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Pricing effects when competitors arrive: The case of discount certificates in Germany

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ABSTRACT

This article investigates how overpricing of outstanding certificates, also called master certificates, changes when competing products that duplicate the features of master certificates are issued. I argue that competition effects may be reverted and overpricing may increase rather than decrease after competitors arrive, when retail investors fail to detect implications of credit risk differences on certificates' values. Using difference-in-differences estimations on matched samples, I find that overpricing of master certificates decreases after the competing products have been issued, but only when the master issuer's credit risk is lower than that of the duplicate issuer, while it increases when the credit risk difference is positive. These findings are robust to controlling for retail investors' demand in various ways. Thus, the study indicates that retail investors' failure to detect the value implications of issuers' credit risk can undermine product competition.

1. Introduction

Many studies show that market prices of structured financial products exceed theoretical values of these products. Such overpricing has been observed for both simple products (e.g., Ruf, 2011) and complex products (e.g., Baule and Tallau, 2011; Stoimenov and Wilkens, 2005; Wallmeier and Diethelm, 2009). It has also been observed for financial market segments in countries such as Austria (Fischer et al., 2001), Germany (Baule and Tallau, 2011; Wilkens et al., 2003; Wilkens and Stoimenov, 2007), the Netherlands (Szymanowska et al., 2009), Switzerland (Burth et al., 2001; Grünbichler and Wohlwend, 2005), and the United States (Benet et al., 2006; Henderson and Pearson, 2011). Few studies have reached different conclusions (e.g., Wasserfallen and Schenk, 1996). While overpricing of structured financial products can partly be explained by the costs of structuring, advertising, and so forth, it also contains a hidden cost component, which issuers do not disclose to retail investors at products' issuance (Jorgensen et al., 2012).

Consequently, competition among structured financial products, defined here as products issued by a bank that combine at least one derivative instrument with other instruments, is required in these segments of financial markets to reduce overpricing so that retail investors can gain access to these products at more favorable prices. This paper, therefore, investigates pricing effects when competitors arrive. I investigate a simple product—namely, discount certificates with the DAX performance index as the underlying—for the period 2008–2010. I do not use more complex products because overpricing increases as the complexity of structured financial products increases (e.g., Grünbichler and Wohlwend, 2005; Henderson and Pearson, 2011), such that identifying competitor effects is even more difficult for more complex products. The chosen product type allows me to base the analysis on the notion that some discount certificates are issued whose features, which determine the certificates' payoff structure, are identical to those that another issuer brought to the market at an earlier time. The certificate issued first is denoted as the "master certificate," and the one issued later is the "duplicate." The issuance of such duplicates offers a good opportunity to examine the effects of the arrival of competitors in financial market segments for retail investors, as not only the number of issues but also the number of duplicates issued in the period under focus were substantial, as Fig. 1 illustrates.

One might expect a duplicate's issuance to exert pressure on the master certificate's overpricing because, after the duplicate has been issued, retail investors have more than one certificate available with identical features. However, some researchers argue

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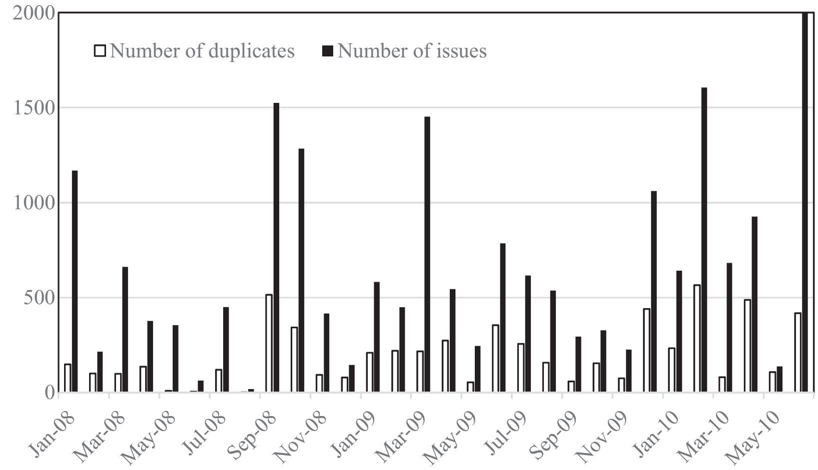

Fig. 1. Issuance of discount certificates. *Note:* This graph depicts the number of discount certificates with the DAX performance index as the underlying issued in the German market and the number of duplicates, which are certificates that were identical to another outstanding certificate in terms of CAP and reference date.

that retail investors may lack the knowledge or suffer from behavioral biases, preventing them from dealing with the effects of issuers' credit risk on products' values adequately (Baule et al., 2008; Entrop et al., 2015). I argue that in this situation, under particular circumstances the competition mechanism might be reverted such that issuers increase the prices of master certificates when they have higher credit risk than duplicate issuers. Such reversals are more likely to occur when credit risk of the issuing institutions differs substantially than when credit risk is low overall, because small credit risk differences do not lead to large differences in theoretical values of structured financial products. Therefore, I focus on a period in which credit risk of the issuing institutions differed substantially. If retail investors know that higher credit risk comes with lower prices but systematically underestimate the value implications of issuing institutions' credit risk, certificates with identical features might be traded at similar prices, even if the credit risk of the master and duplicate issuers differs substantially. Thus, the pricing effects when competitors arrive may depend on the credit risk difference between the two issuers.

Measuring pricing effects of the duplicates' issuances on master certificates' overpricing requires determining what could be expected without the issuance event. Pricing effects are then given as abnormal deviation in overpricing of the master certificate at the issuance of the duplicate. I argue that event-study methodology is not appropriate to measure these effects and therefore develop difference-in-differences estimations. In line with the competition hypothesis, I find that margins of master certificates decrease, but only when the master issuer has lower credit risk than the duplicate issuer. Conversely, margins of master certificates increase when the master issuer has higher credit risk than the duplicate issuer. With positive credit risk differences between master and duplicate issuers, margins increase regardless of whether they are calculated with or without adjustment for issuers' credit risk. Moreover, these findings are robust to various tests that control for retail investors' demand.

Controlling for influences from retail investors' demand is essential because the co-existence of certificates with identical features may be a reflection of retail investors' demand, which may go hand-in-hand with higher rather than lower overpricing. Recent research shows evidence of the so-called order-flow hypothesis (Baule, 2011): issuers set higher prices when retail investors buy certificates and lower prices when they sell their certificates. Thus, it could be argued that when retail investors buy particular certificates, issuers increase the prices of these certificates, and these price increases attract other issuers that then issue certificates with identical features. Consequently, identifying the effects of the arrival of competitors requires disentangling overpricing, competition, and retail investors' demand. Recent research has used Granger causality tests to gain insights into the relationship between overpricing and retail investors' demand (Baule and Blonski, 2015). I follow another identification strategy, because basic requirements to apply causality tests are not met in my setting. To ensure that the pricing effects that I measure at the issuances of the duplicates are not caused by demand, I make use of the empirical observation that many certificates have not been demanded before (and also after) duplicates were issued, which I combine with arguments from recent literature that retail investors prefer particular features.

A recent strand of literature on structured financial products investigates behavioral explanations for retail investors' demand. Breuer and Perst (2007) derive issuance advice by comparing the product choices of rational investors and investors relying on hedonic framing between discount reserve convertibles and reverse convertible bonds. Empirical research has also addressed behavioral explanations. Analyzing investors' realized risk-adjusted performance in discount certificates, Entrop et al. (2014) find that retail investors are prone to the disposition effect. Examining the trading behavior of retail investors in leveraged certificates, Meyer et al. (2014) find that the release of news on the underlying comes with much higher trading activity, but not with higher performance. Entrop et al. (2015) find that familiarity with the product or issuer determines retail investors' purchasing behavior. Relevant for my identification strategy is the finding by Baule and Blonski (2015) for bank-issued warrants and Entrop et al. (2015) for discount certificates. They find that retail investors demand products with round strikes more intensely than products without. I use this finding to investigate whether effects of duplicates' issuance on master certificates' margins depend on whether retail investors' expected demand is high or low.

Causal interpretation of the difference-in-differences estimations is only appropriate if the duplicate's issuance does not depend on the price charged by the master issuer—it must be an exogenous event for the master issuer. According to practitioners, there is little reason to believe that issuers systematically screen outstanding products to duplicate only the most successful ones. Issuers offer a wide range of structured financial products to investors, including various combinations of certificates' features, as retail investors may be interested in using them either for hedging or for speculative reasons. The costs for structuring, selling, and advertising an additional product may be negligible because part of the costs is independent of the number of products issued. In addition to this argument, I investigate which outstanding certificates receive duplicates and find no evidence that master issuers stimulate the issuance of duplicates with setting high prices. Rather, outstanding certificates from issuers with higher credit risk changes have greater chances of receiving duplicates. From these results, I conclude that the issuance of duplicates does not depend on the price that the issuer of the master certificate requests.

This study contributes to the literature addressing overpricing of structured financial products (e.g., Baule, 2011; Benet et al., 2006) and competition in and among financial markets (e.g., Battalio et al., 2004; Bessembinder, 2003; De Fontnouvelle et al., 2003; Mayhew, 2002) in four important ways. First, although investigating the effects of competition in markets for structured financial products is not novel, to the best of my knowledge, this study is the first to offer insights into pricing effects of the arrival of competitors that can be interpreted in a causal way. Other researchers investigate the relationship between indicators for product competition and overpricing. For example, Baule (2011) finds that discount certificates' margins decline with the number of available certificates with similar features. Second, this study investigates the role of two competing issuers' credit risk on their price setting behavior. So far, the literature has only investigated how issuers' credit risk affects their price setting (e.g., Baule, 2011) and retail investors' trading behavior (Entrop et al., 2015). Third, this study employs difference-in-differences estimations in the case of structured financial products. This approach could be helpful for other research questions, as well. For example, it offers an alternative way to investigate when and how issuers begin to adjust their prices to retail investors' demand. Fourth, although research rarely questions how competitors come into existence (e.g., Baule, 2011; Bartram and Fehle, 2007), the current study investigates the likelihood of receiving a duplicate issued by another issuer.

The remainder of the paper is organized as follows: Section 2 discusses the institutional background of discount certificates and derives their theoretical values. Section 3 outlines the empirical strategy to measure the pricing effects of duplicates' issuances on master certificates' overpricing and develops hypotheses. Section 4 describes how master certificates were identified for this study and how the data set was constructed; it also presents descriptive statistics on overpricing and features of master certificates and duplicates. Section 5 discusses how the issuance of duplicates affects master certificates' overpricing and what determines the likelihood that an outstanding stand-alone certificate, which is a certificate that offers new features to investors at its issuance, becomes a master certificate. Section 6 concludes with a brief discussion of limitations of this study.

2. Institutional background and valuation

2.1. Institutional background

Discount certificates allow retail investors to buy an underlying at a specified future time and at a discount to the current market price of the underlying. In exchange for this discount, investors participate in the performance of the underlying only up to a specified value, which is called the *CAP*. Because of market bottlenecks, issuers—but not retail investors—can construct the payoff structure of discount certificates from components traded in other segments of financial markets. Transaction costs and/or security nondivisibility as well as short-sale restrictions give rise to these market bottlenecks. For example, retail investors' costs and commissions for trading structured financial products are usually lower than those of the instruments required to replicate the payoff structure of a structured product (Stoimenov and Wilkens, 2005).

Retail investors can buy and sell discount certificates over the counter (OTC) as well as on secondary markets. Most discount certificates are listed either at the European Warrant Exchange, which belongs to the Stuttgart Stock Exchange, or at the Certificate Stock Exchange, which belongs to the Deutsche Börse. In the secondary market, market makers provide bid and ask prices (Erner et al., 2004). If a retail investor requests a price quote, market makers must simultaneously offer both bid and ask prices. Issuers of certificates are frequently the market makers in the secondary markets (Baule and Blonski, 2015; Baule et al., 2004), and therefore the market price should not be equated with a price determined by demand and supply in a well-functioning financial market.

The possibility of exploiting arbitrage opportunities on the secondary market is almost absent, because retail investors face restricted access to the markets in which the components of the structured financial products are traded and because short-selling of these products is not possible. Thus, issuers are in a position to set prices above theoretical values of the certificates. In the end, the payoff that retail investors receive from such a product, either when the product matures or when they repurchase the product, always comes from the issuer from whom they bought it. As such, an investor that bought a certificate can sell it to the issuer from whom s/he bought it in either an OTC transaction or secondary markets. Both sales and buybacks are carried out at prices that are often above theoretical values, but the premium included when selling certificates to retail investors exceeds that when rebuying the certificates from investors (Entrop et al., 2009). Therefore, issuers gain by decreasing the implicit premiums over the lifetime of the certificates (Wilkens and Stoimenov, 2007).

Issuers usually do not bring one certificate for a particular underlying to the market, but rather offer many certificates at a time to retail investors. According to practitioners, issuers want to offer a full range of products to retail investors with respect to maturity and performance. Therefore, they bring new certificates to the market at regular time intervals. Often, several certificates are issued that mature at the same future point in time, clustered around the maturity dates of EUREX options. CAPs are chosen in such a way that certificates that give retail investors a range of performance possibilities are offered. Thus, certificates that are in the money, at the money and out of the money are usually issued. Computer programs help in designing the various CAP and maturity-date combinations. Issuers claim that the range of products issued does not contain any market forecasts. Nevertheless, issuing activity may depend on issuers' characteristics (e.g., their credit risk). In summary, the issuance procedure may indicate that issuers do not search the market to identify certificates with high prices, given their features offered by other issuers, but rather offer a broad range of certificates in terms of CAPs and times to maturity.

Issuers provide newsletters and make use of other information technologies to announce new product issues to retail investors. According to practitioners, the time needed to bring a certificate to the market is between four and seven days, though, occasionally, products are brought to the market within one day. Writing prospectuses and the like does not take much time because the routine of issuing certificates is standardized, which means that only a few parameters must be plugged into a standardized text to prepare a prospectus. Choosing which CAPs to introduce may not be a big issue, as listing fees for the one-time inclusion of structured financial products are moderate because they are calculated on annual inclusion packages (Börse Frankfurt, 2013). For example, the listing fee of 5000 inclusions per calendar year amounts to €75,000.

2.2. Valuation of discount certificates

The payoff of a Call discount certificate at its reference date is given by $min\{S_\tau; CAP\}$, where S_τ is the price of the underlying at reference date, τ, on which the repayment value of the certificate to the investor is determined. Its promised payoff equals that of a replication portfolio consisting of a zero-strike Call on the underlying security and a short position in a European Call option written on the respective underlying whose strike equals the certificate's CAP, which specifies the value up to which investors participate in the performance of the underlying. In addition, the European Call option's maturity date equals the certificate's reference date, τ. Because no dividend payment needs to be considered, as the underlying under focus is the DAX performance index, the theoretical value of a discount certificate can be determined by applying Black and Scholes's (1973) standard model.

However, a discount certificate differs in two ways from the replication portfolio described in the previous paragraph. First, at the reference date of the discount certificate, the repayment value is fixed (i.e., the repayment value no longer changes with the value of the underlying after this date), but the repayment to the retail investor takes place at the maturity date, which is usually a few days after the reference date. The delay in repayment between the reference date, τ, and the maturity date, T, of a certificate is accounted for by discounting its theoretical value with the forward rate that applies to the time gap between the reference date and the maturity date. Second, discount certificates have a so-called cover ratio, α, that in most cases specifies a fraction of the underlying to which the certificate refers. This cover ratio is taken into account by multiplying the certificate's theoretical value by its respective ratio. Using Black–Scholes valuation and adjusting the theoretical value for the two aspects of discount certificates mentioned previously lead to the following theoretical value (DC) of a certificate i:

$$DC_{i,t}^{BS} = \alpha_i e^{-r^{FW}(T_i-\tau_i)}\left(S_t N(-d_{i,1}) + CAP_i e^{-r(\tau_i-t)} N\left(d_{i,1} - \sigma_{i,t}\sqrt{\tau_i - t}\right)\right) \tag{1}$$

$$\text{with } d_{i,1} = \frac{\ln(S_t/CAP_i) + \left(r + \sigma_{i,t}^2/2\right)(\tau_i - t)}{\sigma_{i,t}\sqrt{\tau_i - t}},$$

where t is the day for which the theoretical value is calculated, T is the maturity date, τ is the reference date, S is the price of the underlying, r is the spot rate for $\tau - t$, r^{FW} is the implied forward rate for $T - \tau$, and σ is the volatility of the underlying.

The most important way a discount certificate differs from the replication portfolio is that, from a legal view, discount certificates, like other structured financial products, are senior unsecured bonds of the issuing bank, whose redemption depends on other securities' values. Therefore, an investment in structured financial products exposes the retail investor to the credit risk of the issuing institution. Consequently, the theoretical value of a discount certificate depends on the credit risk of the issuing institution. Higher credit risk of the issuer implies that the theoretical value is lower. Hull and White (1995) assume that the price risk is independent of the issuers' credit risk and show that the credit risk can then be addressed by discounting the Black–Scholes theoretical value of a certificate without credit risk with the issuer's credit spread, s:

$$DC_{i,t}^{HW} = e^{-s_i(T_i-t)} DC_{i,t}^{BS} \tag{2}$$

I follow the literature (e.g., Baule et al., 2008; Stoimenov and Wilkens, 2005) and rely on gross margins, defined as the difference between the quoted price and the theoretical value of a certificate:

$$\text{Margin}_{it} = \left(P_{it} - DC_{it}^{HW}\right)/DC_{it}^{HW} \tag{3}$$

where P_{it} denotes the quoted price of certificate i at time t. I used the model by Hull and White (1995) to determine theoretical values because it has been commonly used in recent literature (e.g., Baule, 2011; Baule and Blonski, 2015; Baule et al., 2008; Stoimenov and Wilkens, 2005). Because theoretical values and, thus, margins depend on the underlying model assumptions, I also applied the Black–Scholes model to calculate a *margin without credit risk adjustment*, which I used in robustness tests. The deviations between quoted prices of discount certificates and their theoretical values, thus the margins, are, all else being equal, higher when theoretical values are controlled for issuers' credit risk (Baule et al., 2008).

Gross margins differ from issuers' net margins in several important aspects. First, gross margins do not include particular cost components, because information is lacking on total costs of structuring and advertising retail products and on how issuers distribute these costs among the different types of structured financial products they offer. Second, issuers may use another benchmark model to price their structured financial products. Third, the calculation of gross margins rests on the assumption that issuers can replicate the certificate by using products traded in other segments of financial markets. However, in practice, not all products required to replicate a certificate might be available. Finally, as mentioned previously, issuers profit by decreasing the implicit premiums over the lifetime of the certificates, which means that the average gross margin is higher when they sell a product than when they buy back the product from retail investors.

To investigate effects of duplicate's issuance on the pricing of master certificates, gross margins are preferred to net margins. The reason is that net margins could lead to wrong rankings of the products retail investors prefer, and, if so, competition effects would not be captured accurately. For example, suppose certificate A is offered at a net margin of 0.5%, while B, which has all features identical to A, including issuer's credit risk, is supplied at 1%. Would an investor prefer certificate A because of the lower net margin? Not necessarily, because the low net margin of certificate A could be due to high structuring costs of the issuer, not a lower price charged by this issuer. The price of certificate A could even exceed that of certificate B. Therefore, gross margins are preferred to net margins to investigate the pricing effects when competitors arrive.

3. Empirical strategy and hypotheses

This study aims to measure the effect of duplicates' issuance on master certificates' overpricing. This aim is somewhat similar to those of studies that investigate how the arrival of a competitor affects stock prices (e.g., Chen et al., 2005; Chevalier, 1995). These studies apply event-study methodology and measure the effect of competition by securities' abnormal return, which is the return at or around the event date less the normal return determined by applying particular models (e.g., Brown and Warner, 1980; MacKinlay, 1997). In the case of discount certificates and other structured financial products, however, this methodology cannot be applied, because the prices of these products largely follow changes in prices of the underlying securities. A particular specificity is what the literature describes under the term life-cycle hypothesis: Prices of structured financial products come closer to theoretical values when the products come closer to their maturity (e.g., Stoimenov and Wilkens, 2005; Wilkens et al., 2003). Therefore, the finding that master certificates' overpricing after the issuance of the duplicates is lower than before cannot be interpreted as the pricing effect of the duplicates' issuance.

To investigate pricing effects when competitors arrive, it is necessary to measure changes in the master certificate's price that are not caused by price changes of the underlying. Therefore, I used difference-in-differences estimations, which I combined with a matching method. Such techniques are useful for investigating differences between a treatment group and a comparison or control group both before and after treatment (Meyer, 1995). My treatment group consists of certificates that receive a duplicate at a particular point in time, which is called issue time, $\bar{t}$, because it is defined relative to the issuance date of duplicates. Issue time equals 0 on the day the duplicate is issued, ±1 on the trading day before/after the issuance, and so forth. I consider several days before and after the issuance of the duplicates.

As control group, I did not use all certificates outstanding at the time of the issuance of the duplicate, but rather used a matching strategy to find one control certificate for each master certificate. Difference-in-differences estimations in combination with a matching approach was first invented by Heckman et al. (1997). Propensity scores have often been used when matching, but results may be sensitive to the specification of the propensity score (Smith and Todd, 2005). I do not use a propensity score matching, because in my sample it cannot be combined with a time matching which ensures that all market movements affecting master and control certificates alike can be filtered out. Therefore, the margins of the control certificates are measured on the same calendar days as the master certificates' margins.

Certificates only qualify for the control group if they meet three criteria. First, the certificate does not receive a duplicate at the point in time when the master certificate receives its duplicate. Second, the control and master certificates have been issued by the same issuer. This criterion helps control the role of issuers' credit risk. More specifically, with this criterion, I rule out the possibility that credit risk drives differences in margins of the master and control certificates. Third, the control certificate must have a CAP and maturity date that are close to those of the master certificate. Concretely, their CAPs can differ by no more than 100 index points, and their reference dates can differ by no more than 50 trading days. In robustness tests, I allow for higher differences in the features between master and control certificates.

My baseline difference-in-differences estimation depicted in issue time is as follows:

$$\Delta\text{Margin}_{i\bar{t}} = \beta_1 \times POST_{i\bar{t}} + \beta_2 \times MASTER_i + \beta_3 \times POST_{i\bar{t}} \times MASTER_i + \varepsilon_{i\bar{t}} \quad (4)$$

where $\Delta\text{Margin}_{i\bar{t}}$ denotes the timely changes in the $\text{Margin}_{i\bar{t}}$. These timely changes of certificates' margins account for omitted variables in the *level* of margins. *POST* is a dummy variable that equals 1 after the issuance of the duplicate, regardless of whether certificate *i* is a master or control certificate, and 0 otherwise. The coefficient on *POST* captures all changes that similarly affect master and control certificates after the treatment. According to the life-cycle hypothesis, both master and control certificates may have lower margins after the issuance of the duplicates than before. Therefore, the coefficient on *POST* should be negative. *MASTER* denotes a dummy variable that takes the value 1 when certificate *i* is a master certificate and 0 when it is a control certificate. Thus, this variable controls for all time-invariant differences in the changes of margins between the two types of certificates.

The interaction term between *POST* and *MASTER* is central for the aim of the study because the coefficient on this term captures the additional mean change in margins of master certificates that is related to the issuance of the duplicates. Because the master certificate competes with the duplicate, a negative coefficient on the interaction term between *POST* and *MASTER* is expected, which would suggest that margins of master certificates decrease more after the issuance of the duplicate than the margins of the control group. In line with the competition argument, the prices of master certificates come under pressure, and consequently overpricing should decline after other issuers have brought duplicates of master certificates to the market. H1 summarizes this competition effect:

H1. The duplicate's issuance creates pressure on prices such that the margin of the master certificate declines more than that of the control certificate.

Next, I will argue that credit risk differences between the master and duplicate issuer may, under certain circumstances, revert the competition effect in such a way that master issuers increase rather than decrease their prices when the competing duplicates arrive. To test whether differences in credit risk between the master and duplicate issuers matter for pricing master certificates after their duplicates have been issued, I modify my baseline difference-in-differences estimation and consider two instead of one interaction term:

$$\Delta\text{Margin}_{i\bar{t}} = \beta_1 \times POST_{i\bar{t}} + \beta_2 \times MASTER_i + \beta_3 \times POST_{i\bar{t}} \times MASTER_i \times \text{CDS}^{DIF+} + \beta_4 \times POST_{i\bar{t}} \times MASTER_i \times \text{CDS}^{DIF-} + \varepsilon_{i\bar{t}} \quad (5)$$

where CDS^{DIF+} (CDS^{DIF-}) is a dummy variable that equals 1 when the master issuer has higher (lower) credit risk than the duplicate issuer. Thus, $POST \times MASTER \times \text{CDS}^{DIF+}\left(\text{CDS}^{DIF-}\right)$ contains the effect for master certificates for which the credit risk of the master issuer is higher (lower) than that of the duplicate issuer.

If issuers offer products at theoretical values, plus a money amount for structuring, advertising, and selling the product, plus a profit component (which is reduced over the lifetime of a certificate) to earn some money, an issuer with low credit risk will request, all else being equal, a higher price than an issuer with high credit risk. The price difference would compensate the retail investor for the credit risk difference.[1] However, retail investors may lack the knowledge to glean insights into the value implications of issuers' credit risk, or they may suffer from behavioral biases. They may only know that credit risk is relevant for the certificates' value, and therefore they may have a lower willingness to pay for the certificate from the issuer with the higher credit risk, all else being equal. At what prices will two issuers, one with high and the other with low credit risk, offer certificates with identical features? If retail investors fail to valuate credit risk differences appropriately, the two prices might differ only by a small amount that is not related to the actual credit risk difference between the two issuers. Indeed, Entrop et al. (2015) find that issuers' credit risk does not determine which certificate a retail investor purchases. Then, the issuer with low credit risk offers its product at a higher price than the issuer with high credit risk, though both offer products only as long as their profit components are non-negative (thus, instead of losing money by requesting low prices, issuers may opt to leave the market). The issuer with high credit risk would exploit the nescience of retail investors by requesting a price that is only marginally lower than the price requested by the issuer with low credit risk. Thus, market prices might be determined mainly by issuers with low credit risk, while issuers with high credit risk may respond to the price setting of the former.

The next question to be answered is how the issuer prices its certificate before the competing duplicate arrives, because this will

[1] The difference in theoretical prices according to the model by Hull and White accounts for as much as €5 to €6, depending on the time to maturity and the moneyness of the certificate under consideration, when one issuer has a credit spread of 50 basis points and the other issuer has a credit spread of 500 basis points.

determine the issuer's response to the arrival. Suppose first that before the competitor arrives, the issuer prices the certificate by ignoring its credit risk totally and by including a high profit component; both ignoring its credit risk and including a high profit component lead to high overpricing of the certificate before the issuance of duplicate. Then, the duplicate's issuance reduces overpricing. It might even be argued that this reduction is stronger when the master issuer has higher credit risk than the duplicate issuer, in which case the duplicate issuer determines the market price and the master issuer follows the pricing of the duplicate issuer. The reason here may be that a high-risk issuer has the ability to substantially decrease its price while keeping a positive profit component, while a low-risk issuer has limited leeway to reduce its price given that the profit component should be non-negative. Thus:

H2a. When issuers initially request high prices, the duplicate's issuance reduces the master certificate's overpricing regardless of whether the master issuer has higher or lower credit risk than the duplicate issuer. Thus, $\beta_3, \beta_4 < 0$.

Alternatively, the issuer may consider its credit risk and a moderate profit component when pricing products, such that overpricing is not extremely high before the competitor arrives. This seems likely because recent research suggests that retail investors are price sensitive (Baule and Blonski, 2015; Entrop et al., 2015); they switch between issuers and products (Baule and Blonski, 2015). Thus, if the issuer wants to attract retail investors, it will overprice its products moderately, on average. When retail investors begin demanding a particular product, the issuer may increase prices (Baule, 2011). What then are the pricing implications for master certificates at the arrival of duplicates? When the master issuer has lower credit risk than the duplicate issuer, the potentially lower price of the duplicate puts pressure on the price of the master certificate. The master issuer may reduce its price as long as its profit component is non-negative. A master issuer with higher credit risk than the duplicate issuer, however, might be incentivized by the high price of the duplicate to increase its price. In summary, if retail investors struggle with the value implications of issuers' credit risk and focus on prices requested by the issuers rather than focusing on the products' values, and if master issuers do not heavily overprice their products before competitors arrive, the pricing effects of the duplicates' issuances on master certificates' margins will depend on whether the credit risk difference between the master and duplicate issuers is positive or negative. Thus:

H2b. The duplicate's issuance reduces the master certificate's overpricing when the master issuer has lower credit risk than the duplicate issuer, while it increases overpricing when the master issuer has higher credit risk than the duplicate issuer. Thus, $\beta_4 < 0 < \beta_3$.

Measuring the effects of duplicates' issuance on margins of master certificates requires disentangling them from demand effects. Recent research has dealt with the effects of investors' demand on pricing structured financial products and options (Baule, 2011; Baule and Blonski, 2015; Gârleanu et al., 2009). Baule (2011) documents that several issuers anticipate the trading behavior of retail investors (the order-flow hypothesis mentioned previously). Thus, retail investors may demand master certificates more intensely than the respective control certificates, and issuers may issue preliminary the certificates for which they expect a high demand. To distinguish between pricing effects of duplicates' issuance and retail investors' demand, I empirically observe that most master certificates have not been demanded for long before the issuance of the duplicates. However, because this observed demand might be a poor indicator of expected demand, I follow insights from recent literature that retail investors prefer particular characteristics of structured financial products more than others. Baule and Blonski (2015) and Entrop et al. (2015) show that investors prefer products with round strikes or CAPs to other products. If demand is not the main creator of the issuance of duplicates and the price setting of master certificates, the signs of the coefficients on the interaction terms $POST \times MASTER \times CDS^{DIF+}$ and $POST \times MASTER \times CDS^{DIF-}$ should not change when demand effects are controlled for.

4. Data

4.1. Sample

Between January 2008 and June 2010, 25,000 discount certificates with the DAX performance index as underlying were outstanding, 20,000 of which were issued during this period (see Table 1). ARIVA.DE provided all information on issuing activities and quoted prices of certificates. All certificates issued were examined to determine whether the certificates' features were identical to those of certificates already traded in the market. Thus, for each outstanding certificate, I checked whether the certificate received a competitor during the sample period and thus became a master certificate. A certificate is classified as a master certificate whenever its CAP and reference date equal those of another certificate that has been issued by another issuer later in time. This classification of master certificates covers only the two most important characteristics determining the value of a discount certificate. It does not require that the maturity dates of the master certificate and duplicate are identical. At the maturity date, the investor receives the repayment, while at the reference date, the repayment value is specified. I ignored this delay in repayment when defining master certificates (but not when determining their theoretical values), because the difference with four trading days is small.[2]

I identify as many as 6001 duplicates. The number of master certificates is lower than the number of duplicates because some outstanding certificates had more than one duplicate: 2317 master certificates had 1 duplicate, 846 master certificates had 2 duplicates, and one master certificate even had as many as 12 duplicates issued between January 2008 and June 2010. In total, 3603 master certificates received 1 or more duplicates in the sample period. For master certificates that received more than 1 duplicate, I consider not only the issuance of the first duplicate but also the issuances of all other duplicates that belong to these master certificates; duplicates that receive duplicates issued by another issuer later on are not considered master certificates.

Table 1 also provides the number of certificates for issuers that brought more than 200 certificates per year to the market. In terms of total issues, UBS and Goldman Sachs were the main issuers, followed by Commerzbank and Citibank. UBS was the main issuer of master certificates followed by Citibank. This is mainly due to the large number of certificates that these banks issued during the sample period. Relative to the number of outstanding certificates, certificates issued by HSBC Trinkaus & Burkhardt and Citibank were more likely to be duplicated by another issuer than certificates issued by other issuers. For the total number, Deutsche Bank, BNP Paribas, DZ Bank, and Citibank issued many duplicates, while Dresdner Bank and Commerzbank issued few duplicates. In relative terms, more than 80% of all issuances by Société Générale

[2] Master certificates may also differ from duplicates in other features, such as the cover ratio, the minimum size of the contract, and the form of settlement (cash vs. physical settlement). I used only identical CAPs and reference dates to identify master certificates because these two factors are most relevant for creating competition.

Table 1
Number of discount certificates.

	Outstanding		Issues	
	All	Master certificates	All	Duplicates
Total	25,365	3603	19,928	6001
Main issuers				
BNP Paribas	1913	357	1202	703
Citibank	2540	466	2163	645
Commerzbank	3500	408	2257	150
DZ Bank	1014	94	890	694
Deutsche Bank	2766	406	1802	1022
Dresdner Bank	1861	331	1110	23
Goldman Sachs	3009	36	3007	398
HSBC Trinkaus & Burkhardt	708	176	609	343
Société Générale	649	36	623	536
Royal Bank of Scotland	615	28	526	315
UBS	4678	1095	4000	382
Vontobel Financial Products	611	41	601	191

Note: This table reports the number of outstanding discount certificates with the DAX performance index as the underlying and the number of master certificates, which are certificates that receive duplicates. A duplicate is identical to the master certificate in terms of CAP and reference date but is issued by another issuer later in time. Moreover, it depicts the number of all discount certificates issued and the number of duplicates. Each master certificate counts only once, though more than one duplicate may be issued during the sample period. Issuers are classified as main issuers when they have issued more than 500 discount certificates during the sample period January 2008–June 2010.

were duplicates. Thus, issuers seem to differ in their issuing strategies: some issuers, such as UBS, issued few duplicates compared with their number of master certificates, while other issuers, such as Royal Bank of Scotland, brought more duplicates than master certificates to the market.

The number of duplicates' issuances considered in the difference-in-differences estimations of master certificates' margins is lower than that depicted in Table 1 for several reasons (see Table 2). I do not consider 961 duplicates, because the master certificates' time to maturity was less than six months. Because the issuance of duplicates may influence master certificates' prices for several days, a master–duplicate combination is not considered, when the time difference between two successive issuances duplicating the same master certificate was less than 10 trading days or when the master certificate and duplicate were issued within 10 trading days of each other. To be included requires not only that price data of certificates were available but also that all relevant information necessary to determine theoretical values of the certificates was available, such as the implied volatility of the underlying and the credit risk of the master issuer. For 411 master–duplicate combinations, it was not possible to determine an implied volatility. Master certificates issued by DZ Bank and Vontobel Financial Products had missing credit risk information[3] and thus were deleted from the data set. Note that master certificates that received duplicates from issuers with missing credit risk information were not excluded. I have all relevant information on 3804 master–duplicate combinations. For 1818 master–duplicate combinations, a control certificate that has an absolute difference in CAP no larger than 100 index points and an absolute difference in the reference date of no more than 50 trading days could be identified. After these adjustments, the final data set consists of master certificates from the following issuers: BNP Paribas, Citibank, Commerzbank, Deutsche Bank, Dresdner Bank, Goldman Sachs, HSBC Trinkaus & Burkhardt, Morgan Stanley, Société Générale, Royal Bank of Scotland, and UBS.

[3] The German derivatives association offers information on CDS spreads, if available, for all issuers active in the German market (see http://www.derivateverband.de/ENG/Transparency/CreditSpreads).

Table 2
Number of master certificates in the sample.

	Number
All duplicates	6001
Remaining lifetime of the master certificate is less than 6 months	961
Master certificate receives two duplicates within 10 days	322
Master certificate and duplicate are issued within 10 days	55
CDS spread of master issuer is missing	216
Implied volatility is missing	411
Price of master certificate is missing	232
Master certificates with available data	3804
Master certificates with matched control certificate	1818

Note: The total number of duplicates is shown, and all explanations why particular observations are not considered in the sample are stated.

4.2. The control group

Table 3 depicts information on the characteristics of master and control certificates measured on the day the duplicates were issued. Creditworthiness of the issuers is captured by the credit default swap (CDS) spreads, which were collected from Thomson Datastream and adjusted for coupon payments. The issuers' CDS spreads of master certificates and the control group, which is depicted for a 1-year horizon in basis points, does not differ by definition, because for each master certificate a control certificate from the same issuer was selected.

I define the moneyness of certificate i as $MONEY_{it} = \frac{S_t - CAP_i}{CAP_i}$, where S_t denotes the DAX performance index at time t. The moneyness of master certificates is similar to that of certificates in the control group. Of note, and in line with the assumption of the difference-in-differences approach, the master and control certificates do not differ significantly in terms of their moneyness. Two dummy variables capture whether the CAP is a round number. $Round^{500}$ indicates that more than 24% of master and control certificates have a CAP that can be divided by 500 without a leftover. $Round^{200}$ indicates that 59.2% of the master certificates and 55.5% of the certificates in the control group have a CAP that can be divided by 200 without rest.

Several dimensions of the lifetime of certificates are also depicted. I calculated the remaining lifetime, $LIFE_{it} = T_i - t_{it}$, in years (see Table 3). Master certificates have a similar remaining lifetime to certificates in the control group. Importantly, the remaining lifetime of master and control certificates does not differ significantly according to a two-sided sign test on matched pairs. In addition, Table 3 depicts the time gap between the maturity date and the reference date for the two types of certificates, which is, on average, a bit more than four days. For master certificates, I calculated $AGE_{it} = (t_{it} - T_i^{Issue})$, which indicates that master certificates are, on average, issued 1.16 yrs before their respective duplicates were issued.

Table 3 finally depicts the trading activity of master and control certificates because this activity might shed light on whether retail investors demand master certificates more intensely than control certificates, even if trading activity is only part of the demand, because information on OTC transactions is missing. To do so, I used data from the European Warrant Exchange and Certificate Stock Exchange provided by the Karlsruher Kapitalmarktdatenbank (KKMDB). For each certificate, I determined the number of trades at the two exchanges over a window of three and alternatively six months before the issuance of the duplicate. Unfortunately, sales and rebuys cannot be distinguished, which is not much of a problem, because many of the certificates are never traded. Consequently, I generated two dummy variables for each certificate, $TRADE^{3m}$ and $TRADE^{6m}$, which equal 1 when at least one trade was executed in the three months and six months before

Table 3
Characteristics of control certificates.

Number	Master certificates 1818		Control certificates 1818		Difference tests	
	Mean	sd	Mean	sd	Paired *t*-test (*t* values)	Sign test (*p* values)
CDS spread (1 yr, bp)	160.2	101.8	160.2	101.8		
MONEY	0.224	0.360	0.224	0.361	-0.87	0.81
$Round^{500}$	0.243		0.246			0.71
$Round^{200}$	0.592		0.555			0.00***
LIFE (yrs)	1.468	0.714	1.464	0.728	1.81*	0.22
Time gap (days)	4.378	2.228	4.316	1.989		
AGE (yrs)	1.161	1.141				
$TRADE^{3m}$	0.288		0.305			0.00***
$TRADE^{6m}$	0.341		0.355			0.00***

Notes: Descriptive statistics are reported for master and control certificates. The characteristics are measured on the day the duplicates were issued. ***, **, and * indicate that the difference between the variable's value of the master certificate less the value of the control certificate is significant at the 1%, 5%, and 10% levels, respectively.

the issuance of the duplicates and 0 otherwise. I find that only 28.8% of the master certificates and 30.5% of the control certificates were traded in the three months before the issuance of the duplicate. The numbers for the six-month window are slightly higher.

4.3. Margins

4.3.1. Inputs for calculating theoretical values

Calculating the theoretical values requires information on credit spreads of the issuing bank, the default-free spot-rate structure, and the volatility of the underlying. Spreads of CDS with times to maturity of 0.5, 1, 2, 3, 4, 5, and 7 yrs were used to calculate issuer-specific time-variable measures of the credit spreads, *s*.[4] To match the time to maturity of the CDS spreads to the time to maturity of the certificates, I interpolated CDS spreads linearly in the time dimension.

The default-free spot-rate structure is the governmental spot-rate curve provided by the Deutsche Bundesbank. This spot-rate curve is based on Nelson and Siegel's (1987) approach with Svensson's (1994) extension. I used it to calculate the spot rate, *r*, and the implied forward rate r^{FW} for the time between reference date, τ, and maturity date, *T*.

The stock price volatility estimates were calculated from daily settlement prices of EUREX options with the DAX performance index as the underlying retrieved from the Thomson Datastream. These prices are not necessarily traded prices. Because put and call options with identical strike and time to maturity produce different implied volatilities, a weighting procedure is recommended. The approach taken herein follows that of Hentschel (2003), who suggests calculating the implied volatility on the basis of a hypothetical value of the underlying that follows from applying the put–call parity. Thus, I used first prices of put and call options to calculate the hypothetical value of the underlying under the assumption that the put–call parity holds. Then, I used this hypothetical value of the underlying to calculate the implied volatility. For each day, a multitude of implied volatility estimates that differ according to their strikes and times to maturity were produced.

These implied volatility estimates were then used to find an appropriate volatility estimate for valuating a discount certificate *i* at time point *t*. Whenever a pair of put–call options whose strike equals the certificate's CAP and whose maturity date equals the certificate's reference date was observed, the implied volatility of these options was used to calculate the theoretical value of the certificate. However, the features of the EUREX options often differ from those of the certificates. Therefore, volatilities were determined using a two-dimensional interpolation of the options whose features were closest to those of the discount certificate (e.g., Baule et al., 2008). More specifically, I first interpolated the implied volatilities of two pairs of put–call options maturing before the certificate (the strike of one pair is higher than the certificate's CAP, and the other one is lower) and of two pairs of put–call options maturing after the certificate (again, the strike of one pair is higher than the certificate's CAP, and the other one is lower). Finally, I interpolated in time dimension by using the interpolated volatilities of options maturing before and after the certificate.

4.3.2. Margins in issue time

Table 4, Panel a, presents margins calculated with quoted closing prices of certificates on the Frankfurt Stock Exchange and depicts them for master certificates and their control certificates for selected days before and after the issuance of the duplicates. Master certificates have, on average, lower margins than the respective control certificates, and this difference is according to paired *t*-tests statistically significant for all days before the issuance of the duplicates. After the issuance of the duplicates, master certificates' margins are closer to the margins of control certificates than before the issuance; the difference is even insignificant on selected trading days.

Table 4, Panel b, presents margins for all pairs of master certificates and their respective duplicates.[5] At the issuance day and all following days, the margins of duplicates are lower, on average, than those demanded by issuers of master certificates. According to paired *t*-tests, the difference in margins is highly statistically significant. Duplicates offered at lower margins are likely to put pressure on the master certificates' prices. However, retail investors that struggle with valuating issuers' credit risk or that suffer from behavioral biases may look at pure prices unadjusted for the issuers' credit risk. Therefore, the margins based on the Black–Scholes model are also depicted. Margins without credit risk adjustment give a different picture: On all days, except on the issuance day of the duplicates, master certificates have lower prices than duplicates, which is not surprising because the average paired difference in one-year CDS spreads of the master and duplicate issuers is approximately 31 basis points.[6] The same conclusion prevails when restricting the comparison to master–duplicate pairs with matched control certificates. Margins in Panel a (master certificates with control certificates) are lower than those in Panel b (master certificates with and without control certificates). The reason for this is that master certificates without control certificates (considered in Panel b but not in a) have a longer time to maturity and are deeper in or out of the money than master certificates for which control certificates could be matched.

The average margins depicted in Table 4 are higher than those reported in the literature. Using theoretical values from applying the model by Hull and White (1995), Baule et al. (2008) report margins of certificates with single DAX stocks as underlying between 0.78% (Deutsche Bank) and 2.39% (Société Générale),

[4] Other researchers have used average credit spreads of the industry (e.g., Stoimenov and Wilkens, 2005), which may be appropriate when the issuers' credit spreads do not change much over time and do not differ much across issuers.

[5] The number of observations in this comparison is lower than that stated in Table 2 because some issuers of duplicates have missing credit risk information.

[6] I also tested whether master issuers with higher (lower) credit risk than duplicate issuers offer their certificates at lower (higher) prices than duplicate issuers. On average, prices of master certificates are significantly lower (higher) than those of duplicates when the credit risk of the master issuer is higher (lower) than that of the duplicate.

Table 4
Margins in issue time.

Number	Issue time	Master certificates 1818 Mean (%)	sd (%)	Control certificates 1818 Mean (%)	sd (%)	Paired *t*-tests
Panel a: Margins of master and contol certificates						
Margin	−5	3.16	3.50	3.19	3.49	−2.72***
	−2	3.25	3.55	3.28	3.56	−3.02***
	−1	3.24	3.46	3.27	3.44	−2.77***
	0	3.21	3.52	3.23	3.51	−2.24**
	1	3.15	3.46	3.16	3.45	−1.21
	2	3.12	2.99	3.13	2.99	−1.69*
	5	3.13	3.12	3.14	3.11	−1.05
Number	Issue time	Master certificates 2842 Mean (%)	sd (%)	Duplicates 2842 Mean (%)	sd (%)	Paired *t*-tests
Panel b: Margins of master certificates and duplicates						
Margin	−5	3.37	3.55			
	−2	3.50	3.71			
	−1	3.54	3.63			
	0	3.45	3.67	3.29	2.92	2.99***
	1	3.46	3.62	3.23	3.16	4.27***
	2	3.40	3.30	3.17	2.84	4.34***
	5	3.34	3.34	3.15	2.73	3.60***
Margin w/o Credit risk adjustment	−5	0.26	0.65			
	−2	0.35	0.78			
	−1	0.40	0.69			
	0	0.44	0.84	0.39	1.00	2.08**
	1	0.29	0.65	0.33	0.69	−2.81***
	2	0.32	0.71	0.39	0.90	−4.61***
	5	0.23	0.83	0.36	0.88	−8.55***
CDS spread (1 yr, bp)		186.8	173.5	156.0	107.1	20.0***

Note: Descriptive statistics of margins are reported for master certificates, a control group, and duplicates. Issue time measures time relative to the issue date of the duplicates. ***, **, and * indicate that the difference between the margin of the master certificate less the margin of the control certificate or duplicate is significant at the 1%, 5%, and 10% levels, respectively.

and Baule (2011) reports margins of certificates with the DAX performance index as underlying between 0.34% (Citibank) and 1.06% (DZ Bank). In contrast, the margins reported herein are higher for at least three reasons. First, the life-cycle hypothesis (e.g., Stoimenov and Wilkens, 2005; Wilkens et al., 2003) helps explain the difference. Baule (2011) uses a sample with an average time to maturity of approximately 1.1 yrs, while the average time to maturity here is more than 1.46 yrs. Thus, the time to maturity in this sample is higher than that used in the literature. Second, margins of master and control certificates can hardly be compared with numbers reported in the literature, because these certificates are likely a particular selection of all certificates available in the market. Third, the sample spans a period in which issuers' credit risks increased and decreased substantially, which might have given issuers additional freedom in setting prices. With less informed retail investors that may not effectively address issuers' credit risk (Baule et al., 2008; Entrop et al., 2015), a high credit risk period might offer issuers the opportunity to create high margins. For example, issuers may have incentives to respond to increases in their own credit risk with a delay and thus keep prices constant, whereas theoretical values based on the model by Hull and White track changes in issuers' credit risk instantly.

5. Empirical analyses

5.1. Changes in margins at duplicate's issuance

To investigate how the issuance of the duplicates affects the margins of master certificates, I used the model given in Eq. (4) and added moneyness and remaining lifetime of the certificates as independent variables (e.g., Stoimenov and Wilkens, 2005). Moreover, I followed recent studies and considered moneyness squared as an additional independent variable (Baule and Blonski, 2015). My baseline difference-in-differences estimation equation now looks like:

$$\Delta\mathrm{Margin}_{i\tilde{t}} = \beta_1 \times POST_{i\tilde{t}} + \beta_3 \times POST_{i\tilde{t}} \times MASTER_i + \beta_4 \times MONEY_{i\tilde{t}} + \beta_5 \times MONEY\ SQ_{i\tilde{t}} + \beta_6 \times LIFE_{i\tilde{t}} + \varepsilon_{i\tilde{t}} \quad (6)$$

I specified that the disturbance term, $\varepsilon_{i\tilde{t}}$, contains a fixed effect for each certificate. This fixed effect is perfectly collinear with the dummy variable *MASTER*, which is therefore not included in Eq. (6). It is also perfectly collinear with dummy variables for issuers, round CAPs, years and months, and all other certificate-specific characteristics that are time constant. I clustered standard errors on certificates because conventional difference-in-differences estimations may underestimate the standard error of the treatment effect (Bertrand et al., 2004). Table 5 presents the results based on margins that are observed three days before and up to three days after the issuance of the duplicates.

I used variance inflation factors to check whether the independent variables are too highly correlated to be included jointly in the estimations. When I considered only moneyness and remaining lifetime as independent variables, all variance inflation factors were below 3. The linear and squared terms of moneyness are highly correlated and create high variance inflation factors. However, including them jointly does not change the results.

In Column 1 of Table 5, I used all master certificates, regardless of whether a control certificate could be matched, and all control certificates without considering additional independent variables, which are added in Column 2. The coefficient on the interaction term *POST* × *MASTER* measures how master certificates' margins change, relative to the control group, after the issuance of duplicates. I find that the coefficients on the interaction term are

Table 5
Masters' margins at duplicates' issuance.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
POST × *MASTER*	−0.003	−0.005						
	(0.004)	(0.005)						
POST × *MASTER* × CDS^{DIF+}			0.031***	0.019***	0.065***	0.052***	0.127***	0.044***
			(0.005)	(0.005)	(0.007)	(0.008)	(0.033)	(0.007)
POST × *MASTER* × CDS^{DIF-}			−0.023***	−0.020***	−0.016***	−0.011*	−0.008	−0.012*
			(0.005)	(0.005)	(0.006)	(0.006)	(0.019)	(0.007)
POST × *MASTER* × W/O			0.015**	0.012*	0.023**	0.017*	−0.088**	0.027***
			(0.006)	(0.007)	(0.01)	(0.01)	(0.035)	(0.01)
POST	−0.015***	−0.100***	−0.015***	−0.099***	−0.015***	−0.072***	0.064***	−0.092***
	(0.004)	(0.007)	(0.004)	(0.007)	(0.004)	(0.008)	(0.022)	(0.008)
MONEY		−1.494***		−1.472***		−1.691***	−8.110***	−1.006***
		(0.079)		(0.08)		(0.105)	(0.415)	(0.101)
MONEY SQ		0.464***		0.455***		0.600***	3.554***	0.303***
		(0.066)		(0.067)		(0.07)	(0.377)	(0.067)
LIFE		−5.937***		−5.882***		−4.013***	−0.367	−4.741***
		(0.339)		(0.34)		(0.415)	(1.098)	(0.447)
No of observations	39,330	39,330	39,330	39,330	25,440	25,440	3652	21,788
No of certificates	5622	5622	5622	5622	3636	3636	540	3128
... thereof master certificates	3804	3804	3804	3804	1818	1818	270	1564
F-test	38.4***	176.3***	36.7***	131.1***	30.8***	78.6***	85.5***	46.5***

Note: This table depicts results from difference-in-differences estimations on margins of master certificates around the day their competitors were issued. Columns 1–4 contain all master certificates regardless of whether a control certificate could be found. Columns 5–8 contain matched master and control certificates; that is, for each master certificate one control certificate is included that has a maximum absolute CAP difference of 100 index points and a maximum maturity difference of 50 trading days. Column 7 is based on the sample before Lehman collapsed, and Column 8 depicts a sample after the Lehman collapse. Standard errors clustered on certificates are in parentheses (Petersen, 2009). ***, **, and * indicate that the coefficient is significant at the 1%, 5%, and 10% levels, respectively.

negative but insignificant. In unreported regressions, I dropped all master certificates for which I could not find a control certificate and find similar results. Thus, the arrival of a competitor does not decrease margins of master certificates, on average, as H1 predicts.

To determine whether credit risk differences between the master and duplicate issuers matter, as H2a and H2b predict, I split the interaction term *POST* × *MASTER* into parts as in Eq. (5). I find that margins of master certificates increase when the master issuer has higher credit risk than the duplicate issuer while they decrease when the master issuer has lower credit risk than the duplicate issuer, regardless of whether all master certificates are included (Columns 3 and 4, Table 5) or only those with a matched control certificate (Columns 5 and 6, Table 5). The economic effect of *POST* × *MASTER* × CDS^{DIF+} is large because it accounts for 19.1% of the change in margins' standard deviation (Column 6, Table 5). Thus, the issuance of duplicates creates pricing effects that depend strongly on the credit risk difference between the issuers of master certificates and duplicates. This evidence is in line with H2b but contradicts H2a.

Because my sample contains master certificates that compete with duplicates offered by issuers without credit risk information, I consider a third interaction term, *POST* × *MASTER* × *W*/*O*. The issuers of duplicates without credit risk information are Vontobel Financial Products, DZ Bank, and Sal. Oppenheim. Thus, while master certificates issued by these issuers are not considered, the effects potentially created by their duplicates are taken into account. Missing credit risk information of the duplicate issuers comes with higher changes in margins of master certificates (Columns 3–6, Table 5).

Because the sample covers duplicates issued before and after the collapse of Lehman Brothers, I also run difference-in-differences estimations on two subsamples: One covers master certificates when the duplicates were issued before the collapse (Column 7, Table 5), and the other contains master certificates when duplicates were issued after the collapse (Column 8, Table 5). Again, I find that the pricing implications of duplicates' issuance depend on credit risk differences. Both subsamples give results that are broadly consistent with the findings from the full sample; one exception, however, is that changes in margins of master certificates for which the credit risk information of the duplicate issuer is missing decrease before the Lehman collapse, while they increase after it. It could be argued that before the Lehman collapse, retail investors did not pay much attention to issuers' credit risk, and therefore the arrival of duplicates from issuers without credit risk information created pressure on prices. However, many alternative arguments may explain this finding.

Before discussing the effects of other independent variables, I put forth tests to check whether retail investors' demand is driving the effects. Table 6 depicts the results of these tests. I first focused on all the master certificates that have not been traded in the last three months before the duplicates were issued. Because trading information starts in January 2008 only, master certificates issued before 2008 that received a duplicate in the first three months of 2008 are not considered. Accounting for non-traded master certificates and their respective control certificates reduces the number of certificates from 3636 to 2460 and does not deliver any new insights (Column 1, Table 6). Next, I also excluded control certificates from the sample (and their respective non-traded master certificates) when they were traded in the three months before the duplicates' issuance, because control certificates might be in a phase in which either issuers predominantly sell them to retail investors (positive effect on the changes in margins) or issuers predominantly buy them back (negative effect on the changes in margins). No new insights are gained (Column 2, Table 6). Finally, I restricted the focus to the pairs of master and control certificates that were both not traded in the six months before the date at which the duplicates were issued. Only 1700 master and control certificates are considered, which produce, however, the same results (Column 3, Table 6). These findings suggest that retail investors' demand is not the main driver of the pricing effects of competitors.

Excluding certificates traded on exchanges gives insight into whether retail investors' realized demand offers an alternative explanation, but it may indicate little about expected demand. Issuers will not bring products to the market when they expect no retail investors to be interested in them. Therefore, I focused next on another difference that is correlated with expected

Table 6
Masters' margins and demand.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
POST × *MASTER* × CDS^{DIF+}	0.050***	0.044***	0.036***	0.062***	0.021**	0.108***	0.036***
	(0.007)	(0.008)	(0.008)	(0.016)	(0.009)	(0.014)	(0.011)
POST × *MASTER* × CDS^{DIF-}	−0.029***	−0.037***	−0.038***	−0.038***	−0.034***	−0.071***	−0.061***
	(0.007)	(0.008)	(0.008)	(0.013)	(0.01)	(0.021)	(0.014)
POST × *MASTER* × W/O	0.052***	0.054***	0.050***	0.038*	0.055***	0.200***	0.145***
	(0.009)	(0.01)	(0.011)	(0.02)	(0.013)	(0.034)	(0.016)
POST	−0.090***	−0.076***	−0.052***	−0.133***	−0.003	−0.146***	0.014
	(0.008)	(0.009)	(0.009)	(0.015)	(0.01)	(0.023)	(0.015)
MONEY	−0.899***	−1.047***	−0.987***	−0.823***	−1.090***	−0.203	−0.306**
	(0.1)	(0.1)	(0.105)	(0.156)	(0.146)	(0.222)	(0.152)
MONEY SQ	0.358***	0.467***	0.443***	0.430***	0.445***	0.252**	0.188*
	(0.075)	(0.06)	(0.063)	(0.093)	(0.089)	(0.112)	(0.103)
LIFE	−4.145***	−3.624***	−2.568***	−6.318***	−0.325	−5.022***	2.780***
	(0.438)	(0.446)	(0.458)	(0.71)	(0.589)	(0.984)	(0.779)
No of observations	17,214	13,902	11,858	4510	7348	1764	4222
No of certificates	2460	1986	1700	646	1054	252	604
... thereof master certificates	1230	993	850	323	527	126	302
F-test	48.2***	48.7***	38.6***	23.4***	24.9***	27.5***	30.2***

Note: This table depicts results from difference-in-differences estimations on margins of master certificates around the day their competitors were issued. Column 1 considers only master certificates that were not traded in the three months before their competitors were issued. For each master certificate considered, the respective control certificates is also included. Column 2 includes master and control certificates when both were not traded in the three months before the issuance of the duplicate, while Columns 3–7 include master and control certificates when both were not traded in the six months before the issuance of the duplicate. Columns 4 and 6 include certificates with $Round^{200} = 0$ and $Round^{500} = 0$, and Columns 5 and 7 include certificates with either $Round^{200} = 1$ or $Round^{500} = 1$. In Columns 6 and 7, I consider only master certificates that were not traded before the issuance of their duplicates. Standard errors clustered on certificates are in parentheses (Petersen, 2009). ***, **, and * indicate that the coefficient is significant at the 1%, 5%, are 10% levels, respectively.

demand: I distinguished between whether or not the certificates' CAP is round. Using the restriction that both master and control certificates were not traded in the six months before the duplicates' issuance, I present results for certificates without round CAPs in Column 4 and for certificates with round CAPs in Column 5 of Table 6. Again, the pricing effects of the duplicates' issuance depend on the credit risk difference between the master and duplicate issuer. My final test considered only certificates that have never been traded before the issuance date of the duplicates. Columns 6 and 7 present the results for certificates without and with round CAPs, respectively. Previous findings are confirmed. In summary, demand seems not to be the main driver of the effects. However, because retail investors can also buy and sell products OTC, demand cannot fully be ruled out as an underlying rationale. Nevertheless, the evidence suggests particular pricing patterns, which are in line with the argument that retail investors fail to deal with issuers' credit risk appropriately. These pricing patterns may indicate that issuers try to exploit retail investors' limited capabilities of dealing with credit risk. How much they gain by doing so cannot, however, be determined with the data at hand.

The findings on the other independent variables are as follows: The coefficients on *POST*, which are expected to be negative because of the life-cycle hypothesis, indicate that margins of master certificates and their control group are significantly lower after the issuance of the duplicates than before, except in the pre-Lehman sample (Column 7, Table 5).[7] The economic effect of this decline depends on whether further independent variables are included and on the specification. Without further independent variables, the effect is moderate; it accounts for only 5.6% of the change in margins' standard deviation (Columns 1, 3, and 5, Table 5). With additional independent variables, the economic effect accounts for approximately 37% of the change in margins' standard deviation when all master certificates are considered (Columns 2 and 4, Table 5). Restricting the sample to master certificates with a matched control certificate gives an economic effect of 26.5% (Column 6, Table 5). Restricting the sample further to master certificates that have not been traded before the issuance of the duplicates increases the economic effect of *POST*: It accounts for more than 36% of the change in margins' standard deviation (Column 1, Table 6).

The changes in margins depend significantly on characteristics of the certificates. Unfortunately, the effects cannot be compared with findings in recent literature, because such literature has investigated margins and not the timely changes therein. I find that the change in margins in most specifications of Tables 5 and 6 decreases significantly with the remaining lifetime (*LIFE*) and the moneyness (*MONEY*). The economic effect of moneyness is negligible compared with that of the remaining lifetime. The latter effect is explained by the life-cycle hypothesis (e.g., Stoimenov and Wilkens, 2005; Wilkens et al., 2003), while the former might be explained by how issuers' price setting responds to retail investors' price sensitivity (Baule and Blonski, 2015).

I conducted three types of robustness tests.[8] The first type contains seven tests and deals broadly with sampling issues by mainly using the estimation given in Column 6 of Table 5. First, I performed placebo tests by switching the point in time at which the duplicates were issued by one quarter in the future or past. The coefficients on *POST* keep their signs and significances, while the coefficients on the interaction terms turn insignificant, as expected. Second, I changed the number of trading days considered in the estimations and used a window of either 15 days (7 days before/after the issuance date) or 21 days (10 days before/after the issuance date). Using a 21-day window, the competition effect of negative credit risk differences loses its significance, while the effect of a positive credit risk difference between the master and duplicate issuers keeps its sign and significance level. Third, the effects of the duplicates' issuance likely depend on whether a master certificate is duplicated for the first time or whether it has already received several duplicates in the past. Therefore, I split the sample in duplicates' issuances that are the first competitor for a master certificate and those that are

[7] This positive coefficient estimate should not be overemphasized, because when I used 10 trading days before and after the issuance of the duplicate, I found a significantly negative coefficient on *POST* for the pre-Lehman sample (results are not reported). This might indicate that the price adjustment was slower in 2008 than later in the sample period.

[8] Results of the first and second type of tests are not reported here but are available on request.

the second or higher competitor. A positive credit risk difference between the master and duplicate issuers comes with higher margin changes in both samples, while a negative credit risk difference creates lower margin changes only when a duplicate is the first competitor. Fourth, I alternatively used a sample with an absolute CAP difference of up to 200 index points and an absolute maturity difference of up to 100 trading days between the master and control certificates. This increases the number of master certificates with matched control certificates from 1818 to 2613. The results do not change; I only observe an overall increase in significance levels. Fifth, I used a subsample of certificates whose moneyness is within the range of ±0.15 and with a remaining lifetime of no more than 1.5 yrs to rule out that illiquidity of EUREX options from which implied volatilities are calculated are the driving factor. For this subsample, the pricing implications of duplicates' issuances are confirmed. Sixth, I used another subsample that includes master and control certificates when both have a remaining lifetime of longer than 2 yrs and when both were not traded in the three months before the duplicate's issuance, because recent literature finds that retail investors purchase mainly products with a moderate rather than a long time to maturity (Baule and Blonski, 2015; Entrop et al., 2015). This subsample, which reduces the chance that the pricing effects are driven by OTC transactions, confirms my results. Finally, for five issuers I have sufficient data to perform the estimation depicted in Column 5, Table 5, for each issuer separately. All of them increase the margins of master certificates when their CDS spread is higher than that of the duplicate issuer. For three issuers, which issued almost 70% of all master certificates, the effects are highly significant.

The second type of robustness tests deals with additional explanatory variables, which I added to the estimation given in Column 6 of Table 5. First, the effects of duplicates' issuance may depend on master issuers' market power. To measure market power, I counted how many outstanding certificates the issuer has when its master certificate receives a duplicate and tied this number to the overall number of outstanding certificates at this point in time. I used subsamples of certificates from master issuers with low and high market power and again find that master certificates' margins are increased when the master issuer has higher credit risk than the duplicate issuer. Second, I added issuers' CDS spreads and the comovement between the issuers' CDS spreads and the return of the underlying as independent variables.[9] My previous findings are confirmed. Third, I added a product competition measure (Baule, 2011; Entrop et al., 2015), $COMP_{it} = 1 - \frac{1}{1+n_{it}}$, where n_{it} denotes the number of certificates with which certificate i competes. I counted for each certificate i and time t the number of certificates supplied by another issuer whose CAPs differ from the one under focus by no more than 100 index points and whose reference dates differ from the one under focus by no more than 14 days, except if the CAP and reference date are identical. Positive credit risk differences still influence changes in margins significantly and positively, but negative credit risk differences no longer matter for changes in margins.

Although the first and second types of robustness tests confirm my previous findings, especially with respect to margin increases after the duplicates' issuance when the master issuer has higher credit risk than the duplicate issuer, they do not offer insights into whether this result is driven by the valuation model chosen. Thus, the findings presented so far might be the outcome of calculating margins by applying the model by Hull and White (1995) and not by the duplicates' issuance. Therefore, I used alternatively margins without credit risk adjustment in my third type of robustness tests. I present estimation results in Table 7 for various specifications that differ in terms of controlling for issuers' credit risk (Columns 1–4) and whether the master certificate was traded before the issuance of the duplicate (Columns 5–6). The coefficient on $POST \times MASTER$ remains insignificant, as previously, while the coefficient on $POST \times MASTER \times \mathrm{CDS}^{DIF+}$ is again positive and significant in all specifications. Thus, my main finding is again confirmed. In addition, the coefficient on $POST \times MASTER \times \mathrm{CDS}^{DIF-}$ is negative in most specifications, but lacks statistical significance. These tests reduce the likelihood that the outcomes are driven by the valuation model chosen to calculate margins. They support the reasoning that issuers of master certificates increase rather than decrease prices after the duplicates' issuances, when their credit risk is higher than that of the duplicate issuer, as H2b predicts.

5.2. When do competitors show up?

The causal interpretation of the findings from difference-in-differences estimations in the previous section is based on the assumption that issuers of master certificates do not initiate the issuance of duplicates. However, it could well be that issuers increased the margins of master certificates in the weeks before the duplicates were issued and this increase in margins attracted other issuers that might have interpreted it as a signal for high expected demand. I investigate whether increases in margins come with greater chances that a stand-alone certificate receives a duplicate. For each month, I created a variable, *PROB*, which equals 1 if a stand-alone certificate was duplicated in this month by another issuer and 0 if it was not duplicated. Thus, the data set is a panel of stand-alone certificates tracked over time. I used probit models to determine how changes in margins influence the duplication likelihood. I also varied the certificate's features, such as moneyness, remaining lifetime, and dummy variables capturing whether or not the certificate has a round CAP. In addition, I included for each issuer, except one, a dummy variable that equals 1 if the respective issuer has issued the certificate, in line with literature documenting pricing differences among issuers (Burth et al., 2001). Moreover, dummy variables for each year and month were employed. Table 8 presents the marginal effects.

The monthly change in the margins of stand-alone certificates has a significant and positive effect on their duplication probability (Column 1, Table 8). The marginal effect may indicate that when issuers increase prices for particular certificates, which lead to positive changes in margins, other issuers may be attracted to duplicate this particular certificate. Three reasons may counteract the premise that margin increases lead to higher duplication probabilities. First, the effect of the monthly change in margins on the duplication probability may be driven mainly by price increases on the issuance day of the duplicates. Thus, causality might go the other way around. Therefore, I employed the monthly change in margins based on prices observed five days before the monthly window for measuring *PROB* begins (Column 2, Table 8).[10] I still find that the monthly change in margins correlates positively and significantly with the probability that a stand-alone certificate receives a duplicate.

Second, both the duplication probability and the change in margins might be driven by an unobserved variable—namely, retail investors' demand. To glean insights into whether demand is a driver, I excluded all certificates that have been traded (and thus demanded) from the analysis (Column 3, Table 8). Importantly, a

[9] I calculated the correlation between the daily change in the issuers' CDS spread and the daily return of the DAX performance index for a window consisting of the 120 trading days before measuring the certificates' margins.

[10] Employing the monthly change in margins based on prices observed one day before the monthly window for measuring *PROB* begins, yielded similar results.

Table 7
Margins without credit risk adjustment.

	(1)	(2)	(3)	(4)	(5)	(6)
POST × *MASTER*	0.021					
	(0.073)					
POST × *MASTER* × CDS^{DIF+}		0.235**	0.235**	0.235**	0.322**	0.253*
		(0.108)	(0.108)	(0.108)	(0.132)	(0.147)
POST × *MASTER* × CDS^{DIF-}		−0.046	−0.046	−0.043	−0.05	0.007
		(0.089)	(0.089)	(0.088)	(0.121)	(0.137)
POST × *MASTER* × W/O		−0.209*	−0.208*	−0.216*	−0.270**	−0.263*
		(0.116)	(0.116)	(0.116)	(0.137)	(0.151)
POST	−0.229***	−0.222***	−0.223***	−0.223***	−0.340***	−0.420***
	(0.081)	(0.081)	(0.081)	(0.081)	(0.103)	(0.117)
MONEY	−0.508	−0.33	−0.438	−0.227	0.395	0.23
	(1.126)	(1.131)	(1.124)	(1.132)	(1.43)	(1.642)
MONEY SQ	0.994	0.872	0.948	0.904	1.484*	1.907**
	(0.674)	(0.677)	(0.673)	(0.678)	(0.796)	(0.888)
LIFE	−14.9***	−14.39***	−14.52***	−14.39***	−21.35***	−27.24***
	(4.294)	(4.308)	(4.316)	(4.311)	(5.422)	(6.161)
log(CDS spread)	−1.174***	−1.091***	−1.279***	−1.585***	−0.651	0.366
	(0.398)	(0.397)	(0.45)	(0.423)	(0.614)	(0.704)
CDS spread SQ			0.016			
			(0.014)			
ΔCDS				0.831***	0.386	1.004**
				(0.259)	(0.422)	(0.507)
No of observations	25440	25440	25440	25440	17214	13902
No of certificates	3636	3636	3636	3636	2460	1986
. . . thereof master certificates	1818	1818	1818	1818	1230	993
F-test	4.4***	4.8***	4.3***	5.8***	6.0***	6.1***

Note: This table depicts results from difference-in-differences estimations on margins of master certificates around the day their competitors were issued. Margins used are not adjusted for issuers' credit risk. Columns 1–4 contain matched master and control certificates; that is, for each master certificate, one control certificate that has a maximum absolute CAP difference of 100 index points and a maximum maturity-date difference of 50 trading days is included. Column 5 considers only master certificates that were not traded in the three months before their competitors were issued. For each master certificate considered, the respective control certificates is also included. Column 6 includes master and control certificates when both were not traded in the three months before the issuance of the duplicate. Standard errors clustered on certificates are in parentheses (Petersen, 2009). ***, **, and * indicate that the coefficient is significant at the 1%, 5%, and 10% levels, respectively.

certificate that was traded in one particular month is neither considered in this month, nor in all successive months of its lifetime. Therefore, certificates issued before 2008 are not considered, as I lack trading data before 2008. When I focus on non-traded certificates, I still find that the monthly change in the margins affects the duplication probability significantly positively. Thus, a reason other than investors' demand might be driving the findings.

Third, the change in margins considered so far contains two types of variations that have different meanings for issuers that duplicate a certificate from another issuer. Assume, for example, that the margin of a stand-alone certificate of issuer A increased. Issuer A may not have changed its price of the stand-alone certificate but may have experienced an increase in credit risk. According to Eq. (3), an increase in credit risk comes with higher margins of issuer A, all else being equal. This margin increase of the stand-alone certificate of issuer A cannot be exploited by issuer B, when its credit risk is lower than that of issuer A. Thus, issuer B does not have an incentive to duplicate this stand-alone certificate. Alternatively, issuer A may have increased its price of the stand-alone certificate without that its credit risk changed. Then, the margin increase might signal an increase in expected demand, which might offer issuer B a promising and exploitable duplication possibility.

Therefore, I decomposed the monthly change in the margins into the monthly change in the margins based on Black and Scholes's (1973) model, which does not include issuers' credit risk but certificates' prices, and the monthly change in issuers' CDS spreads.[11] The monthly change in the margins not adjusted for issuers' credit risk has no significant effect on the duplication probability (Column 4, Table 8). In unreported regressions, I confirmed that neither the signs nor the significances of the coefficients on the two variables change when I included them separately. This finding emphasizes that the issuance of duplicates is indeed not initiated by the prices that master issuers charge. Therefore, the findings from difference-in-differences estimations can be interpreted causally because price changes of stand-alone certificates do not attract other issuers.

An increase in issuers' CDS spreads increases the chances of receiving a duplicate. Thus, changes in the CDS spread of the stand-alone issuers correlate significantly with the issuance of duplicates by other issuers. Issuers with high credit risk seem to have an issuance strategy of structured financial products that differs from that of issuers with low credit risk. It could be that high numbers of structured financial products issued by some issuers increased these issuers' credit risk. It could also be that issuers with high credit risk introduced a high number of products to the market. In both cases, it holds that compared with issuers with a low number of outstanding products, issuers with a high number of products have higher chances that one of their products will be duplicated by other issuers.

The other independent variables yield the following results: stand-alone certificates with round CAPs have greater chances of being duplicated. The effect of the remaining lifetime on the probability of receiving a duplicate is negative. This negative effect is implausible because it implies that a certificate maturing in 1 month has a greater probability of being duplicated than a certificate maturing in 6 months. Therefore, a squared term of remaining lifetime (*LIFE SQ*) is introduced, because the duplication likelihood of a certificate that matures in 12 months or so is likely to be higher than that of both certificates maturing in 1 month and certificates maturing in 4 yrs. Because coefficient estimates of squared terms cannot be interpreted separately from their linear

[11] The monthly change in CDS spreads is defined as $\Delta\text{CDS spread}_{it} = \text{CDS spread}_{it}/\text{CDS spread}_{it-1} - 1$, where CDS spread_{it} is the issuer spread of certificate *i* at the beginning of month *t*. Using the monthly change in CDS spreads, based on values observed five days before the monthly window for measuring *PROB* began, yielded similar results.

Table 8
Probability of receiving a duplicate.

	(1)	(2)	(3)	(4)	(5)
ΔMARGIN	1.118***				
	(0.086)				
Δ^5MARGIN		1.211***	1.226***		
		(0.102)	(0.105)		
Δ^5MARGIN w/o credit risk adjustment				−0.002	0.000
				(0.018)	(0.013)
ΔCDS spread				0.021***	0.015***
				(0.001)	(0.001)
Round^{500}	0.004***	0.004***	0.004***	0.004***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Round^{200}	0.006***	0.006***	0.006***	0.006***	0.006***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
LIFE	−0.004***	−0.004***	−0.004***	−0.003***	
	(0.001)	(0.001)	(0.001)	(0.001)	
MONEY	−0.004***	−0.004***	−0.004***	−0.003***	
	(0.001)	(0.001)	(0.001)	(0.001)	
LIFE + LIFE SQ					0.005***
					(0.002)
MONEY + MONEY SQ					0.055***
					(0.003)
BNP Paribas	0.020***	0.019***	0.019***	0.023***	0.024***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Citibank	0.043***	0.042***	0.042***	0.042***	0.033***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)
Commerzbank	−0.016***	−0.015***	−0.015***	−0.015***	−0.011***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Deutsche Bank	0.001	0.001	0.001	0.002	0.005***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Dresdner Bank	−0.017***	−0.017***	−0.017***	−0.017***	−0.011***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Goldman Sachs	−0.026***	−0.026***	−0.027***	−0.025***	−0.018***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
HSBC Trinkaus & Burkhardt	0.085***	0.087***	0.092***	0.087***	0.060***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.006)
Société Générale	0.071***	0.067***	0.068***	0.069***	0.041***
	(0.011)	(0.011)	(0.011)	(0.01)	(0.007)
Royal Bank of Scotland	−0.003	−0.004	−0.003	−0.002	−0.005***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.001)
Months and year effects	Yes	Yes	Yes	Yes	Yes
No of observations	70683	70683	67547	67547	67547
No of certificates	8296	8296	8177	8177	8177
χ^2	3452.7***	3445.2***	3261.6***	3461.4***	3812.4***

Note: Marginal effects from probit models on the probability that a certificate that was stand-alone when issued is duplicated by another issuer are depicted. The dependent variable equals 1 when the certificate is duplicated in month t and 0 otherwise. In Column 5, I included linear and non-linear effects of *LIFE* and *MONEY*. Marginal effects evaluated at the sample means, or for the change in dummy variables from 0 to 1, are depicted. The marginal effects of the remaining lifetime and moneyness in Column 5 come from combining the linear and squared terms of the variables. Standard errors clustered on certificates are in parentheses (Petersen, 2009). ***, **, and * indicate that the marginal effect is significant at the 1%, 5%, and 10% levels, respectively.

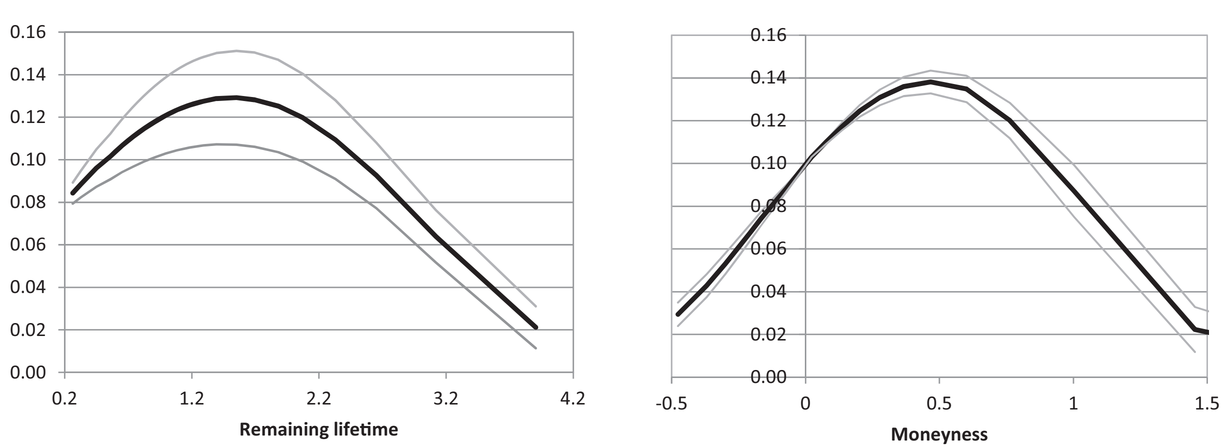

Fig. 2. The effects of remaining lifetime and moneyness on duplication probability. *Note:* These graphs depict the probability of a duplicate existing for various values of remaining lifetime and for various values of moneyness. Valuations are based on the estimation given in Column 5 of Table 8.

counterparts in models for binary dependent variables (Ai and Norton, 2003), Table 8, Column 5, presents the joint marginal effect of the linear and squared term of the remaining lifetime, which is significantly positive when evaluated at the mean of the remaining lifetime. To gain insights into the nonlinear relationship between the duplication probability and remaining lifetime, I evaluated the model for various values of the remaining lifetime, with all other variables set at their means, and depict the duplication probability in Fig. 2. For a remaining lifetime of approximately 1.5 yrs,[12] the duplication probability reaches a maximum. At this maximum, the marginal effect is insignificant, and the initially positive effect turns negative. In conclusion, certificates with both a short and a long remaining lifetime are less likely to be duplicated than certificates with a medium remaining lifetime. This nonlinear effect of the remaining lifetime explains the implausible negative effect of the remaining lifetime on the duplication probability documented in Table 8, Columns 1–4.

The marginal effect evaluated at the average moneyness is highly significant and positive. Fig. 2 depicts the duplication probability evaluated for different values of moneyness, which correspond to the values in the sample. The duplication probability reaches a maximum at a moneyness of approximately 0.45. Thus, certificates with high moneyness are especially likely to be duplicated, while certificates out of the money or deeper in the money are less likely to be duplicated. Including squared terms of remaining lifetime and moneyness as additional independent variables does not change the marginal effects of the monthly change in the issuers' credit risk and in margins not adjusted for issuers' credit risk on duplication probability.

I performed robustness tests of the estimation depicted in Column 5, Table 8. First, I checked whether the lagged level of the issuers' CDS spreads is also significantly positively related to the duplication probability. I find that this is the case. Thus, both the lagged level and the monthly change in CDS spreads are positively correlated with the duplication probability. Second, I checked whether the correlation between price and credit risk plays a role. I find that the level of this correlation is negatively correlated with the duplication probability, while the change in correlation is positively related. Third, I checked how the product competition measure is related to the duplication probability. I find that both the level and change in product competition come with higher duplication probabilities. This indicates that duplicates are surrounded by many other certificates that have similar CAPs and maturity dates. Fourth, I addressed the repeated observations of certificates over time by using a conditional logit specification (Andersen, 1970; Chamberlain, 1980), which provides a semiparametric estimation of a logit model without estimating the individual certificate fixed effects. The signs of the coefficients are similar to those presented in Column 5. Finally, for six issuers I have a sufficient number of observations to perform estimations for issuers separately. Five of the six issuers have a positive correlation between changes in their credit risk and the probability that one of their stand-alone certificates receives a duplicate. These robustness tests confirm that changes in credit risk, and not changes in prices, correlate with duplication probabilities. Thus, master issuers' price setting does not stimulate other issuers to bring duplicates to the market.

6. Conclusions

I argued that effects of competition in financial market segments for structured financial products may not be as clear-cut as they are in other financial market segments, especially when issuers' credit risk is high. To measure pricing effects when competitors arrive, I used the issuance of duplicates that have identical features to outstanding discount certificates. If retail investors know the value implications of issuers' credit risk, the issuance of a duplicate should reduce the price of the master certificate. However, if retail investors have difficulties determining how much issuers' credit risk influences the value of certificates, because they either lack the knowledge or suffer from behavioral biases, the outcome might be different. Instead of considering products' theoretical values, retail investors may only deduce that higher credit risk comes with lower prices. Then, an issuer with high credit risk has, under certain circumstances, leeway to increase rather than decrease the price of the master certificate that "must compete" with a duplicate from an issuer with low credit risk. Thus, I argued that pricing effects of the duplicates' issuance on the already existing master certificates depend on the credit risk difference between the issuers of the competing products.

Using difference-in-differences estimations on margins of master certificates, I found that the pricing implications of duplicates' issuance depend on the credit risk difference between the master and duplicate issuers: when the difference is positive, margins of master certificates increase; when it is negative, they decrease. These findings, especially the margin increase of master certificates when the credit risk difference is positive, are confirmed in several robustness tests: they hold for subsamples of certificates that differ in terms of retail investors' expected demand, such that demand seems not to be the driver behind this pricing pattern. They also hold for margins adjusted as well as not adjusted for issuers' credit risk, such that it seems unlikely that the valuation model used to calculate margins drives the pricing pattern. Finally, they hold for subsamples of certificates from issuers with high and low market power. These results suggest that in markets for structured financial products, competition effects are undermined because retail investors struggle with the implications of issuers' credit risk on the value of the products.

I also checked whether the event of duplicates' issuance is independent of the prices that master issuers charge for their products, which is required to interpret difference-in-differences estimations in a causal way. Anecdotal evidence from practitioners as well as statistical evidence corroborates this assumption. I determined which outstanding stand-alone certificates get duplicates and found that lagged changes in prices of stand-alone certificates do not correlate with duplication probabilities. Rather, changes in issuers' CDS spreads positively correlate with this probability. This may indicate that issuers with higher credit risk issued more certificates with longer times to maturity than other issuers, such that certificates from high-risk issuers have naturally greater chances of being duplicated. In summary, master issuers' pricing does not attract duplicates, a situation that allowed me to interpret the results of the difference-in-differences estimations in a causal way.

As with every empirical study, the analyses herein have several limitations. First, investigating factors that determine overpricing of structured financial products is always a joint hypothesis problem, because overpricing can only be determined by applying a valuation model that relies on particular assumptions. Although the conclusions are insensitive to whether margins with or without credit risk adjustment were used, some model risk remains. Second, input data used to calculate margins have limitations. Margins were calculated from quoted closing prices from Frankfurt. Because I could not identify whether the quoted price was a bid or ask price, the margin measurement might suffer from a bid–ask bias. However, such a bias is unlikely to affect the results, because much of the analyses is based on margins before retail investors begin trading certificates, which means that the analysis

[12] The mean remaining lifetime used in calculating the marginal effect in Column 5 of Table 7 is 1.39 yrs.

is built on settlement prices. It is not a severe concern that prices come from Frankfurt, as most certificates are listed on both exchanges (i.e., Frankfurt and Stuttgart). Finally, the results may be specific for the period under focus, which was characterized by high credit risk differences between master and duplicate issuers. Future research might investigate whether pricing effects of duplicates' issuance also exist with moderate credit risk differences.

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References

Ai, C., Norton, E.C., 2003. Interaction terms in logit and probit models. Economics Letters 80, 123–129.
Andersen, E.B., 1970. Asymptotic properties of conditional maximum-likelihood estimators. Journal of the Royal Statistical Society 32, 283–301.
Bartram, S.M., Fehle, F., 2007. Competition without fungibility: evidence from alternative market structures for derivatives. Journal of Banking & Finance 31 (3), 659–677.
Battalio, R., Hatch, B., Jennings, R., 2004. Does a national market system exist for US exchange-listed equity options? Journal of Finance 59, 933–962.
Baule, R., 2011. The order flow of discount certificates and issuer pricing behavior. Journal of Banking & Finance 35 (11), 3120–3133.
Baule, R., Blonski, P., 2015. The demand for warrants and issuer pricing strategies. Journal of Futures Markets 35 (12), 1195–1219.
Baule, R., Tallau, C., 2011. The pricing of path-dependent structured financial retail products: the case of bonus certificates. Journal of Derivatives 18 (4), 54–71.
Baule, R., Rühling, R., Scholz, H., 2004. Zur Preisstellung der Emittenten von Discountzertifikaten. FinanzBetrieb 12, 825–832.
Baule, R., Entrop, O., Wilkens, M., 2008. Credit risk and bank margins in structured financial products: evidence from the German secondary market for discount certificates. Journal of Futures Markets 28 (4), 376–397.
Benet, B.A., Giannetti, A., Pissaris, S., 2006. Gains from structured product markets: the case of reverse-exchangeable securities (RES). Journal of Banking & Finance 30 (1), 111–132.
Bertrand, M., Duflo, E., Mullainathan, S., 2004. How much should we trust differences-in-differences estimates? Quarterly Journal of Economics 119, 249–275.
Bessembinder, H., 2003. Quote-based competition and trade execution costs in NYSE-listed stocks. Journal of Financial Economics 70 (3), 385–422.
Black, F., Scholes, M., 1973. The pricing of options and corporate liabilities. Journal of Political Economy 81 (3), 637–654.
Börse Frankfurt, 2013. General terms and conditions of Börse Frankfurt Zertifikate AG for the trading with structured products in the regulated unofficial market on the Frankfurter Wertpapierbörse. <www.deutsche-boerse-cash-market.com/blob/1187654/61f54620fe6cab03a4d1f89139030cfd/data/General-Terms-Zertifikate.pdf>.
Breuer, W., Perst, A., 2007. Retail banking and behavioral financial engineering: the case of structured products. Journal of Banking & Finance 31, 827–844.
Brown, S.J., Warner, J.B., 1980. Measuring security price performance. Journal of Financial Economics 8, 205–258.
Burth, S., Kraus, T., Wohlwend, H., 2001. The pricing of structured products in the Swiss market. Journal of Derivatives 9, 30–40.
Chamberlain, G., 1980. Analysis of covariance with qualitative data. Review of Economic Studies 47, 225–238.
Chen, S.S., Ho, K.W., Ik, K.W., 2005. The wealth effect of new product introductions on industry rivals. Journal of Business 78 (3), 969–996.
Chevalier, J.A., 1995. Capital structure and product-market competition: empirical evidence from the supermarket industry. American Economic Review 85 (3), 415–435.
De Fontnouvelle, P., Fishe, R.P.H., Harris, J.H., 2003. The behavior of bid-ask spreads and volume in options markets during the competition for listings in 1999. Journal of Finance 58, 2437–2464.
Entrop, O., Scholz, H., Wilkens, M., 2009. The price-setting behavior of banks: an analysis of open-end leverage certificates on the German market. Journal of Banking & Finance 33 (5), 874–882.
Entrop, O., McKenzie, M.D., Wilkens, M., Winkler, C., 2014. The performance of individual investors in structured financial products. Review of Quantitative Finance and Accounting, forthcoming.
Entrop, O., Fischer, G., McKenzie, M., Wilkens, M., Winkler, C., 2015. How does pricing affect investors' product choice? Evidence from the market for discount certificates. Available at: <http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2417775>.
Erner, C., Wilkens, S., Röder, K., 2004. Die Kursstellung bei Aktienanleihen und Diskontzertifikaten. Zeitschrift für Bankrecht und Bankwirtschaft 16, 105–113.
Fischer, E., Keber, C., Schuster, M., 2001. Fallstudie aus Financial Engineering: Darstellung, Bewertung und Analyse des Raiffeisen Garantiezertifikates 2000–2004. Journal für Betriebswirtschaft 3, 106–118.
Gârleanu, N., Pedersen, L.H., Poteshman, A.M., 2009. Demand-based option pricing. Review of Financial Studies 22 (10), 4259–4299.
Grünbichler, A., Wohlwend, H., 2005. The valuation of structured products: empirical findings for the Swiss market. Financial Markets and Portfolio Management 19 (4), 361–380.
Heckman, J., Ichimura, H., Todd, P., 1997. Matching as an econometric evaluation estimator: evidence from evaluating a job training programme. Review of Economic Studies 64, 605–654.
Henderson, B.J., Pearson, N.D., 2011. The dark side of financial innovation: a case study of the pricing of a retail financial product. Journal of Financial Economics 100 (2), 227–247.
Hentschel, L., 2003. Errors in implied volatility estimation. Journal of Financial and Quantitative Analysis 38, 779–810.
Hull, J.C., White, A., 1995. The impact of default risk on the prices of options and other derivative securities. Journal of Banking & Finance 19, 299–322.
Jorgensen, P.L., Norholm, H., Skovmand, D., 2012. Overpricing and hidden costs of structured bonds for retail investors: evidence from the Danish market for principal protected notes. Available at <http://ssrn.com/abstract=1863854>.
MacKinlay, C., 1997. Event studies in economics and finance. Journal of Economic Literature 35, 13–39.
Mayhew, S., 2002. Competition, market structure, and bid-ask spreads in stock option markets. Journal of Finance 57, 931–958.
Meyer, B.D., 1995. Natural and quasi-experiments in economics. Journal of Business and Economic Statistics 13, 151–161.
Meyer, S., Schroff, S., Weinhardt, C., 2014. (Un)skilled leveraged trading of retail investors. Financial Markets and Portfolio Management 28 (2), 111–138.
Nelson, C., Siegel, A., 1987. Parsimonious modeling of yield curves. Journal of Business 60, 473–489.
Petersen, M., 2009. Estimating standard errors in finance panel data sets: comparing approaches. Review of Financial Studies 22 (1), 435–480.
Ruf, T., 2011. The dynamic of overpricing in structured products. SSRNe Library, retrieved 2013/03/13 from <http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1787216>.
Smith, J.A., Todd, P.E., 2005. Does matching overcome LaLonde's critique of nonexperimental estimators? Journal of Econometrics 125, 305–353.
Stoimenov, P.A., Wilkens, S., 2005. Are structured products 'fairly' priced? An analysis of the German market for equity-linked instruments. Journal of Banking & Finance 29 (12), 2971–2993.
Svensson, L.E.O., 1994. Estimating and interpreting forward interest rates: Sweden 1992–1994. Working Paper, International Monetary Fund.
Szymanowska, M., Horst, J.T., Veld, C., 2009. Reverse convertible bonds analyzed. Journal of Futures Markets 29 (10), 895–919.
Wallmeier, M., Diethelm, M., 2009. Market pricing of exotic structured products: the case of multi-asset barrier reverse convertibles in Switzerland. Journal of Derivatives 17, 59–72.
Wasserfallen, W., Schenk, C., 1996. Portfolio insurance for the small investor in Switzerland. Journal of Derivatives 3, 37–43.
Wilkens, S., Stoimenov, P.A., 2007. The pricing of leverage products: an empirical investigation of the German market for 'long' and 'short' stock index certificates. Journal of Banking & Finance 31 (3), 725–750.
Wilkens, S., Erner, C., Röder, K., 2003. The pricing of structured products in Germany. Journal of Derivatives 11, 55–69.