estimations are only available for the two subsequent payments, we exclude discount certificates with a remaining time to maturity of >2 years, which results in 63,955 certificates to be valued. Certificates are unsecured securities and are therefore exposed to issuer default risk. According to the Hull and White (1995) model, the value of a defaultable security can be obtained by discounting its default-free value with the issuer's credit spread s, resulting in:

$$DC_t^{cr} = DC_t^{df} e^{-s(T-t)} = \alpha e^{-s(T-t)-r(T-\tau)} \left((S_t - Div_t) N(-d_1) + X e^{-r(\tau-t)} N\left(d_1 - \sigma\sqrt{\tau - t}\right) \right). \quad (6)$$

[9] The formulas of the double-linear interpolation scheme are provided in Appendix A. We use call options as standard for implied volatilities. As for 26% of our valuation points, the underlying has no dividend payments before maturity of the respective options; this allows us to omit calculating the early exercise premium for a significant part of our data and by doing so to avoid an additional source of error. However, if suitable call options are not available, we use put options instead. The method of Hentschel (2003) – for example applied by Baule (2011) – is not applicable in our case as it is based on put-call parity which, however, does not hold for American options.

Table 2
Moneyness and time to maturity at purchase and volume per purchase trade. This table presents means, medians and quartiles of the moneyness, the time to maturity in years, and the volume per purchase trade of 3997 investors with discount certificates at the purchase date. Moneyness is defined as the underlying's stock price minus the certificate's cap level, divided by the cap.

Year	Moneyness at purchase				Time to maturity (in years) at purchase				Volume per purchase trade				# of purchases
	25%	Mean	Median	75%	25%	Mean	Median	75%	25%	Mean	Median	75%	
2004	−7.86%	3.59%	0.11%	12.38%	1.06	1.69	1.23	1.62	1698	5882	3018	5470	1808
2005	−6.19%	5.33%	1.86%	11.75%	0.98	1.30	1.18	1.41	1107	6075	2552	5202	5182
2006	−6.08%	7.65%	3.96%	16.64%	0.81	1.18	1.12	1.36	1242	10,489	2909	6326	4151
2007	−2.21%	13.69%	6.80%	25.00%	1.02	1.32	1.16	1.45	1719	10,895	3557	8004	4483
2008	−17.10%	13.21%	4.24%	32.87%	0.40	0.95	0.96	1.18	1437	9376	3241	7980	10,704
All years	−8.35%	10.19%	3.65%	21.24%	0.64	1.17	1.08	1.36	1395	8920	3074	6766	26,328

We obtain issuer-specific one- and two-year CDS spreads for senior debt from Datastream. For discount certificates with a time to maturity of less than one year, the one-year CDS spread is applied. For a time to maturity of between one and two years, we interpolate between the one- and two-year CDS spread. For some issuers CDS spreads are not available in our sample period. In this case we only calculate the default-free margin and exclude the respective certificates when analyzing the credit risk margin in the following.[10]

3.2. Margins of discount certificates

Based on the fair theoretical values, the default-free margin DFM_t, the credit risk margin CRM_t, and the total margin TM_t can be defined:

$$DFM_t = \frac{DC_t^{close} - DC_t^{df}}{DC_t^{df}}, \tag{7}$$

$$CRM_t = \frac{DC_t^{df} - DC_t^{cr}}{DC_t^{cr}}, \text{ and} \tag{8}$$

$$TM_t = \frac{DC_t^{close} - DC_t^{cr}}{DC_t^{cr}}, \tag{9}$$

where DC_t^{close} is the certificate's daily 5:35 p.m. mid quote (average of bid and ask quotes) on the Euwax, which was chosen to ensure the best possible match with the underlying stock's day t closing price.[11]

The average *DFM*, *CFM*, and *TM*, which are based on more than 10 million valuations, are reported in Table 3. The number of valuations varies much between the issuers as they had very different numbers of certificates outstanding. Across all issuers where CDS are available, discount certificates are priced 0.88% above their fair theoretical value.[12] The credit risk margin accounts for 39% of the total margin, whereas the default-free margin is 54 basis points on average.

Fig. 4 presents a plot of the daily mean and standard deviation of the credit spread for all issuers where CDS are available during our sample period, and reveals that CDS spreads were relatively stable until 2007 and increased significantly during 2008. Based on this result, we reestimated the average margins for the period April 2004 through December 2007 and January 2008 through December 2008. The results are provided in Appendix B and clearly document the considerable increase in margins that occurred during the global financial crisis. Credit risk margins and therefore total margins jump from very low levels of 0.10% and 0.58% until 2007 to economically large 0.63% and 1.24% in 2008. Default-free margins are about 10 basis points higher during the second subperiod, which is statistically highly significant.[13]

Variations in default-free margins are relatively low among the various issuers and range from 0.35% (BNP Paribas) to 0.87% (DZ Bank) for the whole sample period. *CRM* and *TM* variations among issuers have to be interpreted with caution as these numbers largely depend on the number of outstanding certificates during the months of extreme credit spreads in 2008. For example, the total margin of only 0.46% for ING's discount certificates can be explained by the fact that there weren't any outstanding discount certificates on DAX stocks offered by ING in 2008. Nonetheless, these results offer some interesting insights: it appears that the issuing banks did not adjust the certificate prices to their fair defaultable value during the financial crisis, when the default risk in the financial sector was very high. Instead, it seems that the banks utilized certificates as a cheap refinancing instrument in a time of extreme illiquidity in the interbank market. For example, the number of issued discount certificates on DAX stocks in 2008

[10] Alternatively, one could use issuer-rating specific spreads from the iBoxx indices for corporate financials. However, these spreads are not issuer-specific by definition and may include a significant liquidity premium that would hinder the comparison of results across banks, as credit risk margins would be overestimated for these issuers. Additionally, CDS also lead the bond market with regard to the price discovery process (e.g., Blanco et al., 2005; Forte and Peña, 2009).

[11] Note that due to hedging and structuring costs, the issuers' effective margins are lower than the calculated margins. However, this paper investigates certificate pricing from the investors' point of view. As retail investors usually do not have information about the issuers' specific cost structures, DFM_t, CRM_t, and TM_t are the most objective measures for overpricing.

[12] Examining discount certificates with DAX stocks as underlyings, Baule et al. (2008) find margins of between 0.67% and 2.39%. Stoimenov and Wilkens (2005) estimate average margins of 2.11% for discount certificates and reverse convertibles, which are of similar structure as discount certificates, on DAX stocks. Neglecting issuer default risk, Wilkens et al. (2003) report average margins of 4.20% for discount certificates on DAX stocks, however for a period in 2002 when margins were higher due to low competition.

[13] The Hull and White (1995) model assumes independence between market (underlying price) risk and credit (default) risk of the issuer. This typically results in an overestimation of the negative impact of the default risk on the certificates' value, i.e. values are underestimated, and the total margin *TM* and credit risk margin *CRM* are overestimated (Baule et al., 2008). To estimate the significance of this overestimation, we randomly draw 3000 discount certificates from our data set and calculate the margins using the model of Baule et al. (2008). This is a structural model for the pricing of vulnerable options, i.e. it assumes that issuer's default is driven by its asset value that is correlated with the underlying stock. Then, the certificate's value positively depends on this correlation. If the correlation is zero, the results coincide with the Hull and White model, and if the issuer is default-free, the value coincides with the Black and Scholes value. Following the calibration procedure by Baule et al. (2008) for listed issuers, we find that the average estimated credit risk margin (and consequently the total margin) is 0.11 percentage points lower than in the Hull and White model. However, differences are higher (0.22 percentage points) when only considering the year 2008 as the spread level is larger and correlations typically increase in times of strongly falling markets. We still prefer the Hull and White model to the structural model for the following reasons. First, a sound calibration of the structural model requires the issuer to be listed which is not the case for all issuers. Second, default risk in the value of discount certificates is not the main focus of the paper but rather the investors' product choice. We think it would be hard for private investors to apply a sophisticated model like the structural one; if they calculated the 'fair' value under credit risk at all, it is more likely that they calculated the certificate's 'fair' value in the Hull and White way, i.e. only based on the standard Black and Scholes formula and the issuer's credit spread, and base their decision on this value.

Table 3
Average margins by issuers. This table reports average margins for discount certificates written on DAX stocks in the secondary market from 04/2004 to 12/2008. Margin definitions for default-free (*DFM*), credit risk (*CRM*), and total margin (*TM*) are given in Eqs. (7)–(9), respectively. *CRM* / *TM* is the fraction of the average credit risk margin on the average total margin. Observations is the sample size for each issuer. Certificates is the number of issued certificates per issuer. To correct for data and valuation errors, we truncated the lowest and highest 1% of the *DFM* distribution.

Issuer	Mean DFM	Mean CRM	Mean TM	CRM/TM	Observations	Certificates
ABN Amro	0.71%	0.55%	1.26%	43.65%	135,941	1588
BHF-Bank	0.77%	N/A	N/A	N/A	128,549	929
BNP	0.35%	0.16%	0.51%	31.37%	1,462,807	7048
Citibank	0.59%	0.65%	1.25%	52.00%	778,710	4971
Commerzbank	0.49%	0.30%	0.79%	37.97%	2,047,392	12,871
Deutsche Bank	0.52%	0.25%	0.78%	32.05%	829,604	5607
Dresdner Bank	0.53%	0.33%	0.86%	38.37%	670,980	5966
DZ Bank	0.87%	0.37%	1.24%	29.84%	345,911	2577
Goldman Sachs	0.61%	1.04%	1.66%	62.65%	240,036	2460
HSBC Trinkaus	0.62%	0.23%	0.85%	27.06%	526,989	2715
ING	0.44%	0.02%	0.46%	4.35%	216,396	628
LBBW	0.49%	0.50%	0.99%	50.51%	216,210	1168
Sal. Oppenheim	0.53%	N/A	N/A	N/A	800,399	3954
Société Générale	0.53%	0.06%	0.60%	10.00%	602,496	2235
UBS	0.70%	0.50%	1.20%	41.67%	1,253,732	8184
Others	0.74%	N/A	N/A	N/A	160,234	1054
All issuers	0.54%	0.34%	0.88%	38.64%	10,416,386	63,955

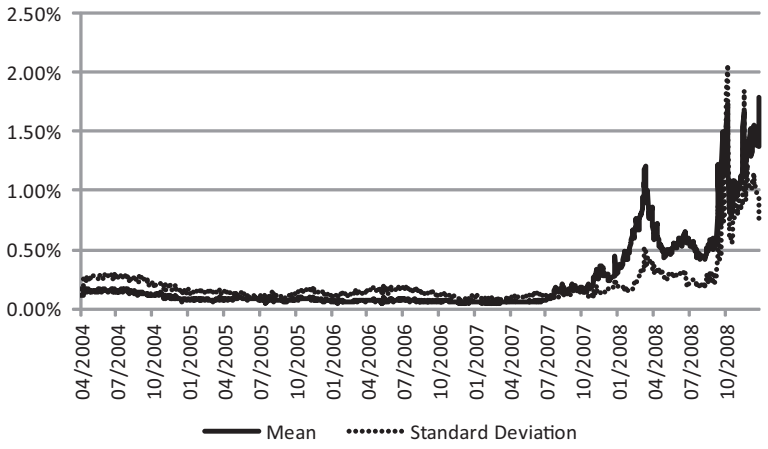

Fig. 4. Credit spreads. This figure shows the mean (solid line) and standard deviation (dotted line) of the credit spread for all issuers calculated for each day.

(≈ 35,000) is only slightly less than the amount of certificates issued in the previous four years (2004 through 2007) and is highest in October and November 2008, when the financial crisis reached its peak.

3.3. Explanation of margins

The analysis in Section 3.2 raises some interesting questions about the pricing behavior of discount certificates. To provide further insights into this issue, we derive and empirically test a model of the determinants of the total margin. To construct this model, we begin by drawing on the previously discussed 'lifecycle hypothesis', which suggests that margins will be relatively high shortly after issuance and progressively reduce over the product's lifetime (see Wilkens et al., 2003, and Stoimenov and Wilkens, 2005). This phenomenon is thought to result from issuers setting margins high at the outset, when sales are at their maximum, to cover operational and hedging costs. As maturity draws nearer, however, the uncertainty surrounding volatility, dividends, and the risk-free rate is reduced and retail investors can estimate the certificates' fair values relatively easily. To test the lifecycle hypothesis, we define the absolute time to maturity (in years) of certificate i on trading day t as

$$LIFE_{i,t} = T_i - t, \tag{10}$$

where T is the certificate's maturity date. Based on this definition, we expect the impact of *LIFE* on the total margin to be positive.

Baule (2011) finds a non-linear relationship between order flow and certificate maturity, which is attributed to an idiosyncratic tax effect. In Germany, capital gains on certificates realized less than one year after the purchase date were subject to a form of speculative tax. If the certificates were sold or redeemed more than one year after purchase however, the gains were tax-free which led many investors to buy certificates with a time to maturity of a little more than one year (this speculative tax remained in effect until the end of 2008).[14] If issuers anticipated this behavior, they could have set high markups for maturities of more than one year and reduce them for shorter maturities. We follow Baule (2011) and generate the following dummy variables to test the order flow effect:

$$TAX_{i,t} = 1_{\{T_i - t > 1\}} \tag{11}$$

and

$$MAT_{i,t} = 1_{\{T_i - t < 0.3\}}, \tag{12}$$

indicating whether the time to maturity is above one year or below 0.3 years, respectively.

[14] We also observe this behavior for the investors in our data set.

To measure the impact of competition between issuers on the certificate margins, we again follow Baule (2011) and calculate

$$COMP_{i,t} = 1 - \frac{1}{n_{i,t}}, \tag{13}$$

where $n_{i,t}$ stands for the number of similar certificates offered by other issuers. We define a discount certificate as similar if it has the same underlying, a similar cap level (±5%) and similar time to maturity (±14 days). If there is no competition, *COMP* is 0, whereas *COMP* tends to 1 for a high level of competition.

Earlier studies reveal some additional factors which could affect the margins of certificates. For example, the moneyness of the embedded option, as calculated in (2), may have a negative impact on the margin as the option is more sensitive to underlying price changes when it is at the money, giving the issuer more leeway for higher markups. This leeway shrinks when the underlying price is above the cap level. We also test whether margins have changed over the years of the sample period by including the variable $TIME_{i,t}$, which is defined as the time between t and the starting date of our sample period. We also include the issuer credit risk spread, $CREDIT_{i,t}$, into our series of explanatory variables as the credit risk margin makes up to a large part of the total margin (see previous section). Finding a zero coefficient for $CREDIT_{i,t}$ would imply that issuers reduce prices when their credit risk increases; a positive coefficient means that issuers do not (or do not fully) compensate investors for the credit risk but widen the total margin.

As our data is for discount certificates written on single stocks (rather than the DAX index as is most commonly the case), we are able to include individual stock information in our model. The first of these variables captures information on the stocks' expected dividends. Recall that investors do not receive dividend payments through their discount certificate positions. Therefore, they should be compensated for this loss of profit in a fair price setting with an adjustment for expected dividends (see Eqs. (4) and (6)). On the other hand, issuers have an incentive to neglect dividends when setting prices to maximize their own profits. This would result in higher margins for discount certificates written on stocks with higher expected dividend payments. As such, we calculate

$$DIV_{i,t} = \frac{Div_{i,t}}{S_{i,t}} \tag{14}$$

as a further potential determinant of the total margin, where $Div_{i,t}$ are the aggregate discounted dividend payment estimates for between t and τ. A second individual stock variable we include in our model is the implied volatility level ($VOLA_{i,t}$) of the underlying asset. We expect a positive relation between margins and volatility since issuers are likely to want to be compensated for increased overnight risk in times of high volatility.

Thus, we specify the following functional form for our empirical model of margins, which we estimate separately for each issuer where CDS are available[15]:

$$\begin{aligned} TM_{i,t} = {} & \alpha + \beta_2 LIFE_{i,t} + \beta_3 TAX_{i,t} + \beta_4 MAT_{i,t} + \beta_5 COMP_{i,t} \\ & + \beta_6 MONEY_{i,t} + \beta_7 TIME_{i,t} + \beta_8 DIV_{i,t} + \beta_9 VOLA_{i,t} \\ & + \beta_{10} CREDIT_{i,t} + \epsilon_{i,t}. \end{aligned} \tag{15}$$

For each issuer a separate pooled regression is performed, where the index i denotes a particular certificate and t denotes the day. The coefficients of this regression are given in Table 4. Our results confirm the lifecycle hypothesis, suggesting that all issuers reduce the total margins over the certificates' lifetimes. The coefficients of our order flow dummy variables, however, give less clear indications. For 5 of 13 issuers, the *TAX* coefficient has the expected positive (and significant) sign, whereas *MAT* is significantly negative for 9 of 13 issuers. For only 3 issuers, the combination of *TAX* and *MAT* is as expected. This implies that, in contrast to Baule (2011), the hypothesis of order flow-anticipating issuers can only partially be confirmed for the full sample period.

Competition has in most cases a significant and negative impact on margins in the market for discount certificates. The effects of moneyness and time are all negative except time for one issuer. The nearly overall positive and significant *DIV* coefficients suggest that issuers do not pass on profits from dividend payments to investors, whereas all issuers increase margins in times of high volatility. All coefficients of *CREDIT* are positive and significant which indicates that higher credit risk is used by issuers to widen the total margins. In Section 4 we find that credit risk does not influence the product choice of investors which explains why issuers can impose higher total margins when credit risk increases.

To test the impact of the credit crisis on our results, we re-estimate this model using data sampled from April 2004 to December 2007 and January 2008 to December 2008. The estimated coefficients are given in Appendix C. The results for the first subperiod provide an even clearer picture of the central relationships compared to the full period results. The effects of the certificates' lifetimes, credit spreads, underlying volatilities and dividends on total margins are again positive and significant across all issuers (with one exception for credit spread), and higher competition correlates with lower margins in most cases. *MONEY* is negative for all issuers during the first subperiod, implying larger markups for discount certificates whose implied call options are out of the money. The in most cases negative *TIME* coefficients suggest shrinking margins from 2004 to the end of 2007. During the first subperiod, only half of the issuers set higher margins for maturities of more than one year but most issuers lowered margins significantly during the final 0.3 years of the certificates' lifetime.

For the second subperiod, the results are more mixed. The lifecycle hypothesis can be confirmed, but the order flow effect can be found for only half of the issuers. Dividends (except three issuers), implied volatility, and credit spreads still correlate significantly positively with total margins. Interestingly, in most cases the total margins increased during 2008, keeping all other variables constant.

4. Determinants of investor choice

The analysis of the previous section suggests that default-free margins and credit risk margins play a significant role in the price-setting of discount certificates. In this section, we consider the perspective of the investors and attempt to identify the factors that affect their purchasing decisions.

4.1. Model

Dorn (2012) investigates the buying and selling behavior of warrant traders by addressing the question: Given an investor buys a call on the DAX, what makes him choose that particular call from a set of similar call options? Our question is somewhat different in that we are focusing on the role of implicit and explicit mispricing within buy decisions of retail investors. We assume that investors purchase certificates to pursue a certain trading strategy based on: their market expectations; the need to diversify their portfolios; to hedge existing portfolio positions; to generate returns for free cash positions; or for straightforward speculation. For all these motives, it can be assumed that the investor's certificate selection process begins with the choice of the product type (=payoff profile), the

[15] We apply Newey–West adjusted standard errors. We choose the lag length issuer-specific as $H = \text{int}(4(\frac{N}{100})^{\frac{2}{9}})$, see Newey and West (1994), where N is the average time series length of the certificates of an issuer.

Table 4
Determinants of total margins. This table reports estimated coefficients of regression (15), which is run separately for each issuer where CDS are available. The total margin *TM* is the dependent variable; explanatory variables are described in Section 3.3. Obs. is the number of observations. Robust Newey–West *t*-values are in parenthesis. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

Issuer	Obs.	Const.	LIFE	TAX	MAT	COMP	MONEY	TIME	DIV	VOLA	CREDIT	Adj. R^2
ABN Amro	135,941	−0.0084***	+0.0137***	−0.0022***	−0.0006***	−0.0011***	−0.0043***	−0.0005***	+0.0049**	+0.0178***	+0.9297***	0.33
		(−13.35)	(61.53)	(−13.24)	(−4.53)	(−3.24)	(−19.98)	(−3.53)	(2.17)	(41.95)	(47.66)	
BNP	1,462,807	−0.0045***	+0.0037***	+0.0000	−0.0021***	+0.0003***	−0.0015***	−0.0004***	+0.0649***	+0.0170***	+0.5096***	0.19
		(−52.92)	(44.66)	(0.27)	(−46.05)	(7.04)	(−34.66)	(−23.58)	(72.03)	(111.02)	(47.42)	
Citibank	778,710	−0.0075***	+0.0065***	+0.0013***	−0.0042***	+0.0016***	−0.0039***	−0.0002***	+0.0705***	+0.0172***	+0.6910***	0.50
		(−53.78)	(60.80)	(16.63)	(−52.10)	(23.56)	(−50.93)	(−8.76)	(56.41)	(65.06)	(143.11)	
Commerzbank	2,047,392	−0.0089***	+0.0060***	+0.0005***	−0.0004***	−0.0001***	−0.0044***	−0.0001***	+0.0731***	+0.0241***	+0.5098***	0.34
		(−134.03)	(96.95)	(12.55)	(−8.93)	(−4.58)	(−93.92)	(−8.34)	(104.68)	(162.72)	(78.80)	
Deutsche Bank	829,604	−0.0082***	+0.0086***	−0.0002***	+0.0002***	+0.0001**	−0.0020***	−0.0006***	+0.0616***	+0.0225***	+0.7014***	0.37
		(−75.81)	(86.50)	(−3.51)	(3.16)	(2.20)	(−23.83)	(−31.14)	(50.77)	(82.28)	(62.54)	
Dresdner Bank	670,980	−0.0089***	+0.0080***	+0.0001	−0.0015***	−0.0022***	−0.0020***	+0.0004***	+0.0143***	+0.0179***	+1.0463***	0.33
		(−55.44)	(79.36)	(0.88)	(−19.49)	(−22.96)	(−25.50)	(10.35)	(11.60)	(66.26)	(75.91)	
DZ Bank	345,911	−0.0052***	+0.0113***	−0.0005***	−0.0015***	−0.0010***	−0.0053***	−0.0016***	−0.0043**	+0.0377***	+0.3556***	0.33
		(−22.07)	(72.44)	(−4.03)	(−14.88)	(−8.26)	(−40.72)	(−37.64)	(−2.22)	(78.54)	(16.56)	
Goldman Sachs	240,036	−0.0049***	+0.0104***	+0.0016***	+0.0014***	−0.0017***	−0.0011***	−0.0002***	+0.1354***	+0.0075***	+0.5694***	0.63
		(−20.20)	(47.60)	(9.40)	(10.05)	(−11.20)	(−5.55)	(−4.84)	(57.50)	(12.01)	(77.89)	
HSBC Trinkaus	526,989	−0.0088***	+0.0067***	+0.0011***	−0.0023***	+0.0003**	−0.0049***	−0.0004***	+0.0352***	+0.0298***	+0.6151***	0.32
		(−50.34)	(52.01)	(11.75)	(−26.95)	(2.34)	(−46.71)	(−11.64)	(22.95)	(74.98)	(40.22)	
ING	216,396	+0.0008***	+0.0019***	−0.0011***	−0.0027***	−0.0022***	−0.0049***	−0.0013***	+0.0488***	+0.0255***	+0.3890***	0.16
		(3.25)	(10.81)	(−8.53)	(−27.73)	(−13.05)	(−27.81)	(−27.74)	(20.97)	(39.66)	(6.93)	
LBBW	216,210	−0.0106***	+0.0123***	+0.0065***	+0.0006***	−0.0007***	−0.0010***	−0.0012***	+0.0769***	+0.0271***	+0.5320***	0.50
		(−48.04)	(57.05)	(46.96)	(4.82)	(−8.02)	(−6.45)	(−27.63)	(34.75)	(58.72)	(76.68)	
Société Générale	602,496	−0.0043***	+0.0053***	−0.0001	−0.0022***	−0.0034***	−0.0038***	−0.0001***	+0.0577***	+0.0271***	+0.3666***	0.26
		(−35.08)	(50.50)	(−0.72)	(−35.22)	(−41.33)	(−42.03)	(−4.96)	(36.87)	(83.82)	(22.32)	
UBS	1,253,732	−0.0104***	+0.0100***	−0.0003***	−0.0000	−0.0025***	−0.0052***	−0.0007***	+0.0524***	+0.0320***	+0.9333***	0.60
		(−114.18)	(137.71)	(−4.63)	(−0.14)	(−60.13)	(−84.43)	(−40.33)	(59.06)	(114.99)	(160.52)	

certificate's underlying, strike, and time to maturity. Having made this decision, the investor is then confronted by a vast number of close substitute products[16] that differ solely in terms of their quoted price and issuer. Thus, our model addresses the question: Given that an investor decided to buy a discount certificate with a given underlying, strike and time to maturity, what makes him buy that particular certificate but not a similar certificate? We define a similar certificate as a discount certificate featuring the same underlying, a similar cap level (±5%) and a similar time to maturity (±14 days) compared to the actually purchased certificate.

Following Grinblatt and Keloharju (2001), we employ a Logit regression where the dependent variable is set to 1 for every discount certificate purchase made by an investor in our trade file on a particular day. It is set to 0 for every similar, available discount certificate the investor has not purchased on that trading day. Our model includes a range of variables that may be grouped into three different categories: rational factors, behavioral factors, and control variables.

4.1.1. Rational factors

For the first group of variables, we include the certificate's default-free margin (*DFM*), credit risk margin (*CRM*), and bid/ask spread on the respective trading day. These variables will provide insights into the question of whether the choice behavior of retail investors is rational or not. If investors were rational, they would choose the certificate with the lowest relative difference between the quoted ask price and the fair theoretical value from the group of similar certificates.[17] We would therefore expect a negative impact of *DFM*, *CRM*, and the bid/ask spread on the propensity to buy a certain certificate.

4.1.2. Behavioral factors

A number of behavioral factors may also have an influence on investors' buy decisions. For example, issuers with a large market share could attract more investors as their strong market presence leads to higher product visibility. Therefore, the number of outstanding certificates of the issuer in relation to the total number of outstanding discount certificates on the day of the trade is included as an issuer market share proxy. Further, investors may be more likely to buy a certificate they are familiar with or trade with an issuer they have previously dealt with. These familiarity factors are represented by two dummy variables which are 1 if the investor has traded the certificate before (*TradedCertBefore*) or has traded any discount certificate with the issuer before (*TradedwithIssuer*), and 0 otherwise. To control for the potential effects of marketing campaigns designed to promote certain products, we include the certificate's trading volume (*CertTradeVolEuwax*) on the respective trading day on the Euwax (number of certificates traded), adjusted by the number of that certificate the investor himself traded on the Euwax on that day. Baule and Blonski (2014) find that individual investors have a strong preference for 'round' strike prices, i.e., they prefer a discount certificate with a strike price of EUR 20 over an otherwise identical certificate with a strike price of EUR 20.50, for example. Therefore, we include the dummy variables $RoundStrike_1$, $RoundStrike_5$, and $RoundStrike_{10}$ which are 1 if the certificate's strike is divisible by EUR 1, 5, and 10, respectively, and 0 otherwise.

4.1.3. Control variables

The control variables we include in the regression are: the certificates' time since issuance, 34 dummy variables for the number of similar certificates at the purchase date to control for a varying number of alternative certificates over time[18], 34 dummy variables for each underlying stock (with Volkswagen as omitted dummy), and 55 dummy variables for each month in the sample period (12/2008 as omitted dummy) to control for calendar effects.

The resulting model is formally specified as follows:

$$P(CertificatePurchase_j = 1) = \Lambda(Constant + \beta_1 X_{1,j} + \beta_2 X_{2,j} + \beta_3 X_{3,j}), \tag{16}$$

where $CertificatePurchase_j$ equals 1 if observation j is a purchase. Λ denotes the logistic cumulative distribution function, $X_{1,j}$ denotes the vector of rational attributes that could affect choices of rational investors (*DFM*, *CRM*, and bid/ask spread), $X_{2,j}$ denotes the vector of visibility and familiarity factors, and $X_{3,j}$ denotes the vector of control variables.

4.2. Results

An overview of the major attributes of certificates bought and not bought is given in Table 5. Of the 126,572 data points, 14,950 are observations where a purchase is made and 111,622 are observations where a decision was made not to purchase. This equates to an unconditional purchase probability of 11.8%. In other words, an investor can choose among 8.5 similar certificates on average when buying a discount certificate with a DAX stock as underlying. The average and median *DFM* and *CRM* are lower for purchased certificates compared to the other certificates available, while bid/ask spreads are very similar in size for both groups.[19] Interestingly, 24.3% of the certificates bought have already been traded by the same investor previously, and this effect is mainly caused by investors who sequentially increase their certificate holdings.

The Logit regression analysis is carried out for the certificates where *CRM* were available. First, we consider the first column of results in Table 6, where the control variable coefficients are not reported to conserve space. The *DFM* coefficient is negative and significant, implying the default-free margin has a negative impact on the probability of purchase of discount certificates. However, despite the statistical significance, the effect is small in size as a one-standard deviation increase of *DFM* lowers the purchase probability by only 1.31%. The estimates for the bid/ask spread are qualitatively similar, being negative and statistically significant, while having a low economic influence on buy decisions of retail investors (a one-standard deviation bid/ask spread increase lowers the purchase probability by only 0.96%). Perhaps the most surprising result of this regression is the insignificance of the *CRM* coefficient. Assuming risk-aversion, one would expect investors to choose the certificate which is issued by the bank with the lowest default risk from the range of similar, available products. Instead, the credit risk margin appears to have no impact on investors' choices.

[16] As can be observed from Fig. 3, investors could choose between almost 50,000 discount certificates with only 30 different DAX stocks as underlying assets at Euwax by end of 2008.

[17] All our explanatory variables are calculated once per day which may cause matching errors as the actual trades can occur at any time of the trading day. In an unreported test, we checked intraday variations of *DFM* and bid/ask spreads and found them to be relatively stable over the day. In addition to that, we have to assume that *DFM* and bid/ask spreads do not vary across exchanges and trading platforms as these variables are based on Euwax quotes whereas the actual trades can be, but do not necessarily have to be executed at Euwax.

[18] The maximum number of similar available certificates at the purchase date is 36. As we do not consider buys where the purchased certificate is the only available product, and as 36 is the omitted variable, 34 dummy variables are included in the model. Unreported tests show that our results are robust to using the inverse number of available certificates at the purchase day as an alternative measure.

[19] It should be noted that the issuers where CDS are not available (see also Section 3.1) are excluded when the numbers related to *CRM* are calculated, while all other figures (such as *DFM*) are calculated for the full dataset. However, calculating the other figures on the restricted data set would change the results by only ±0.01 to 0.03 percentage points.

Table 5
Attributes of purchased and available certificates. When an investor purchases a discount certificate, it is classified as a 'certificate bought'. Those certificates which are similar to the purchased certificate (same underlying, strike ±5%, time to maturity ±14 days), but have not been purchased by the investor on that day, are classified as 'certificates not bought'. This table reports attributes of purchased and not purchased certificates on the respective trading day. The attribute variables are described in Section 4.1.

Observations	Certificates bought 14,950			Certificates not bought 111,622			All certificates 126,572		
	Mean	Std	Median	Mean	Std	Median	Mean	Std	Median
DFM	0.47%	0.79%	0.38%	0.67%	0.84%	0.58%	0.65%	0.84%	0.55%
CRM	0.21%	0.37%	0.07%	0.30%	0.45%	0.15%	0.29%	0.44%	0.13%
BidAskSpread	0.24%	0.23%	0.17%	0.24%	0.31%	0.16%	0.24%	0.30%	0.16%
IssuerMarketShare	14.7%	7.6%	14.8%	10.1%	6.9%	8.8%	10.7%	7.2%	9.4%
TradedwithIssuer	0.683	0.465	1	0.208	0.406	0	0.264	0.441	0
TradedCertBefore	0.243	0.429	0	0.006	0.077	0	0.034	0.181	0
CertTradeVolEuwax	627	8997	0	130	1484	0	189	3395	0

Table 6
Probability of choosing a certificate from similar certificates. This table reports the results of two Logit regressions according to Eq. (16), where the dependent variable is 1 for every discount certificate purchase made by an investor on a particular day, and it is set to 0 for every similar available discount certificate not bought by the investor. Explanatory variables and unreported control variables are described in Section 4.1. Certificates of issuers where CDS are not available are excluded. Coefficients are reported with the respective standard errors, which are robust to heteroscedasticity and correlation across same-investor observations (clusters on investor level). Columns three and five report effects on the purchase probabilities of a continuous variable's one-standard deviation increase or a change from 0 to 1 for dummy variables, evaluated at the mean of the other regressors. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

Strike	±5%		±1%	
Time to Maturity	±14 days		±3 days	
Regressor	Coefficient (SE)	Effect on purchase prob.	Coefficient (SE)	Effect on purchase prob.
Constant	−5.246*** (0.275)		−2.240*** (0.446)	
DFM	−29.517*** (2.079)	−1.31%	−25.444*** (2.355)	−2.89%
CRM	+4.157 (8.512)	+0.10%	+16.689* (9.293)	+1.11%
BidAskSpread	−60.892*** (18.443)	−0.96%	−81.774*** (21.255)	−3.98%
IssuerMarketShare	+4.530*** (0.816)	+1.75%	+7.281*** (1.626)	+6.97%
TradedwithIssuer	+1.633*** (0.174)	+12.83%	+1.817*** (0.226)	+30.72%
TradedCertBefore	+3.317*** (0.229)	+54.46%	+3.732*** (0.276)	+73.19%
CertTradeVolEuwax	+0.000*** (0.000)	+1.47%	+0.000*** (0.000)	+7.48%
$RoundStrike_1$	+0.500*** (0.051)	+2.25%	+0.110 (0.099)	+1.43%
$RoundStrike_5$	+0.155*** (0.050)	+0.81%	+0.012 (0.094)	+0.16%
$RoundStrike_{10}$	−0.057 (0.035)	−0.30%	−0.124*** (0.046)	−1.67%
# of observations	109,731		43,361	
# of clusters (investors)	2843		2507	
Pseudo-R^2	33.3%		37.6%	

In terms of the more behavioral factors we consider in the model, familiarity factors are found to play a very important role when retail investors choose discount certificates. Having traded with the issuer in the past increases the probability to purchase a certificate from the same issuer by 12.83%. The impact of past trading experience in the certificate itself is even stronger as we find that having traded a certain certificate in the past increases the probability that an investor purchases the same certificate again by 54.46%. As previously discussed, this effect most likely reflects the progressive accumulation of positions over time by investors. The issuers' market share and the certificate's trading volume are correlated positively with the purchase probability as well. Our results are partially in line with Baule and Blonski (2014), as we find a preference for round strike prices which are divisible by EUR 1 and EUR 5. The coefficient for $RoundStrike_{10}$, however, is not statistically significant.

To check the robustness of these results to the definition of product similarity, we consider an alternative definition that includes only those discount certificates in the benchmark group featuring the same underlying, a time to maturity deviating not more than 3 days from the purchased certificate's time to maturity, and a cap which is not more than 1% above or below the purchased certificate's cap level. A summary of the data classified according to this alternative definition is provided in Appendix D. The estimated Logit regression equation coefficients are summarized in the second column of results in Table 6, and are qualitatively similar to those from the basic regression (except for the *RoundStrike* dummies). The most important difference is that changes of the determinants have a stronger quantitative impact on the purchase probability. This is likely a direct result of the more restricted similarity definition increasing unconditional purchase probability. Additionally, the credit risk margin becomes significant at the 10% level (with a low positive effect on the purchase probability) and the *RoundStrike* dummies change their significance.

The results of Section 3 show that product margins are significantly different before and during the financial crisis. This raises the question of whether the investors' choice behavior also changes during our sample period. For example, one might expect investors to be more distracted during the crisis and hence make poorer choices. To answer this question, we again perform the Logit regression (see Eq. (16)), separately for a period before the financial crisis (04/2004-12/2007) and during the financial crisis (01/2008-12/2008). The results of these two regressions are given in Appendix E. Overall, the results for both subperiods are relatively similar. The *DFM* and the bid/ask spread coefficients are throughout highly negative and significant. The *CRM* coefficient is not significant in both subperiods, implying that individual investors did not care about default risk when choosing a certificate, even during the financial crisis. The behavioral factors play a very important role in the investor's product choice both before and during the financial crisis. While most of them are very similar during both subperiods, investors show a stronger preference for round strike prices during the financial crisis. The differences in the effects of factor changes on the purchase probabilities have to be interpreted with caution since the unconditional purchase probability is higher during the first subperiod. This is due to the higher number of available products in 2008. To sum up the results of this analysis, the investors' choice behavior does not change much from before to during the financial crisis. In both subperiods, their choice is dominated by behavioral factors instead of rational factors.

In general, the results of this section suggest that retail investors' choice of certificates exhibits a degree of irrationality as, while

the effects of default-free margins and bid/ask spreads on the buying behavior are statistically significant, they are not economically though. In addition, retail investors do not care about the issuer's default risk when choosing a certificate. The familiarity of the investor with both the issuer and the certificates, however, is found to play a very important role in the certificate selection process.[20] These findings raise the question about the degree and the costs of irrational choice for retail investors which we address in the following section.

5. Quality of certificate selection

To investigate the degree of investor irrationality in the certificate selection process, we compare actual certificate choices to the 'best' possible choice. To this end, we rank every discount certificate purchase in our sample and similar available certificates using the metric:

$$DFMask_t = \frac{DC_t^{ask} - DC_t^{df}}{DC_t^{df}}, \tag{17}$$

where DC_t^{ask} is the daily 5:35 p.m. ask quote on the Euwax and similarity is defined as per Section 4 (i.e., the same underlying, strike ±5%, and time to maturity ±14 days). Given that the decision was made to buy a discount certificate with a certain underlying, strike, and time to maturity, a rational and informed investor would choose the certificate with the lowest *DFMask* (rank = 1) from the range of similar, available products, which we refer to as the 'best' or 'optimal choice'.[21] If default-free margin and bid/ask spread do not play a role in the selection process, the investor would choose randomly regarding *DFMask* and the average rank would be $(N+1)/2$, where N is the number of similar available certificates at the purchase day ('random choice').

The average ranks of chosen certificates are presented in Fig. 5, clustered by the number of similar available certificates at the respective purchase date. We note that Fig. 5 shows a larger distance between actual choice and optimal choice than between actual choice and random choice. The average rank of the actually chosen certificates is consistently smaller than the hypothetical rank if certificates were chosen randomly. These findings are consistent with the previously reported Logit findings of a negative and statistically significant, but economically insignificant, impact of the default-free margin and the bid/ask spread on the purchase probability.

Fig. 6 presents the average *DFMask* for the actual buy trades (solid line), the hypothetical average *DFMask* if investors chose randomly with respect to the default-free margin and the bid/ask spread (dashed line), and the mean *DFMask* if investors chose the certificates with the lowest *DFMask* from the range of similar products (dotted line). These plots suggest that investors typically pay a premium over the certificates' fair default-free values (and on defaultable values). These findings are robust to the definition of similarity as the more restricted definition (same underlying, strike ±1%, time to maturity ±3 days) produces quantitatively similar results (see Appendix F.1 and Appendix F.2).

To quantify investors' wealth losses due to suboptimal certificate choice, it is misleading to simply look at the size of the surcharge the investors pay compared to the benchmark certificate with the lowest surcharge at the day of purchase. Recall from Section 3.3 that margins are determined by many factors and often do not decrease monotonically over the certificate's lifetime. As such, retail investors may sell the certificates back to the issuer at a relatively higher margin and we need to take this possibility into account.

To answer the question as to what extent the investors' suboptimal *DFMask* choice results in performance losses, we measure the difference between the actual roundtrip returns of the purchased certificate and the similar available certificate with the lowest *DFMask* at the purchase date, which we refer to as 'poor-choice losses' hereafter. To rule out intraday effects, we assume that both the actual and the hypothetical buy transactions are executed at the respective closing ask price at the day of purchase. Thus, roundtrips which are closed through a sale transaction are assumed to be executed at the closing bid quote. If a certificate is held until maturity, we use the respective closing mid quotes of the purchased certificate's last trading date. If a position is not entirely closed until the end of our sample period, we assume that the certificates are sold at the closing bid quote of December 30, 2008.

Table 7 presents average return differences across all roundtrips, for roundtrips completed through a sale or through maturity, and for incomplete roundtrips. A negative return difference would therefore imply a loss caused by suboptimal choice. If the actually purchased certificate is the best possible choice, the roundtrip difference would be zero. Across all observations, the average return difference is −0.18%, which is statistically significantly different from zero. Given the average buy volume in our sample (see Table 2), this suggests that retail investors are losing EUR 15.70 per roundtrip trade as a result of their inability to identify the cheapest alternative substitute discount certificate. The return differences are negative and significant for all subcategories (with one exception) and even more negative when measured in annualized terms. The mean return difference in column 3 of Table 7 shows that our results are robust with respect to the definition of product similarity. Annualized losses of about 0.2% per roundtrip trade do not seem to be economically significant. However, these losses have to be added to other losses resulting from mispricing, transaction costs, and poor underlying selection. The investors could easily avoid this 'loss surplus' by comparing prices among close substitutes.

6. Investor-level data

This section contributes to the previous analyses by focusing on the individual investor-level data linking investors' personal and trading characteristics to their poor-choice losses and purchase decisions. We examine in more detail the factors determining poor-choice losses (Section 6.1), the quality of investors' certificate selection (Section 6.2) and what determines investors' decision to continue trading (Section 6.3).

We enrich our trade data with some available personal characteristics for most investors, i.e. gender, age and marital status, and calculate, based on the individual trading behavior, measures for experience, performance and other measures as described below.

[20] We also ran regression (16) with issuer-fixed effects for the whole sample period and the pre-crisis and crisis periods, respectively. The results proved to be robust. However, *IssuerMarketShare* loses significance, which is not surprising as this variable does not show much variation over time for each issuer, so that the effect nearly vanishes when issuer-fixed effects are included.

[21] Recall that the analysis of the previous section found that issuer default risk does not play a role in the retail investors' certificate selection process. As such, for the purposes of this analysis we assume default risk is not relevant to this decision process. One could argue that there might be investors in the sample who take issuer default risk into account when buying a certificate. But if they do, they would either not buy any certificate during the financial crisis as it would be much cheaper to buy an ordinary bond, or they would significantly underestimate default probabilities compared to other market participants. If these investors were risk-seeking, including the credit risk margin in the following analyses would be merely a matter of testing risk-perception changes or default probability timing. Further to these arguments, unreported results show that the quality of certificate selection with regard to *DFMask* is independent of issuer default risk. Therefore, we performed the tests of this section separately for two subperiods before and during the financial crisis.

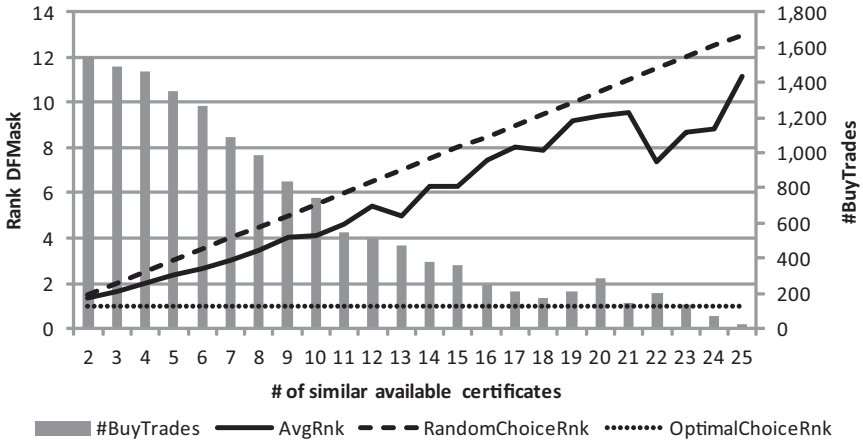

Fig. 5. Ranks of purchased certificates. This figure shows the average rank of purchased certificates relative to all similar certificates including the purchased certificate (strike ±5% and time to maturity ±14 days; solid line, left axis). The gray bars (right axis) stand for the number of buy trades which underlie the average rank. The dotted line represents the rank of the optimal choice (=1), the dashed line indicates the average rank if the certificates had been chosen randomly (left axis). The horizontal axis indicates the number of similar certificates on the respective purchase days.

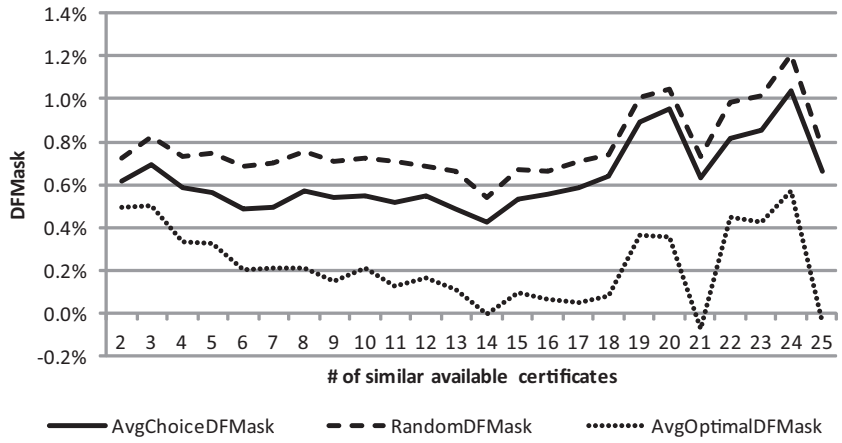

Fig. 6. Average *DFMask* of purchased certificates. This figure plots the average *DFMask* of purchased certificates (solid line) dependent on the number of similar available certificates on the respective purchase day (strike ±5% and time to maturity ±14 days; solid line). The dotted line plots the average *DFMask* if the investors had chosen the certificates with the lowest *DFMask* at every purchase (rank = 1). The dashed line plots the average *DFMask* if the certificates had been chosen randomly.

Table 8 depicts key individual characteristics for the full sample period, pre-crisis period (2004–2007) and crisis period (2008). We only consider investors for whom the personal characteristics are available and who are at least 18 years old. This leaves us with 2415 investors. We also report the average number of purchases and purchase volume (EUR Volume) per individual investor.

80% of the investors are male or even more when only the year 2008 is considered. Age does not vary during the subperiods, with 70% of the investors being older than 40 years. Experienced investors also trade more discount certificates where experience is measured as the log number of trades in structured products ex discount certificates. The purchase volume shows a pattern similar to that in Table 2, but increasing in 2008. 48% of the investors in our sample are married. Investors who are male, older and have more experience in trading structured products execute on average more purchases in line with a higher purchase volume.

6.1. Determinants of poor-choice losses

To analyze the effect of investors' personal and trading characteristics on their poor-choice losses (see Section 5), we perform an OLS-regression on investor-level data, where the dependent variable is the purchase volume-weighted average poor-choice loss for each investor. This means we have one observation per investor. We consider the average to reduce noise in an individual investor's decisions.

First, the regressors include the personal characteristics of gender and marital status ('male' and 'unmarried' are omitted) and age in years. Second, we control for trading characteristics: *LogNoTradesDiscount* is the investors' individual trading activity in discount certificates (log number of trades in discount certificates) and *LogNoTradesSPexDiscount* is the log number of trades in structured products ex discount certificates as a proxy for trading experience. *CertTradeVolEuwax* and *RoundTripLength* are basically defined as before (see Section 4 and Section 5, respectively) but now capture the respective purchase volume-weighted averages, i.e. *CertTradeVolEuwax* is the average certificates' trading volume of the respective trading days on the Euwax and *RoundTripLength* is the average round trip length. We also add two dummy variables which are 1 if the investor always traded with the same issuer (*TradedWithSameIssuer*) or traded only one underlying (*TradedWithSameUL*), if the investor executed at least two purchases, and 0 otherwise.

Third, we include two proxies for search incentives and search costs, following Dorn (2012), to analyze whether these have an effect on poor-choice loss. *LogSize*, which is the log of purchase

Table 7
Performance impact of certificate selection. This table reports average roundtrip return differences between purchased certificates and a similar available certificate with the lowest *DFMask* at the purchase date. Column two presents results for the sample where the available certificates are defined as similar when they have the same underlying, a similar strike (±5%) and a similar time to maturity (±14 days) compared to the purchased certificate at the respective buy date. In column three, the similarity definition is more restricted (same underlying, strike ±1%, and time to maturity ±3 days). The definition of Roundtrips is described in Section 5. ***, **, and * denote that the return differences are significantly different from zero at the 1, 5, and 10 percent levels, respectively, under the assumption that observations are independent. The return differences have been winsorized at the 1% level.

Strike	±5%	±1%
Time to Maturity	±14 days	±3 days
Panel A: All Roundtrips (not ann.)		
Mean difference	−0.18%***	−0.13%***
p-Value	(0.000)	(0.000)
Std of difference	0.80%	0.36%
# of observations	11,311	9040
Panel B: Roundtrips completed through a Sale in < 100 Days (not ann.)		
Mean difference	−0.14%***	−0.12%***
p-Value	(0.000)	(0.000)
Std of difference	0.49%	0.36%
# of observations	3212	2608
Panel C: Roundtrips completed through a Sale in ⩾ 100 Days (not ann.)		
Mean difference	−0.16%***	−0.12%***
p-Value	(0.000)	(0.000)
Std of difference	0.80%	0.36%
# of observations	2830	2252
Panel D: Roundtrips completed through a Sale in ⩾ 100 Days (ann.)		
Mean difference	−0.24%***	−0.18%***
p-Value	(0.000)	(0.000)
Std of difference	1.32%	0.63%
# of observations	2830	2252
Panel E: Roundtrips completed through Maturity in < 100 Days (not ann.)		
Mean difference	−0.02%	−0.05%***
p-Value	(0.565)	(0.000)
Std of difference	0.74%	0.20%
# of observations	638	474
Panel F: Roundtrips completed through Maturity in ⩾ 100 Days (not ann.)		
Mean difference	−0.22%***	−0.14%***
p-Value	(0.000)	(0.000)
Std of difference	0.97%	0.32%
# of observations	3913	3105
Panel G: Roundtrips completed through Maturity in ⩾100 Days (ann.)		
Mean difference	−0.23%***	−0.14%***
p-Value	(0.000)	(0.000)
Std of difference	1.02%	0.32%
# of observations	3913	3105
Panel H: Incomplete Roundtrips (not ann.)		
Mean difference	−0.30%***	−0.30%***
p-Value	(0.000)	(0.000)
Std of difference	0.96%	0.64%
# of observations	718	601

volume-weighted average purchase volume in EUR for each investor, is a proxy for search incentives, as a higher purchase volume should increase the incentive to find a well-priced product. *NoAvailableCertificates* is, like above, the average number of similar (i.e. same underlying, strike ±5%, and time to maturity ±14 days) certificates but here also the respective purchase volume-weighted average. This serves as a proxy for search costs.

The results of the regression are given in Table 9 and were performed for the full investor sample as well as separately for different average roundtrip lengths. First considering the full sample, age is significant and negative, implying higher losses for older investors.[22] In contrast, gender and marital status has no influence. We also do not find significant factor loadings for trading activity and trading experience. The highly significant coefficient for roundtrip length implies that, on average, longer holding periods lead to higher losses from poor certificate selection. The coefficient for *LogSize* is not significant, implying that a larger purchase size is not related to choosing a better-priced certificate, while higher search costs, i.e. a higher number of similar available certificates, actually result in higher losses – despite the small economic significance of this factor.

Categorizing the investors with regard to average roundtrip length reveals a similar pattern, although some coefficients gain or lose significance. Striking is the fact that – when considering average roundtrip lengths of less than 100 days – investors realize smaller poor-choice losses if trading with the same issuer, possibly due to more favorable margins offered by the issuer, and larger losses if investors had always bought the same underlying. However, all in all, the considered investors' personal and trading characteristics do not explain much of the variability in the poor-choice loss.

6.2. Determinants of quality in certificate selection

The previous section examined for each investor the determinants of poor-choice losses, which depend on the purchase choice as well as the decision to sell the product on a given day. Now, we focus solely on the determinants of buying a discount certificate with a 'good' price quality. For each purchase of an investor, we take the purchased certificate and the corresponding similar certificates, and divide these certificates into quartiles by ranking *DFMask* (see Section 5) from 'good' (Q1) to 'bad' (Q4).[23] For each purchased certificate we set a binary equal to 1 if it was a good selection (lowest quartile, Q1), and 0 otherwise (Q2 to Q4). We use the resulting binaries in a pooled Logit regression as dependent variable.

As the first group of independent variables, we use the personal characteristics of investors from the previous Section 6.1. Second, we include variables for trading characteristics, more precisely *LogNoTradesDiscount* and *LogNoTradesSPexDiscount* (both defined analogously to Section 6.1, but here calculated until the purchase day) and *CertTradeVolEuwax*, *TradedwithIssuer* and *TradedCertBefore* (all defined in Section 4.1). As proxies for search incentives and search costs, we use *LogSize* (purchase volume in EUR) and *NoAvailableCertificates* (number of similar certificates) defined analogously to Section 6.1 but now using purchase date-specific values instead of averages. Finally, we use *BidAskSpread*, *IssuerMarketShare*, *TimesinceIssuance* and *Roundstrike,* as well as dummies for underlying and month as controls (see Section 4.1 for the description of variables).

Table 10 reports the results for the full sample period and divided into purchases made from 2004 until 2007, and in 2008. First looking at the full sample, females possess a higher probability of selecting a fairly priced certificate, while married investors are less likely to choose a certificate that is in the good choice quartile. Age as well as the trading activity and experience proxies are not significant.

The proxy for search incentives *LogSize* is positive and significant, implying a higher probability of choosing better priced certificates when executing a larger trade. The proxy for search costs *NoAvailableCertificates* has a significant negative sign, meaning that a larger number of certificates to choose from reduces the probability of selecting a well-priced certificate. Both effects are in line with expectation. Among the controls, the positive and significant coefficient of *IssuerMarketShare* is noticeable while the negative and positive coefficients of *BidAskSpread* and

[22] It is clear that poor-choice loss is usually negative as it represents the roundtrip return minus the return of the 'best' similar certificate.

[23] As before, a certificate is similar if it has the same underlying, a similar cap level (±5%) and similar time to maturity (±14 days). We omit purchases where the number of similar certificates to choose from is smaller than four.

Table 8
Summary statistics of investor characteristics. This table presents percentage, number of observations and means for gender, age in years, investor experience by quartiles (log number of trades in structured products ex discount certificates) and marital status of 2415 investors. The mean Number of Purchases and mean Purchase Volume (EUR Volume) is reported for each personal characteristic. The summary statistics are reported separately for the subperiod from 04/2004 to 12/2007 and for the subperiod from 01/2008 to 12/2008.

Investor Base	2004–2008				2004–2007				2008			
	%	N	Ø Number of purchases	Ø Purchase volume	%	N	Ø Number of purchases	Ø Purchase volume	%	N	Ø Number of purchases	Ø Purchase volume
Male	80	1936	4.33	6131	79	1555	4.25	5941	84	685	2.60	7042
Female	20	479	3.78	5237	21	407	3.85	5424	16	133	1.83	4882
Age: 18–25	4	90	2.26	3553	4	75	2.20	3669	3	24	1.58	4469
Age: 26–40	26	639	3.12	4727	25	500	3.08	3982	26	214	2.14	6423
Age: 41–55	38	918	4.25	6198	38	748	4.04	6191	38	309	2.86	6836
Age: 56–100	32	768	5.33	6963	33	639	5.41	7118	33	271	2.37	6932
Low Exp	26	633	1.78	5533	28	544	1.79	5677	26	214	1.59	6231
Exp Q2	24	580	2.60	5783	23	448	2.56	5659	24	195	1.90	6384
Exp Q3	25	601	3.81	5292	25	483	3.83	5674	25	206	2.31	6102
High Exp	25	601	8.78	7221	25	487	8.64	6328	25	203	4.12	8066
Unmarried	52	1244	4.20	6324	52	1012	4.18	5949	52	426	2.34	7734
Married	48	1171	4.25	5560	48	950	4.15	5710	48	392	2.61	5556
Total	100	2415	4.22	5953	100	1962	4.17	5834	100	818	2.47	6690

Table 9
Determinants of poor-choice loss on investor-base. This table reports the estimated coefficients of the OLS-regression with the purchase volume-weighted average poor-choice loss per investor as the dependent variable; explanatory variables are described in Section 6.1. The regression is performed for the full investor sample and separated by different average roundtrip lengths. Obs. is the number of observations. Heteroscedasticity-robust *t*-values are in parenthesis. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

Regressor	Coef	RoundTrip length	
	(*t*-Stat)	<= 100	>100
Constant	+0.000	−0.001	+0.001
	(0.350)	(−0.460)	(0.590)
Female	+0.000	+0.001	+0.000
	(0.370)	(0.920)	(0.090)
Age	−0.000**	+0.000	−0.000**
	(−2.030)	(0.610)	(−2.280)
Married	+0.000	−0.000	+0.001
	(1.190)	(−0.190)	(1.370)
LogNoTradesDiscount	+0.000	+0.000	+0.000
	(1.180)	(0.780)	(0.980)
LogNoTradesSPexDiscount	+0.000	−0.000	+0.000
	(0.290)	(−0.270)	(0.270)
CertTradeVolEuwax	+0.000*	+0.000***	+0.000
	(1.760)	(3.450)	(1.280)
RoundTripLength	−0.000***	−0.000*	−0.000**
	(−3.390)	(−1.780)	(−2.390)
TradedWithSameIssuer	+0.000	+0.002**	−0.000
	(1.320)	(2.590)	(−0.130)
TradedWithSameUL	−0.001	−0.002***	−0.000
	(−1.540)	(−2.680)	(−0.600)
LogSize	+0.000	−0.000	+0.000
	(0.480)	(−0.510)	(1.110)
NoAvailableCertificates	−0.000***	+0.000	−0.000***
	(−3.970)	(0.810)	(−5.520)
Adj. R^2	0.017	0.006	0.033
Obs.	2415	599	1816

TimesinceIssuance, respectively, are not surprising; the latter because the life cycle hypothesis implies lower margins for older certificates.

The results for the subperiod 2004–2007 show exactly the same pattern, except for the coefficients of *BidAskSpread* and *NoAvailableCertificates* which are not significant; however, the latter keeps its sign. For the crisis period 2008, the dummy for female investors and *IssuerMarketShare* are no longer significant. Moreover, if an investor traded with an issuer before, the probability of buying a certificate with a good price quality diminishes. The same holds for a higher bid/ask spread, which increased during the crisis and made it more difficult for investors to choose a fairly priced product. This suggests that the *BidAskSpread* effect over the full sample period is mainly driven by 2008. Further, the proxies for search costs and search incentive lose their significance but keep their sign, suggesting that higher search incentives are surprisingly less effective during times of financial turmoil.

6.3. Determinants of continuing trading

To further examine the trading behavior of investors, we look at historically experienced investors' returns from discount certificates and trade characteristics and analyze the respective impact on the probability of buying another discount certificate. We consider monthly time and apply a pooled Logit model where the dependent variable for a specific investor in a certain month equals 1 if the investor bought a certificate in that month, and 0 otherwise.[24] Given 2415 investors and 57 months result in 137,655 observations.

All our time-variant independent variables are lagged. We include two performance-related variables in the model: given an investor and month *t*, *InvestorPerformance* (*closed RT*) is the investor's purchase volume-weighted average gross return where the average is taken over all roundtrips closed before *t*. *InvestorPerformance* (*open RT*) is the hypothetical gross return at the end of the previous month for open roundtrips which have not yet been closed before *t*. *DaxReturn* is the monthly return of the DAX Index in the previous month and indicates the recent market development.

We also include investors' personal characteristics, *LogNoTradesDiscount* and *LogNoTradesSPexDiscount* where the latter are calculated from the trades before *t*. Additionally, we add *CertTradeVolEuwax* and *LogSize* which refer to the last purchase before *t*.[25] *TradedWithSameIssuer* and *TradedWithSameUL* are dummies that equal 1 if at least the last two purchases of the investor before *t* were executed in certificates from the same issuer or with the same underlying, respectively.

Table 11 reports the results. *InvestorPerformance* (*closed RT*) is significantly negative, and thus investors tend to continue buying certificates if they realized losses. On the other hand, if investors

[24] We also performed the Logit regression with investor-fixed effects leaving out time-invariant personal characteristics. This does not change our results.

[25] It should be noted that *LogSize* can here hardly be interpreted as search incentives as it is a lagged variable related to the last investor's purchase. For the same reason we did not include *NoAvailableCertificates*.

Table 10
Probability of purchasing a certificate with 'good' price quality. This table reports the results of the Logit regressions where the dependent variable is 1 for a good purchase decision and 0 otherwise. A purchase decision is good if the purchased certificate belongs to the lowest *DFMask*-quartile by ranking the purchased and similar certificates. Explanatory variables and unreported control variables are described in Section 6.2. Coefficients are reported with the respective standard errors, which are robust to heteroscedasticity and correlation across same-investor observations (clusters on investor level). Columns three, five and seven report effects on the lowest quartile probabilities of a continuous variable's one-standard deviation increase or a change from 0 to 1 for dummy variables, evaluated at the mean of the other regressors. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

Subperiod	04/2004–12/2008		04/2004–12/2007		01/2008–12/2008	
Regressor	Coefficient (SE)	Effect on prob. choosing Q1	Coefficient (SE)	Effect on prob. choosing Q1	Coefficient (SE)	Effect on prob. choosing Q1
Constant	−1.915***		−3.152***		+2.641**	
	(0.492)		(0.537)		(1.266)	
Female	+0.150**	+3.70%	+0.174**	+4.33%	−0.006	−0.14%
	(0.073)		(0.079)		(0.174)	
Age	−0.002	−0.87%	−0.003	−1.26%	+0.003	+1.08%
	(0.002)		(0.002)		(0.004)	
Married	−0.200***	−4.90%	−0.183**	−4.54%	−0.255**	−5.70%
	(0.070)		(0.075)		(0.129)	
LogNoTradesDiscount	+0.008	+0.34%	+0.043	+1.74%	−0.081	−4.05%
	(0.036)		(0.037)		(0.054)	
LogNoTradesSPexDiscount	+0.002	+0.07%	−0.005	−0.23%	+0.017	+0.71%
	(0.024)		(0.027)		(0.044)	
CertTradeVolEuwax	−0.000	−0.20%	−0.000	−0.22%	−0.000	−1.05%
	(0.000)		(0.000)		(0.000)	
TradedwithIssuer	−0.100	−2.46%	−0.119	−2.96%	−0.314**	−7.09%
	(0.072)		(0.081)		(0.150)	
TradedCertBefore	−0.109	−2.66%	−0.098	−2.42%	+0.082	+1.86%
	(0.089)		(0.097)		(0.202)	
LogSize	+0.087***	+2.37%	+0.091***	+2.53%	+0.048	+1.15%
	(0.031)		(0.033)		(0.060)	
NoAvailableCertificates	−0.012**	−1.55%	−0.011	−1.22%	−0.015	−2.38%
	(0.006)		(0.008)		(0.010)	
BidAskSpread	−72.772***	−3.46%	+0.234	+0.01%	−144.546***	−8.52%
	(21.724)		(27.113)		(50.664)	
IssuerMarketShare	+3.833***	+5.83%	+7.360***	+9.11%	+0.583	+1.21%
	(0.618)		(0.871)		(0.997)	
TimesinceIssuance	+0.274***	+3.59%	+0.228***	+2.88%	+0.206**	+2.90%
	(0.055)		(0.065)		(0.102)	
$Roundstrike_1$	+0.435***	+10.29%	+0.783***	+18.18%	−0.678**	−16.23%
	(0.113)		(0.126)		(0.327)	
$Roundstrike_5$	−0.186**	−4.57%	−0.231**	−5.74%	+0.017	+0.39%
	(0.086)		(0.102)		(0.207)	
$Roundstrike_{10}$	+0.104	+2.54%	+0.100	+2.47%	+0.060	+1.34%
	(0.079)		(0.088)		(0.201)	
# of observations	8331		6688		1643	
# of clusters (investors)	2265		1840		727	
Pseudo-R^2	6.63%		7.51%		8.63%	

hold positive unrealized returns in their accounts, which could be realized by selling the certificate, the probability of buying another certificate increases as well. The DAX return from the previous month is significant and positively influences the purchase decision. The personal characteristic variables indicate that older investors are more likely to buy certificates again. The proxies for trading activity (*LogNoTradesDiscount*) and experience (*LogNoTradesSPexDiscount*) have a significant positive coefficient, which is not surprising, as investors who have traded frequently are likely to continue buying certificates. The coefficient of *CertTradeVolEuwax* is significant and negative; hence, investors purchase less if the previously bought certificate has been traded more frequently at EUWAX. The coefficient for *LogSize* is also significant and negative, i.e. investors purchase less if they made large purchases before. If an investor traded so far only with the same issuer, the investor is more likely to continue buying certificates. However, investors who traded only one underlying are less likely to execute another purchase.

As a robustness check, we examine the probability of investors continuing trading into the crisis year 2008. We consider only investors who traded in the period 2004–2007 and set the dependent variable to 1 if an investor also traded in 2008 and 0 otherwise; i.e. we obtain one observation per investor. We employ the same variables as above but now sampled on investor basis, by taking the purchase volume-weighted average[26] for each time-variant explanatory variable over the time period 2004–2007. Applying a Logit regression, the signs and significance of coefficients (not reported here) are comparable to those above but *LogNoTradesSPexDiscount*, *CertTradeVolEuwax*, *TradedWithSameIssuer* and *TradedWithSameUL* are not significant. The same holds if the procedure is carried out analogously for the year 2007, when investors trading in 2004–2006 are considered. This implies that key results are robust and also suggests that there was no substantial break in the crisis period 2008.

Summing up our key results for the determinants of poor-choice losses, the purchase quality and the decision to continue trading, we find that investors' personal characteristics (gender, age and marital status) have no or a very small effect economically. Interestingly, trading experience and trading activity of investors had no significant effect on losses due to poor choices or on the quality of

[26] An exception is *LogNoTradesDiscount*, *LogNoTradesSPexDiscount* and *InvestorPerformance (open RT)*, that is the trading activity and trading experience at the end of 2007, and the hypothetical return if an open position has not been closed at the end of 2007, respectively.

Table 11
Probability of purchase (based on lagged variables). This table reports the results of the Logit regression where the dependent variable is equal to 1, if the investor bought a certificate during that month, and 0 otherwise. Explanatory variables are sampled for each investor on a monthly basis (4/2004–12/2008) and described in Section 6.3. Coefficients are reported with the respective standard errors, which are robust to heteroscedasticity and correlation across same-investor observations (clusters on investor level). Column three reports the effect on the purchase probabilities of a continuous variable's one-standard deviation increase or a change from 0 to 1 for dummy variables, evaluated at the mean of the other regressors. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

Regressor	Coefficient (SE)	Effect on purchase prob.
Constant	−3.693*** (0.070)	
InvestorPerformance (closed RT)	−2.710*** (0.319)	−0.58%
InvestorPerformance (open RT)	+4.114*** (0.362)	+0.83%
DaxReturn	+0.887*** (0.331)	+0.15%
Female	−0.077 (0.047)	−0.28%
Age	+0.006*** (0.002)	+0.34%
Married	−0.067 (0.045)	−0.25%
LogNoTradesDiscount	+0.650*** (0.033)	+2.57%
LogNoTradesSPexDiscount	+0.046*** (0.014)	+0.30%
CertTradeVolEuwax	−0.000* (0.000)	−0.19%
LogSize	−0.098*** (0.009)	−1.50%
TradedWithSameIssuer	+0.184** (0.076)	+0.74%
TradedWithSameUL	−0.356*** (0.118)	−1.15%
# of Observations	137,655	
# of Clusters (Investors)	2415	
Pseudo-R^2	5.98%	

purchases, but – not surprisingly – these factors did increase the probability of the investor continuing trading. Higher search costs – proxied by a higher number of similar certificates – lead to higher choice-related losses and reduce the purchase quality, while greater search incentives, in the form of higher invested volume, increase the purchase quality. However, the latter effect vanished in the crisis year 2008. Finally, investors tend to continue trading if they realized losses or have unrealized positive returns in their accounts.

7. Conclusion

This paper examines retail investors' trading decisions, focusing on the various pricing components of structured financial products. We calculate the fair theoretical values of 72,200 discount certificates on DAX stocks over the period 2004–2008, resulting in more than 10 million daily margin observations. Our results suggest that discount certificates are quoted an average of 0.88% above their theoretical fair value – the 2008 period however, represents a period of abnormally high premiums (the average premium was 1.24% over fair value and above 2% for specific issuers) and the average premium in the pre-crisis period was only 0.58%. Credit risk is found to account for up to 80% of the total margin in 2008. 2008 was also a period of abnormally high certificate issuance, peaking in October and November, with more certificates issued during this period than in total during the 2004–2007 period. We interpret this as evidence of the issuing banks using structured retail products as a source of low cost funding during a time of extreme illiquidity in the interbank market. In addition, we find that bid/ask spreads and default-free margins also increased in the course of the financial crisis.

Investigating the determinants of certificate overpricing, we find clear evidence for the lifecycle hypothesis that margins tend to fall as the product nears maturity. However, only limited evidence is found in favor of the order flow hypothesis, that issuing banks shift margins to profit from anticipated order flows. Further, our results suggest that competition among issuers lowers margins and that certificates on stocks with higher expected dividends and higher volatility are priced with higher margins.

The main focus of this paper is on testing whether investors choose certificates rationally. Using a Logit regression specification, we find that issuer credit risk does not influence investors' product choices, even though it accounts for most of the product overpricing. Instead, non-market factors, such as familiarity with the issuing bank or the product itself, are found to be important determinants of the certificate choice. We also find that investors buy certificates with lower-than-average default-free margins and bid/ask spreads. Ranking all similar alternatives by their default-free margins and bid/ask spreads, however, reveals that the actual choice is close to a random choice, but far from the optimal choice. The suboptimal selection of certificates causes significant performance losses of −0.18% or 15.70 EUR per roundtrip trade which could easily be avoided by comparing prices among a small sample of close substitutes. Trading experience in structured products and trading activity does not have an influence on the poor-choice loss or on the purchase quality. Search incentives, in the form of higher invested volume, increase the purchase quality but results are still far from optimal and the effect vanished in the crisis period. Based on these results, we conclude that investors' product choices are dominated by behavioral factors rather than by the certificates' pricing elements.

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Appendix A. Double linear interpolation scheme for implied volatility matching

T^- and T^+ are maturity dates of call option series closest before and after (or equal to) the reference date τ with the same underlying as the certificate to be evaluated. Four call options with parameters $(T^-, X^-_{T^-})$, $(T^-, X^+_{T^-})$, $(T^+, X^-_{T^+})$, $(T^+, X^+_{T^+})$, where $X^-_{T^-} \leqslant X \leqslant X^+_{T^-}$ and $X^-_{T^+} \leqslant X \leqslant X^+_{T^+}$, are selected (see Baule, 2011). Next, the implied volatilities $\sigma(\cdot,\cdot)$ of the selected options are interpolated in strike dimension for given T^- and T^+:

$$\sigma(T^-, X) = \frac{(X^+_{T^-} - X)\sigma(T^-, X^-_{T^-}) + (X - X^-_{T^-})\sigma(T^-, X^+_{T^-})}{X^+_{T^-} - X^-_{T^-}} \tag{A.1}$$

$$\sigma(T^+,X) = \frac{(X^+_{T^+} - X)\sigma(T^+,X^-_{T^+}) + (X - X^-_{T^+})\sigma(T^+,X^+_{T^+})}{X^+_{T^+} - X^-_{T^+}} \quad (A.2)$$

Finally, $\sigma(T^-,X)$ and $\sigma(T^+,X)$ are interpolated in time dimension:

$$\sigma(\tau,X) = \frac{(T^+ - \tau)\sigma(T^-,X) + (\tau - T^-)\sigma(T^+,X)}{T^+ - T^-} \quad (A.3)$$

Appendix B

See Appendix B.1 and B.2.

Appendix C

See Appendix C.1 and C.2.

Appendix D

See Appendix D.

Appendix E

See Appendix E.

Appendix B.1
Average margins by issuers for the first subperiod from 04/2004 to 12/2007. This table reproduces Table 3, but for a restricted subset of the data.

Issuer	Mean DFM	Mean CRM	Mean TM	CRM/TM	Observations
ABN Amro	0.40%	0.36%	0.76%	47.37%	13,245
BHF-Bank	0.55%	N/A	N/A	N/A	44,152
BNP	0.32%	0.05%	0.38%	13.16%	707,876
Citibank	0.55%	0.11%	0.67%	16.42%	347,085
Commerzbank	0.41%	0.09%	0.50%	18.00%	963,156
Deutsche Bank	0.43%	0.08%	0.51%	15.69%	464,132
Dresdner Bank	0.36%	0.09%	0.45%	20.00%	271,868
DZ Bank	0.85%	0.39%	1.25%	31.20%	277,115
Goldman Sachs	0.68%	0.12%	0.81%	14.81%	142,346
HSBC Trinkaus	0.54%	0.09%	0.63%	14.29%	307,375
ING	0.44%	0.02%	0.46%	4.35%	216,396
LBBW	0.50%	0.38%	0.87%	43.68%	136,402
Sal. Oppenheim	0.52%	N/A	N/A	N/A	640,141
Société Générale	0.53%	0.02%	0.55%	3.64%	508,829
UBS	0.58%	0.05%	0.63%	7.94%	737,924
Others	0.92%	N/A	N/A	N/A	72,960
All Issuers	0.50%	0.10%	0.58%	17.24%	5,851,002

Appendix B.2
Average margins by issuers for the second subperiod from 01/2008 to 12/2008. This table reproduces Table 3, but for a restricted subset of the data.

Issuer	Mean DFM	Mean CRM	Mean TM	CRM/TM	Observations
ABN Amro	0.74%	0.57%	1.32%	43.18%	122,696
BHF-Bank	0.89%	N/A	N/A	N/A	84,397
BNP	0.37%	0.26%	0.64%	40.63%	754,931
Citibank	0.63%	1.08%	1.72%	62.79%	431,625
Commerzbank	0.57%	0.48%	1.05%	45.71%	1,084,236
Deutsche Bank	0.64%	0.47%	1.12%	41.96%	365,472
Dresdner Bank	0.65%	0.49%	1.15%	42.61%	399,112
DZ Bank	0.94%	0.29%	1.24%	23.39%	68,796
Goldman Sachs	0.51%	2.38%	2.89%	82.35%	97,690
HSBC Trinkaus	0.73%	0.43%	1.17%	36.75%	219,614
LBBW	0.47%	0.71%	1.19%	59.66%	79,808
Sal. Oppenheim	0.55%	N/A	N/A	N/A	160,258
Société Générale	0.58%	0.26%	0.85%	30.59%	93,667
UBS	0.87%	1.15%	2.02%	56.93%	515,808
Others	0.58%	N/A	N/A	N/A	87,274
All Issuers	0.61%	0.63%	1.24%	50.81%	4,565,384

Appendix C.1

Determinants of total margins for the first subperiod from 04/2004 to 12/2007. This table reports estimated coefficients for regression Eq. (15) over the period 04/2004 to 12/2007, run separately for each issuer where CDS are available. The total margin *TM* is the dependent variable; explanatory variables are described in Section 3.3. Obs. is the number of observations. Robust Newey–West *t*-values are in parenthesis. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

Issuer	Obs.	Const.	LIFE	TAX	MAT	COMP	MONEY	TIME	DIV	VOLA	CREDIT	Adj. R^2
ABN Amro	13,245	+0.0010	+0.0018**	+0.0007*	−0.0043***	−0.0068***	−0.0129***	−0.0032***	+0.0074	+0.0723***	+0.5998***	0.20
		(0.07)	(2.40)	(1.71)	(−4.70)	(−4.27)	(−14.30)	(−13.51)	(0.70)	(17.01)	(4.84)	
BNP	707,876	−0.0047***	+0.0009***	+0.0010***	−0.0032***	−0.0006***	−0.0061***	−0.0013***	+0.0507***	+0.0381***	+0.5895***	0.16
		(−36.39)	(8.62)	(16.01)	(−49.88)	(−10.21)	(−69.81)	(−50.93)	(36.30)	(94.14)	(16.47)	
Citibank	347,085	−0.0044***	+0.0025***	+0.0001	−0.0018***	+0.0008***	−0.0059***	−0.0016***	+0.0466***	+0.0424***	−0.1159***	0.16
		(−21.67)	(21.16)	(1.11)	(−20.04)	(10.02)	(−45.32)	(−49.57)	(26.78)	(60.52)	(−5.12)	
Commerzbank	963,156	−0.0096***	+0.0046***	−0.0005***	−0.0013***	−0.0013***	−0.0061***	−0.0004***	+0.0387***	+0.0422***	+0.3604***	0.24
		(−89.50)	(60.98)	(−9.67)	(−26.41)	(−31.49)	(−75.61)	(−23.74)	(35.07)	(108.58)	(19.81)	
Deutsche Bank	464,132	−0.0081***	+0.0053***	−0.0001	−0.0000	−0.0002***	−0.0044***	−0.0012***	+0.0315***	+0.0406***	+0.7513***	0.24
		(−56.16)	(48.83)	(−0.95)	(−0.08)	(−4.00)	(−39.99)	(−51.62)	(17.92)	(77.37)	(28.50)	
Dresdner Bank	271,868	−0.0081***	+0.0045***	−0.0002**	−0.0021***	−0.0021***	−0.0047***	+0.0004***	+0.0134***	+0.0291***	+0.6984***	0.19
		(−36.47)	(31.91)	(−1.99)	(−20.25)	(−16.03)	(−36.08)	(7.45)	(5.88)	(45.62)	(11.44)	
DZ Bank	277,115	−0.0102***	+0.0113***	−0.0005***	−0.0016***	−0.0010***	−0.0077***	−0.0011***	+0.0189***	+0.0518***	+0.4246***	0.38
		(−34.78)	(65.86)	(−4.08)	(−15.17)	(−8.72)	(−43.65)	(−21.75)	(7.98)	(63.27)	(18.62)	
Goldman Sachs	142,346	−0.0068***	+0.0067***	−0.0007***	+0.0001	−0.0003**	−0.0061***	+0.0002***	+0.0315***	+0.0295***	+0.8260***	0.31
		(−27.58)	(33.08)	(−4.36)	(1.08)	(−2.32)	(−31.53)	(4.46)	(11.01)	(34.03)	(33.38)	
HSBC Trinkaus	307,375	−0.0091***	+0.0047***	+0.0009***	−0.0031***	−0.0011***	−0.0089***	−0.0014***	+0.0098***	+0.0573***	+0.2707***	0.25
		(−39.88)	(32.52)	(8.35)	(−30.13)	(−8.13)	(−54.65)	(−35.92)	(4.48)	(71.52)	(10.93)	
ING	216,396	+0.0008***	+0.0019***	−0.0011***	−0.0027***	−0.0022***	−0.0049***	−0.0013***	+0.0488***	+0.0255***	+0.3890***	0.16
		(3.25)	(10.81)	(−8.53)	(−27.73)	(−13.05)	(−27.81)	(−27.74)	(20.97)	(39.66)	(6.93)	
LBBW	136,402	−0.0045***	+0.0073***	+0.0076***	−0.0010***	−0.0007***	−0.0063***	−0.0025***	+0.0458***	+0.0379***	+0.3920***	0.48
		(−15.99)	(28.58)	(51.03)	(−6.86)	(−7.12)	(−24.27)	(−47.87)	(14.15)	(36.18)	(18.67)	
Société Générale	508,829	−0.0056***	+0.0051***	+0.0004***	−0.0021***	−0.0034***	−0.0058***	−0.0004***	+0.0474***	+0.0359***	+0.1997**	0.26
		(−40.72)	(46.94)	(5.13)	(−30.88)	(−42.16)	(−53.43)	(−13.94)	(26.87)	(80.43)	(2.31)	
UBS	737,924	−0.0060***	+0.0074***	−0.0005***	−0.0001*	+0.0002***	−0.0034***	−0.0006***	+0.0231***	+0.0232***	+0.1870***	0.27
		(−56.50)	(87.49)	(−8.18)	(−1.90)	(4.60)	(−45.96)	(−31.55)	(18.42)	(60.62)	(6.25)	

Appendix C.2

Determinants of total margins for the second subperiod from 01/2008 to 12/2008. This table reports estimated coefficients for regression Eq. (15) over the subperiod 01/2008 to 12/2008, run separately for each issuer where CDS are available. The total margin *TM* is the dependent variable; explanatory variables are described in Section 3.3. Obs. is the number of observations. Robust Newey–West *t*-values are in parenthesis. ***, **, and * denote significance at the 1, 5, and 10 percent levels, respectively.

Issuer	Obs.	Const.	LIFE	TAX	MAT	COMP	MONEY	TIME	DIV	VOLA	CREDIT	Adj. R^2
ABN Amro	122,696	−0.0104***	+0.0153***	−0.0022***	−0.0001	−0.0003	−0.0036***	−0.0000	−0.0012	+0.0163***	+0.7444***	0.36
		(−11.34)	(66.45)	(−12.22)	(−0.96)	(−0.88)	(−16.71)	(−0.01)	(−0.53)	(35.89)	(37.08)	
BNP	754,931	−0.0139***	+0.0085***	−0.0009***	−0.0005***	+0.0004***	−0.0002***	+0.0017***	+0.0635***	+0.0126***	+0.1931***	0.25
		(−39.13)	(76.13)	(−10.70)	(−9.13)	(7.95)	(−2.86)	(19.65)	(54.73)	(68.91)	(14.31)	
Citibank	431,625	−0.0392***	+0.0144***	+0.0005***	−0.0028***	+0.0009***	−0.0056***	+0.0065***	+0.0638***	+0.0142***	+0.6198***	0.55
		(−73.05)	(94.57)	(4.58)	(−28.58)	(9.79)	(−55.72)	(48.01)	(41.62)	(50.41)	(122.23)	
Commerzbank	1,084,236	−0.0199***	+0.0104***	+0.0005***	−0.0006***	+0.0008***	−0.0052***	+0.0019***	+0.0729***	+0.0205***	+0.4045***	0.36
		(−62.62)	(105.24)	(8.87)	(−9.66)	(22.52)	(−82.13)	(26.43)	(80.86)	(116.80)	(44.75)	
Deutsche Bank	365,472	−0.0317***	+0.0126***	+0.0002*	−0.0001	+0.0033***	−0.0022***	+0.0041***	+0.0721***	+0.0200***	+0.4283***	0.40
		(−70.37)	(85.35)	(1.93)	(−1.36)	(25.15)	(−19.24)	(36.91)	(49.80)	(69.15)	(30.46)	
Dresdner Bank	399,112	−0.0198***	+0.0122***	−0.0001	−0.0025***	−0.0003**	−0.0022***	+0.0020***	+0.0005	+0.0177***	+0.8469***	0.31
		(−38.77)	(96.13)	(−1.33)	(−25.08)	(−2.46)	(−21.82)	(16.54)	(0.37)	(62.69)	(49.39)	
DZ Bank	68,796	−0.0078***	+0.0097***	−0.0007***	−0.0050***	+0.0022***	−0.0050***	−0.0012***	−0.0081***	+0.0314***	+0.9853***	0.23
		(−4.69)	(31.04)	(−3.01)	(−19.19)	(5.63)	(−18.31)	(−2.70)	(−2.62)	(45.17)	(7.96)	
Goldman Sachs	97,690	−0.0004	+0.0240***	+0.0029***	−0.0033***	+0.0026***	−0.0047***	−0.0057***	+0.1032***	+0.0158***	+0.6597***	0.63
		(−0.26)	(60.60)	(9.19)	(−14.04)	(7.38)	(−17.07)	(−13.76)	(35.54)	(24.01)	(73.89)	
HSBC Trinkaus	219,614	−0.0338***	+0.0120***	+0.0015***	−0.0012***	+0.0088***	−0.0055***	+0.0035***	+0.0310***	+0.0218***	+0.5795***	0.38
		(−42.14)	(55.36)	(9.57)	(−8.59)	(22.23)	(−30.69)	(19.89)	(15.02)	(44.50)	(26.86)	
LBBW	79,808	−0.0360***	+0.0201***	+0.0078***	+0.0028***	+0.0012***	+0.0011***	+0.0045***	+0.0769***	+0.0155***	+0.4992***	0.59
		(−35.64)	(57.26)	(29.07)	(16.35)	(8.03)	(4.40)	(18.62)	(26.71)	(27.47)	(65.84)	
Société Générale	93,667	−0.0072***	+0.0097***	−0.0026***	−0.0016***	−0.0043***	−0.0014***	+0.0011***	+0.0853***	+0.0176***	+0.2764***	0.28
		(−7.15)	(29.16)	(−7.85)	(−10.71)	(−8.11)	(−6.98)	(4.52)	(28.25)	(35.74)	(8.27)	
UBS	515,808	−0.0325***	+0.0165***	+0.0006***	−0.0011***	−0.0014***	−0.0073***	+0.0021***	+0.0399***	+0.0417***	+0.7777***	0.59
		(−68.71)	(151.33)	(7.56)	(−9.49)	(−19.06)	(−79.23)	(18.18)	(37.69)	(127.36)	(110.78)	

Appendix D

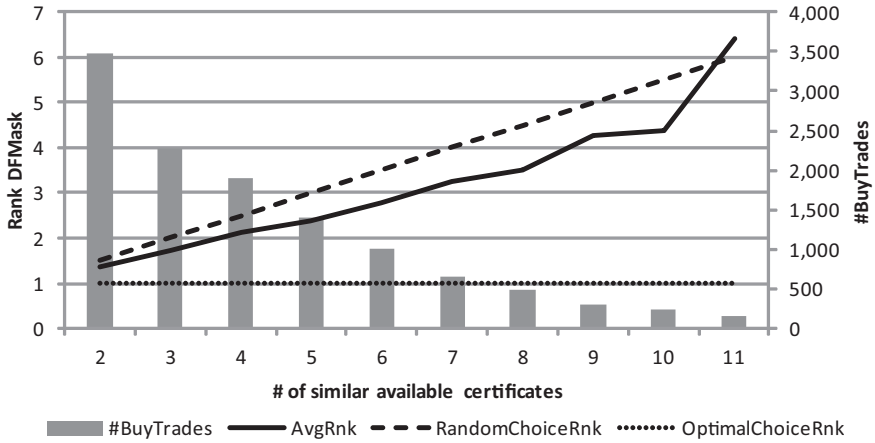
Attributes of purchased and available certificates. When an investor purchases a discount certificate, it is classified as 'certificate bought'. Those certificates which are similar to the purchased certificate (same underlying, strike ±1%, time to maturity ±3 days), but have not been purchased by the investor on that day, are classified as 'certificates not bought'. This table reports attributes of purchased and not purchased certificates on the respective trading day. *DFM* is the certificate's default-free margin, *CRM* is the credit risk margin where issuers without available CDS are excluded, *BidAskSpread* is the latest quoted bid/ask spread of the respective trading day. *IssuerMarketShare* stands for the number of outstanding certificates of the issuer in relation to the total number of outstanding discount certificates on the day of the trade. *TradedwithIssuer* is a dummy variable which is set to 1 if the investor has traded with the issuer before, and 0 otherwise. *TradedCertBefore* is a dummy variable which is set to 1 if the investor has traded the certificate before, and 0 otherwise.

Observations	Certificates bought 11,920			Certificates not bought 38,117			All certificates 50,037		
	Mean	Std	Median	Mean	Std	Median	Mean	Std	Median
DFM	0.46%	0.80%	0.39%	0.62%	0.85%	0.53%	0.59%	0.84%	0.49%
CRM	0.22%	0.39%	0.08%	0.31%	0.52%	0.12%	0.29%	0.49%	0.11%
BidAskSpread	0.24%	0.24%	0.17%	0.28%	0.39%	0.18%	0.27%	0.36%	0.18%
IssuerMarketShare	14.6%	7.6%	14.7%	9.2%	6.1%	8.4%	10.5%	6.9%	9.3%
TradedwithIssuer	0.689	0.463	1	0.180	0.384	0	0.301	0.459	0
TradedCertBefore	0.249	0.433	0	0.002	0.046	0	0.061	0.239	0
CertTradeVolEuwax	659	9956	0	156	1818	0	276	5116	0

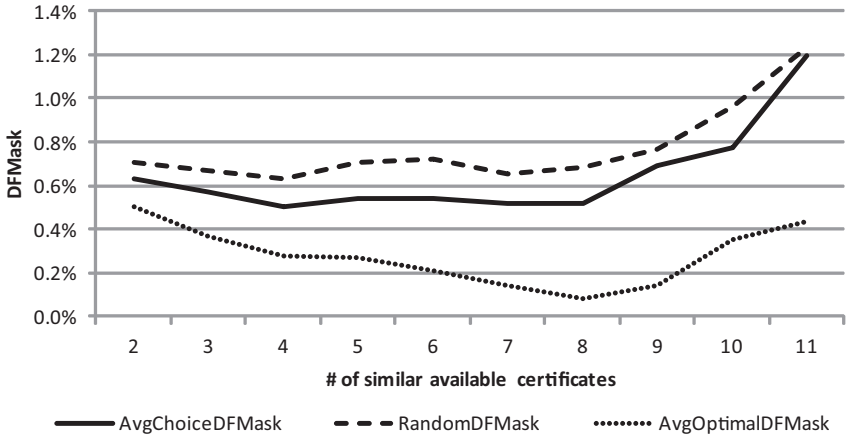
Appendix E

Probability of choosing a certificate from similar certificates for subperiods. This table reproduces Table 6, separately for the subperiod from 04/2004 to 12/2007 and for the subperiod from 01/2008 to 12/2008. Available certificates are defined as similar when they have the same underlying, a similar strike (±5%) and a similar time to maturity (±14 days) compared to the purchased certificate at the respective buy date.

Subperiod	04/2004–12/2007		01/2008–12/2008	
Strike	±5%		±5%	
Time to Maturity	±14 days		±14 days	
Regressor	Coefficient (SE)	Effect on purchase prob.	Coefficient (SE)	Effect on purchase prob.
Constant	−4.105*** (0.251)		−6.231*** (0.623)	
DFM	−34.079*** (2.742)	−1.86%	−21.487*** (2.878)	−0.61%
CRM	−24.479 (17.307)	−0.28%	+13.115 (9.935)	+0.22%
BidAskSpread	−93.097*** (16.713)	−1.39%	−52.497*** (18.379)	−0.62%
IssuerMarketShare	+3.914*** (0.413)	+1.71%	+5.242*** (1.692)	+1.36%
TradedwithIssuer	+1.575*** (0.120)	+16.42%	+1.806*** (0.519)	+8.87%
TradedCertBefore	+3.211*** (0.219)	+59.09%	+3.449*** (0.398)	+44.19%
CertTradeVolEuwax	+0.000*** (0.000)	+1.92%	+0.000*** (0.000)	+0.82%
$RoundStrike_1$	+0.602*** (0.063)	+3.70%	+0.516*** (0.111)	+1.30%
$RoundStrike_5$	+0.013 (0.050)	+0.10%	+0.381*** (0.078)	+1.15%
$RoundStrike_{10}$	−0.035 (0.046)	−0.25%	−0.136*** (0.050)	−0.41%
# of observations	62,860		46,871	
# of clusters (investors)	2275		1014	
Pseudo-R^2	27.8%		42.6%	



Appendix F.1. Ranks of purchased certificates for similar certificates. This figure shows the average rank of purchased certificates relative to all available, similar certificates including the purchased certificate (strike ±1% and time to maturity ±3 days; solid line, left axis). The gray bars (right axis) stand for the number of buy trades which underlie the average rank. The dotted line represents the rank of the optimal choice (=1), the dashed line indicates the average rank if the certificates had been chosen randomly (left axis). The horizontal axis indicates the number of similar available certificates on the respective purchase days.



Appendix F.2. Average *DFMAsk* of purchased certificates for similar certificates. This figure shows the average *DFMask* of purchased certificates (solid line) dependent on the number of similar available certificates on the respective purchase day (strike ±1% and time to maturity ±3 days; solid line). The dotted line represents the average *DFMask* if the investors had chosen the certificates with the lowest *DFMask* at every purchase (rank = 1). The dashed line indicates the average *DFMask* if the certificates had been chosen randomly.

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