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Structured Certificates of Deposit: Introduction and Valuation*

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July 30, 2013

Abstract

This paper examines the properties and valuation of market-linked certificates of deposit (structured CDs). Structured CDs are similar to structured products – debt securities with payoffs linked to market indexes – but while structured products have garnered significant interest in both the financial media and in the academic literature, structured CDs have received relatively little attention. We review the market for structured CDs in the United States and provide valuations for several common product types. Using our methodology, we find significant mispricing of several common types of structured CDs across multiple issuers, which is similar in magnitude to the well-documented mispricing in the structured products market. In particular, we estimate that structured CDs are typically worth approximately 93% of the value of a contemporaneously issued fixed-rate CD. These results suggest that unsophisticated investors may not understand the value, risks, and subtleties of these ostensibly conservative investments.

1 Introduction

Structured certificates of deposit (structured CDs), also referred to as "market-linked CDs", "equity-linked CDs" and "contingent interest CDs," have existed since the late 1980s. Structured CDs are FDIC insured deposits with interest payments that are contingent upon changes in

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the levels of indexes, individual equities, and interest rates, or combinations of indexes, individual equities, and interest rates.

Investors in structured CDs have been described as 'risk-averse' and 'conservative,' but "dissatisfied with the rates available in the traditional fixed-income space."[1] A recent study conducted by the International Organization of Securities Commissions found that, at least in the UK, structured CD investors were typically over 55 or under 35 with high household income.[2] Market observers suggest that banks are issuing increasing quantities of structured CDs to compete with the low yield on traditional CDs and treasury securities. Because structured CDs are not securities registered with the SEC, the size of the structured CD market is not clear, but has been estimated to be in the tens of billons of dollars annually and growing.[3]

Structured CDs typically carry FDIC insurance, but are not risk-free. The SEC has outlined a variety of risks in structured CDs, including liquidity risk, market risk, call risk, as well as special tax considerations.[4] FINRA is reportedly investigating how structured CDs are sold to investors given their increasing complexity and market growth.[5] The FDIC has also issued a short investor alert on structured CDs,[6] and the NYSE has provided guidance to issuers regarding sales practices and disclosures.[7]

Structured CDs are similar to principal protected notes, a type of structured product that returns principal (the zero-coupon bond component) along with a potential upside (the derivative component) that depends on the value of a reference asset during the term of the note if the issuer is solvent at maturity. Like principal protected notes and other structured products, structured CDs' contingent interest payments can be replicated with a combination of option contracts. Unlike structured products, however, a stuctured CD's principal payment and "guaranteed interest payments" are FDIC insured and therefore not subject to credit risk.

There are remarkably few academic papers discussing structured CDs and the valuation of their embedded options remains largely unexplored. As with structured products, the customizability of structured CDs allows issuers to charge either additional gross margin into the product without explicitly stating their impact as commissions and fees. Fees on structured CDs are often between 3-4%, and we have observed all-in fees as high as 8%, but could effectively be higher due to mispricing of the embedded options.

The academic and practioner literature on structured CDs is sparse compared to the considerable body of theoretical and empirical work for structured products.[8] King and Remolona (1987)

[1] (Bloomberg Structured Notes Brief, b)

[2] "Regulation of Retail Structured Products," International Organization of Securities Commissions, April 2013.

[3] (Bloomberg Structured Notes Brief, a), (Bloomberg Structured Notes Brief, c), (Bloomberg Structured Notes Brief, d), (Bloomberg Structured Notes Brief, e).

[4] See `http://www.sec.gov/answers/equitylinkedcds.htm`

[5] (Robinson, 2012)

[6] See `http://www.fdic.gov/consumers/consumer/news/cnspr12/marketlinkedcds.html`

[7] NYSE Information Memos No. 06-12, March 17, 2006.

[8] See for example Henderson and Pearson (2010), Deng et al. (2010), Deng et al. (2011b), Deng et al. (2011a), and

showed that banks can typically hedge structured CDs efficiently using exchange-traded or synthetic options matching the payout of the structured CD.[9] Chance and Broughton (1988) provided additional analysis and interpretation of these products. More recently, Edwards and Swidler (2005) argue that equity-linked structured CDs do not have equity-like returns. Unfortunately, these studies analyzed only a few structured CD types and did not value a significant number of actual products.

We extend this literature by (1) describing the market for structured CDs using a sample of over 2,000 CDs; (2) providing valuations for four of the most common crediting formulas in our sample; and (3) valuing over 300 products issued by a variety of banks and document significant discounts to face value. Our findings suggest that structured CDs tend to be worth less than face value or contemporaneously issued traditional CDs, have a high probability of crediting the minimum return, and have death provisions that are often of negative value to the investor. These properties would not be apparent to retail investors.

2 The Market for Structured CDs

2.1 Our Sample of Structured CD Offering Documents

We have collected a sample of 2,072 structured CDs issued in the past eight years.[10] We searched for CDs issued in the US with more than $1,000,000 issued that reported an underlying security to Bloomberg. The latter requirement confines our sample to structured CDs linked to equities, commodities, and other tangible assets, and therefore excludes structured CDs linked to interest rates, such as steepener and range accrual CDs. While we collected products from as early as 2005, our sample is heavily concentrated in 2009-2013. Both the weighted average term – weighted by amount outstanding – and simple average for the structured CDs in our sample is 5.8 years.

Table 1 summarizes our sample by issuing bank.[11] While other banks' average issue size ranges from $1.3 million to $16 million, Bank of America has the largest average issue size ($81.6 million). Bank of America's large average issue size is due to several large deals including a billion dollar structured CD (CUSIP: 06051ACF7) issued in February 2008.

Deng et al. (2012).

[9] The authors advocate the use of the underlying asset and futures contracts to "dynamically hedge" the position due to high liquidity and low transaction costs.

[10] This sample was collected mainly from Bloomberg using the SRCH function, performed on March 13, 2013. The sample was augmented with additional structured CDs found from other publicly available sources.

[11] We include Wachovia structured CDs in the statistics of structured CDs issued by Wells Fargo.

Table 1: Structured CD Market Sample by Issuer

Issuer	Number	Total Face Value (MM)
HSBC	906	$5,827.6
JP Morgan Chase	499	$2,607.3
Bank of America	27	$2,202.1
Barclays	213	$1,444.6
SunTrust	134	$896.3
Wells Fargo	165	$615.6
Union Bank	23	$370.8
Citigroup	23	$283.5
BMO Harris Bank	30	$161.3
Other Issuers	52	$263.0
Total	2,072	$14,672.0

The great majority of the structured CDs in our sample are linked to baskets of commodities, equities, currencies, indexes or some combination thereof. Table 2 summarizes the major underlying assets within our sample. Two of the top underlying assets are JP Morgan proprietary indexes.[12] *All* of the structured CDs linked to these indexes were issued by JP Morgan. In fact, more than half of the JP Morgan structured CDs in our sample (by aggregate amount outstanding) were linked to a JP Morgan proprietary index. JP Morgan's use of its proprietary index in its CDs adds to the information advantage issuers have over investors.

[12] According to a July 2012 Strategy Guide, the JPMorgan ETF Efficiente 5 Index represents the returns to a basket of twelve exchange traded funds (ETFs) that are rebalanced each month to reflect the allocation that maximizes return for a given level of volatility based on the previous six months of historical data. According to a September 2009 Strategy Guide, the JPMorgan Optimax Market-Neutral Index represents the returns to a basket of 18 to 24 commodity indexes (sub-indecies of the S&P GSCI). The allocation to each commodity is selected by a proprietary algorithm that is "based on modern portfolio theory and momentum theory."

Table 2: Structured CD Market Sample by Underlying Asset

Underlying Asset	Number	Total Face Value (MM)
Baskets	1,293	$9,346.5
S&P 500 Index	210	$1,924.1
JP Morgan ETF Efficiente 5 Index	111	$942.8
Dow Jones Industrial Average	136	$913.3
JP Morgan Optimax Market-Neutral Index	34	$260.7
Dow Jones-UBS Commodity Index	26	$204.2
Russell 2000 Index	37	$135.6
Other Underlying Assets	225	$944.7
Total	2,072	$14,672.0

2.2 How Structured CDs are Marketed and Sold in the US

We have also collected a number of marketing brochures and other sales material related to structured CDs from a variety of issuers. In general, issuers claim that structured CDs combine the safety of CDs with additional market-linked upside. Wells Fargo, for example, claims that structured CDs "can provide a creative solution for investors looking to gain access to the markets while reducing their exposure to market risk when held to maturity."[13] Our results in Section 4 suggest that the potential market-related gains in structured CDs is minimal.

The offering documents for structured CDs and those for structured products are similar.[14] Both disclose the terms and relevant pricing parameters used in the offering, and tend to follow a similar format for each offering from a given issuer. Other marketing materials, such as sales brochures and lists of available products, are also similar to those that exist for structured products (and can often be found on the internet from brokerage firm websites). Structured CD materials, of course, tend to prominantly note FDIC insurance.

However, brokers who sell structured CDs, just like traditional CDs, do not have to be registered nor licensed by any state or federal agency, though many may be associated with banks or licensed broker-dealer institutions.[15] According to the NYSE Rules 401 ("Business Conduct") and 405 ("Diligence as to the accounts"), structured CDs should be "priced at market value on customer account statements, not at the purchase amount or at par unless that is the actual market price".[16] While structured products are now required to prominantly disclose a fair market value on offering

[13] Wells Fargo Securities, "Market Linked Certificates of Deposit.", accessed July 2, 2013.

[14] Structured product offering documents are publically available from the SEC's EDGAR database, filed as form 424B2.

[15] `http://www.investor.gov/investing-basics/investment-products/certificates-deposit-cds`

[16] NYSE Information Memos No. 06-12, March 17, 2006.

materials, there is no such disclosure requirement for structured CDs. As we will demonstrate below, the fair market value of structured CDs is often much less than face value, reflecting a premium to the issuer that is similar in magnitude to those seen in structured products.

In fact, not having to disclose fair market values might be a reason for banks to issue structured CDs over structured products or traditional CDs. FDIC insured banks are limited to offering CD rates that are no more than 75 basis points above the average of yields for CDs of comparable terms within their local market without a waiver from the FDIC.[17] FDIC insured banks and deposit brokers may issue structured CDs to circumvent this limit. For example, instead of issuing a traditional CD at a low fixed rate, a bank could market a structured CD with a higher comparable yield than the FDIC mandated cap. An investor may believe that this product offers higher yield than a traditional CD, even though its fair value might in fact be lower.

3 How to Determine Fair Value

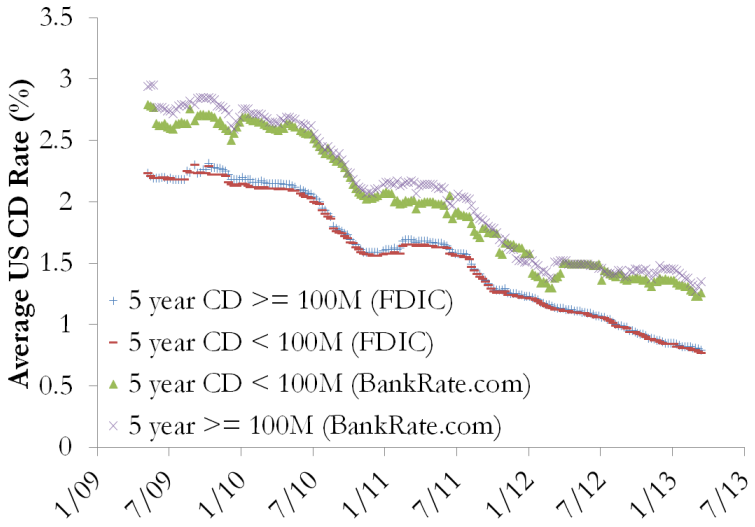
We present a Monte Carlo method for determining the fair value of some common structured CDs. We assume throughout that the underlying asset returns follow geometric Brownian motion (Black and Scholes, 1973; Merton, 1973), and simulate asset values with a Monte Carlo framework in accordance with procedures outlined in (Glasserman, 2003). The variance of that geometric Brownian motion is set to be the longest-term implied volatility of the underlying asset, available from Bloomberg. Investors in structured CDs are not paid distributions and the underlying returns reflect only capital appreciation.

We compare our structured CD values to the present value of contemporaneously issued traditional CDs of a similar maturity. Figure 1 graphs the simple average of traditional CD rates as reported by the FDIC between May 2009 and March 2013.[18] For our analysis, we used the 'non-jumbo' rates (for deposit amounts under $100,000) as these are most likely to be FDIC insured; however, the average difference between jumbo and non-jumbo rates over this period was only two basis points according to the FDIC data.

[17] FDIC Rules and Regulations §337.6

[18] http://www.fdic.gov/regulations/resources/rates/index.html

Figure 1: National Average Rates on Traditional Five Year CDs.



The secondary market rates for short-term CDs as quoted by the Federal Reserve Board are universally higher than those quoted for CDs in an initial offering by the FDIC, often by 50 basis points or more. We include the reported national average rates for five-year traditional CDs from BankRate.com in Figure 1 to show the magnitude of the discrepancy.[19] We use the rates reported by the FDIC as a conservative estimate for the relative value of a structured CD.

3.1 Credit Risk

Investors who purchase structured CDs bear credit risk. The FDIC made clear to investors in the spring of 2012 that its insurance covers only principal repayment at maturity and accrued interest, not any market-linked or contingent interest payments.[20] Therefore, as reflected in our valuation equation in section 4, structured CDs are subject to the credit risk of the issuer insofar as they are exposed to market fluctuations. As a result, a structured CD that is issued by a less credit-worthy bank is worth less than an identical structured CD issued by a more credit-worthy bank.

In addition, there are limits to the amount covered by FDIC insurance.[21] The limit can be

[19] The difference between the rates for jumbo and non-jumbo five year CDs is closer to 8 basis points according to BankRate.com data.

[20] "Market-Linked CDs: Don't Let the Possibility of Higher Returns Cloud Your View of the Potential Risks," FDIC Consumer News, Spring 2012.

[21] The maximum deposit insurance amount was increased from $100,000 to $250,000 by the *Emergency Economic Stabilization Act* of 2008; see Public Law 110–343 §136(a)(1). Subsequently, the *Helping Families Save Their Homes Act* of 2009 extended this increase through December 31, 2013; see Public Law 111—22 §204(a)(1)(A). In 2010, the *Wall Street Reform and Consumer Protection Act* made this increase permanant; see Public Law 111–203 §335(a).

made less restrictive by depositing funds at more than one FDIC insured institution, across several ownership categories or through joint ownership of deposited funds. Investors should also realize FDIC insurance does not protect against losses on early withdrawals, which usually come with heavy penalties or forfeiture provisions.[22] Any investment in a structured CD over the FDIC limit would further expose investors to credit risk.

3.2 Liquidity and Call Risk

There is no public sources for market prices of structured CDs nor any independent marketmakers for structured CDs. Secondary markets for structured CDs, like those for structured products, may be limited to the broker-dealers or banks who issued them, which may in turn limit the price at which an investor can sell his or her investment before maturity.[23] We have not included in our valuations any discount to reflect the illiquidity of structured CDs. Therefore our valuations are conservative.

Some structured CDs include a call feature whereby the issuer may redeem the structured CD at par at certain times before maturity. If a structured CD's underlying asset has increased in value and payment at maturity is likely large, an issuing bank could in theory call back the note at par, depriving the investor of the market-linked return despite having tied up his or her money in the structured CD. Call risk is therefore a potentially significant factor in structured CD valuation, though none of the products in our valuation sample are callable.

4 Valuing Four Common Structured CD Types

The following four subsections introduce common product structures found in our structured CD sample: contingent coupon, vanilla, ratchet, and average-value CDs. Contingent coupon CDs pay periodic coupons based on the return of an underlying asset. Vanilla CDs pay back principal at maturity plus an interest component that reflects the return of the underlying asset over the entire term of the CD. Ratchet CDs also payout only at maturity, but their interest component is based on returns calculated over several periods. The interest component of average value CDs is based on the average of the underlying asset level at several times prior to maturity. We present valuation methods for each type, along with example valuations. Unless otherwise stated, we report the simple average of the valuations for investors aged 25 to 85.

[22] "The FDIC has taken the position in the past that a potential decrease in principal caused by the imposition of an early withdrawal *penalty* does not prevent a product from qualifying as a 'deposit' for insurance purposes." FDIC Letter to Kevin P. Murray, February 27, 2002.

[23] Issuers have a disincentive to maintain such markets, as developed secondary markets may trigger more stringent regulatory requirements.

4.1 Contingent Coupon Certificates of Deposit

The most common type of structured CD in our sample is called a contingent coupon CD. Contingent coupon CDs are typically linked to baskets of assets and pay periodic interest payments contingent upon the return of the basket. Prior to each coupon payment date, the prices of the basket elements are observed. Returns are calculated, capped and floored to produce the component returns. If the weighted average of these component returns is larger than the minimum coupon (usually zero), then a market-contingent coupon payment is paid to the investor. Otherwise, the minimum coupon is paid to the investor, which could be zero.

Component returns for this type of CD are calculated in one of two ways: unbuffered or buffered. An unbuffered component return is a continuous function of the basket element's return. With a buffered component return CD, if the basket element's return is larger than the buffer level, then the investor is credited with the maximum return (the return cap).

The payoff of unbuffered structured CDs includes payoffs to vanilla European options and the payoff of buffered structured CDs includes payoffs to both vanilla and binary options. For the same level of cap and floor, a buffered CD would be worth more than an unbuffered CD (assuming the buffer is less than the cap). As a result, for a buffered CD and an unbuffered CD to be similarly profitable, either the return cap or return floor must be be lower on the unbuffered CD, all else equal.

For an example valuation, we take the contingent coupon CD issued by Barclays Bank Delaware on February 29, 2012, maturing on February 28, 2019. The CUSIP for this CD is 06740ARX9 and the aggregate issue size is $2,915,000. The CD was linked to an equally weighted basket of ten equities. Barclays paid coupons annually at a rate determined by a floor of -25%, a cap of between 6.5% and 9.5% and a buffer of 0%.

We assumed a cap of 8% when valuing this buffered contingent coupon CD and found that the CD was worth approximately $933.79 per $1,000 face value CD – approximately 91% of the value of a contemporaneously issued fixed-rate CD.[24] We found that in two thirds of the simulations, investors received only the minimum return.

As an example of an unbuffered contingent coupon CD, we use the JP Morgan CDs issued on February 29, 2012 with an aggregate face value of $4,241,000 (CUSIP: 48123Y6G6). The products included a return cap of at least 6% and paid coupons annually with a minimum coupon rate is 0.25% per annum. The return floor for this product is -30%. The CDs mature in seven years on February 28, 2019.

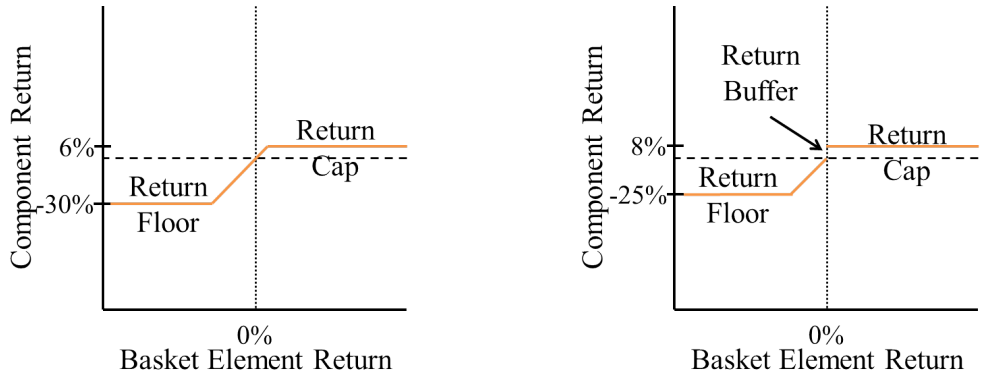
Assuming a 6% cap, we value the JP Morgan unbuffered contingent coupon CD at $933.88 per $1,000 face value CD – approximately 91% of the value of a contemporaneously issued fixed-rate CD. In this case, investors received the minimum return in approximately 80% of the simulations. The increase in this statistic relative to the buffered example can be traced to the fact that this

[24] We note that for some periods of time, CD rates were above treasury rates of the same term. Because we discount both structured and traditional CDs using treasury rates, the value of traditional CDs may exceed face value. On February 29, 2012, implied seven year CD rates were higher than seven year treasury rates.

CD includes a non-zero minimum coupon.

Figure 2 illustrates the component return results for a given basket element return as of each coupon date for both the unbuffered example and buffered examples discussed above above.

Figure 2: Example unbuffered contingent coupon CD with CUSIP 48123Y6G6 (a) and example buffered contingent coupon CDs with CUSIP 06740ARX9 (b)



(a) Unbuffered (b) Buffered

4.2 Ratchet Structured Certificates of Deposit

A second common type of structured CD is the "Ratchet CD," also known as a "cliquet CD". The issuer of a ratchet CD observes the underlying asset's price or level at several points during the term of the CD and calculates returns between each observation date. A local cap, and sometimes a local floor, is applied to each of the observed returns. At maturity, the observed returns are summed, and a global floor is then applied – usually a minimum return or 0% (corresponding to a return of principal). Products with a local cap but without a local floor are exposed to the risk that a large decline in the underlying asset during one period could wipe out many periods of capped positive returns.

This structure is similar to the "Simple Ratchet Equity Indexed Annuity" of Hardy (2003). Hsieh and Chiu (2007) show that for an initial investment P in an equity-indexed annuity (EIA) with guarantee ratio β, minimum guaranteed rate g and term T that the value (V_{EIA}) of the contract is given by

$$V_{EIA} = E^{(T)}\left[Pe^{-rT}\max\left(1+R, \beta(1+g)^T\right)\right] \tag{1}$$

where r is the (assumed) constant and continuously-compounded riskless rate and R is the arithmetic sum of returns given by

$$R = \sum_{i=1}^{nT} \min\left(\max\left(\alpha R_i, R_f\right), R_c\right). \tag{2}$$

Here n is the number of times per year that the underlying asset is observed, $R_i = S(t_i)/S(t_{i-1}) - 1$, R_f is the local return floor, R_c is the local return cap and α is the participation rate.[25] For structured CDs, principal protection sets $\beta = 1$ and typically there is no local floor ($f = -1$) or leverage ($\alpha = 1$). Closed-form solutions for this type of EIA, in the absence of the maturity guarantee, were derived by Hsieh and Chiu (2007).

Although this formula is general and fits nicely into our context, it does not appropriately apply credit risk or FDIC insurance. Including the CDS rate in the overall discount factor would be inappropriate given the guarantees provided by FDIC insurance ($\beta = 1$). We alter Equation 1 to include the credit risk related to components which are sensitive to market returns and obtain the value of the structured CD (V_{SCD})

$$\begin{aligned} V_{SCD} &= E^{(T)}\left[Pe^{-rT} + Pe^{-(r+c)T}\max\left(R, g^T\right)\right] \\ &= Pe^{-rT} + \underbrace{E^{(T)}\left[Pe^{-(r+c)T}\max\left(R, g^T\right)\right]}_{\text{Market/credit risk}} \end{aligned} \tag{3}$$

where c is the continuously-compounded CDS rate of the issuer.

An example of a ratchet CD is the Barclays "Certificates of Deposit Linked to the Performance of the S&P 500 Index due October 27, 2015" issued in October 2010 (CUSIP: 06740AMD8). At maturity, Barclays pays investors a return equal to the sum of the S&P 500 quarterly returns, each capped at between 3% and 5% – subject to a minimum return between 0.25% and 1.00% per annum. The product was priced on October 22, 2010 and will mature on October 27, 2015.

Although this Barclays structured CD has a local cap, it has no local floor. That means that a large negative quarterly return during the term of the note could wipe out the several accumulated capped returns. For example, if the S&P 500 increases at a rate of 10% per quarter for two years, then the CD would have accumulated 3% capped returns for eight quarters. If the S&P 500 subsequently decreases by 24% or more in the next quarter, the total of the capped quarterly returns for this nine quarter period would be zero or less – even though the S&P 500 would have increased over 60% during this period.

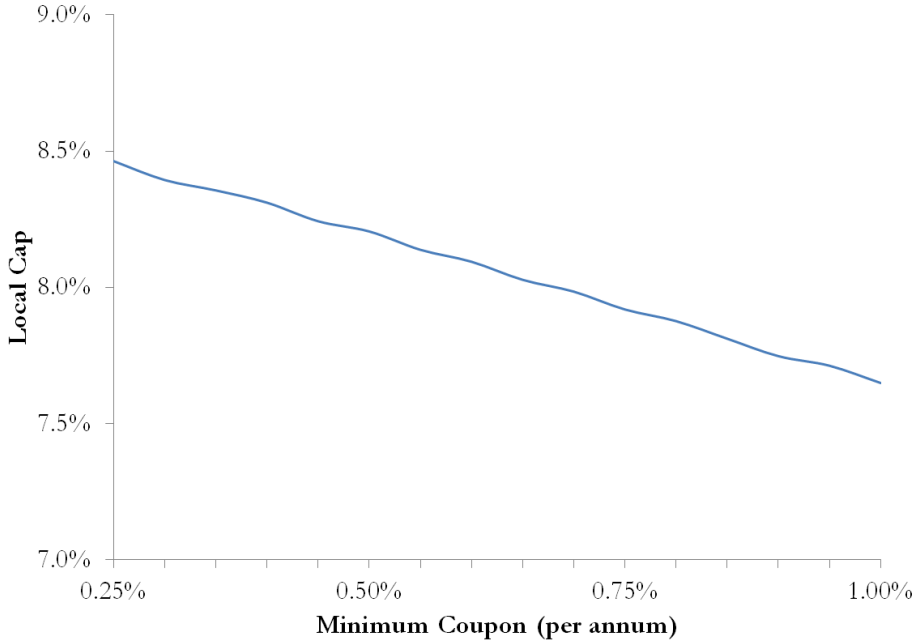
Using the volatilities and market rates as of the pricing date and the mid-point for the terms of the CD (4% local cap and 0.625% minimum return per annum), we obtain a valuation of \$976.46 per \$1,000 face-value CD. We find that there is approximately 97.2% chance of investors earning the minimum return and the average return above the minimum return is approxately 2% per annum. Using the contemporaneous national average rates on traditional CDs from the FDIC, extrapolated to the appropriate term for this CD (1.66%), we find that this CD is worth approximately 95% of a traditional fixed rate CD.

We varied the applied minimum coupon to the structure within the range specified in the preliminary offering document (between 0.25% and 1.00%). For each minimum coupon rate, we

[25] Equation 2 is a trivial generalization of the formula in Hsieh and Chiu (2007) to include more frequent observations.

determined the local cap that will result in an estimated value equal to the value of the structured CD assuming a 25 year old investor and plotted the results in Figure 3.

Figure 3: Contour plot for Barclays Ratchet Structured CD (CUSIP: 06740AMD8)



For this particular structured CD, we find that for each basis point increase in the minimum coupon, Barclays would likely require a basis point decrease in the local cap level to achieve the same level of profit.

4.3 Average Return (Asian) Certificates of Deposit

A third common type of structured CD in our sample resembles an average value option, also known as an Asian option. The issuer of an "average return" CD observes the underlying asset at several (n) points during the term of the CD and then calculates the average of those levels (L_i) to determine the underlying return. A floor (R_f), cap (R_c), and/or participation rate (α) may then be applied to the observed average return to yield the return at maturity

$$R = \min\left(\max\left(\frac{\alpha}{n}\sum_{i=1}^{n}\frac{L_i - L_0}{L_0}, R_f\right), R_c\right) \tag{4}$$

where L_0 is the initial level of the underlying asset.

As with the other types of structured CDs, we can write the value of the structured CD (V_{SCD}) as a component free of credit risk and a component exposed to market/credit risk

$$\begin{aligned} V_{SCD} &= E^{(T)}\left[Pe^{-rT} + Pe^{-(r+c)T}R\right] \\ &= Pe^{-rT} + \underbrace{E^{(T)}\left[Pe^{-(r+c)T}R\right]}_{\text{Market/credit risk}} \end{aligned} \tag{5}$$

where P is the face-value of the CD.

As an example, on December 23, 2010 SunTrust issued $13,235,000 worth of Index-Linked Certificates of Deposit linked to the Dow Jones Industrial Average (CUSIP: 86789VLY1) maturing on December 20, 2016. The returns were subject to a minimum return of 8% and a cap of 30%. While the structured CDs only pay out at maturity, SunTrust observes the Dow Jones Industrial Average quarterly and the resulting 24 observed levels are averaged. Based on our valuation methodology, we find that this CD was worth approximately $932.46 when it was issued in December 2010 – approximately 96% of the value of a contemporaneously issued fixed-rate CD.

Averaging periodic levels reduces the value of Asian options compared to traditional European options. The type of crediting formula used in the structured CDs we study here is known as an 'averaging-in' procedure, as it uses periodically observed levels, as opposed to an 'averaging-out' procedure which would average several observations made closer to maturity (Bouzoubaa and Osseiran, 2010). 'Averaging-in' includes levels observed throughout the term of the note, meaning that their average will incorporate returns with widely differing terms. If the expected return on the index is positive, than on average the 'averaging-in' procedure will reduce the value of the product relative to an 'averaging-out' style product, all else constant.

4.4 Vanilla Structured Certificates of Deposit

The simplest structured CDs do not pay coupons but pay a contingent return at maturity if the index increases during the term of the note.[26] The contingent payout can be modelled as payoffs to long-term call options on the linked asset. The return on these CDs is capped at a maximum return, which is equivalent to including the payoffs to a short out-of-the-money call option. The participation rate effectively changes the number of call options the investor is long and short.

Let the participation rate be given by α and the maximum (or capped) return be given by R_c and minimum (floored) return R_F. The value of the structured certificate of deposit (V_{SCD}) with face-value P and term T is given by

$$V_{SCD} = Pe^{-rT} + \underbrace{E^{(T)}\left[Pe^{-(r+c)T}\min(\max\left(\alpha R, R_F\right), R_c)\right]}_{\text{Risky Component}}. \tag{6}$$

[26] A CD of this type was described by Edwards and Swidler (2005).

In Equation 6, r is the risk-free rate and c is the CDS rate of the issuer. Since the market-contingent component is not paid until maturity and these CDs are typically long-dated, a significant liability could build up with respect to such a CD (especially if it is not callable).

Equation 6 can be written in terms of European call options. Let $C(K,T)$ represent the value of a European call option with strike price K, expiring at time T. The value of the structured CD is then given by

$$V_{SCD} = Pe^{-rT} + \underbrace{\frac{P}{S_0}e^{-cT}\alpha\left(C(S_0,T) - C(S_0(1+R_c/\alpha),T)\right) + PR_Fe^{-(r+c)T}}_{\text{Market/credit risk}}. \tag{7}$$

where S_0 is the initial price/level of the linked asset.

As an example, consider the Citibank, N.A. structured CD due January 29, 2016 linked to the S&P 500 (CUSIP: 172986BF7). The CD was priced on January 26, 2010 and issued on January 29, 2010. It pays no interest during the six-year term and, at maturity, pays the return of the S&P 500 subject to a maximum return of 41% (5.89% annual percentage yield) and a minimum return of 0%. The issue size was $1,952,000.

Citibank reported a comparable yield of 3.18% when the average rate for non-jumbo deposits at this time was 2.4% and for jumbo deposits was 2.44%.[27] The difference between the comparable yield on this CD and the average yield for fixed-rate deposits is close to the 75 basis point FDIC cap.

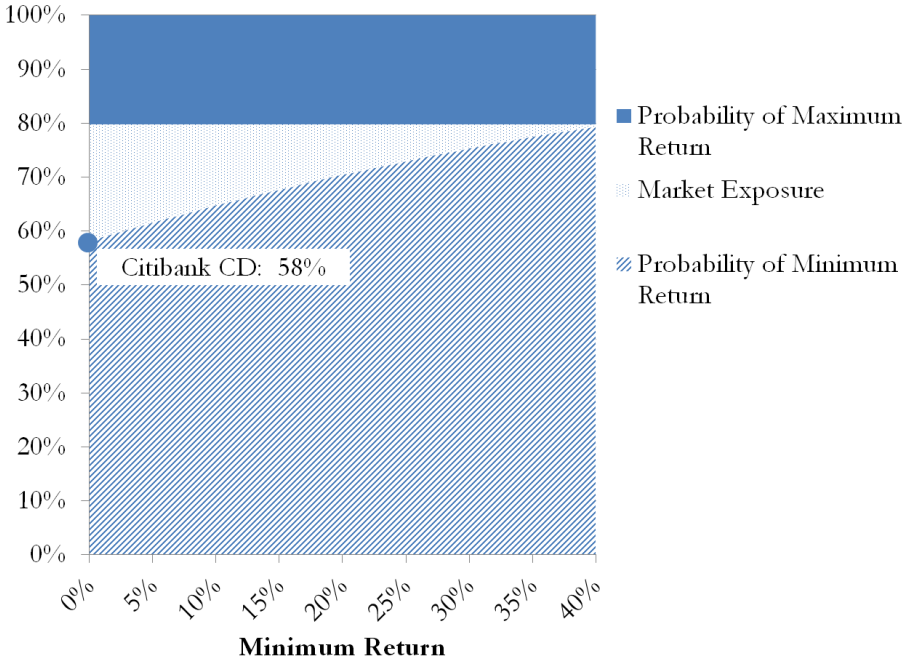
Using the terms of the contract and observable market variables, we obtain a valuation of $938.67 per $1,000 investment in the Citibank structured CD. We find that the structured CD was worth roughly 95% of the value of a contemporaneously issued traditional CD at the national average rate.[28]

We find that as of the issue date there was a 58% chance that the Citibank CD would return no additional payment beyond return of principal investment and a 20% chance that the maximum return would be paid to the investor. To provide intuition for the sensitivity of the structured CD's value to the issuer's discretionary parameters, we show in Figure 4 the likelihood that an investor would realize the maximum return and minimum return as a function of the minimum return.

[27] The FDIC currently reports rates on fixed-rate CDs out to a maturity of 60 months on a weekly basis. We are using the rates observed by the FDIC on January 25, 2010 and using linear extrapolation to determine the implied rate on a 72 month CD.

[28] http://www.fdic.gov/regulations/resources/rates/index.html

Figure 4: Probability of Realizing the Minimum Return and Maximum Return as a Function of the Return Floor (CUSIP: 172986BF7)



There is a very high probability of obtaining the minimum return when holding the CD to maturity. There is only a small probability of returns which would lead to direct market exposure (that is neither capped nor floored), even for a minimum return of zero.

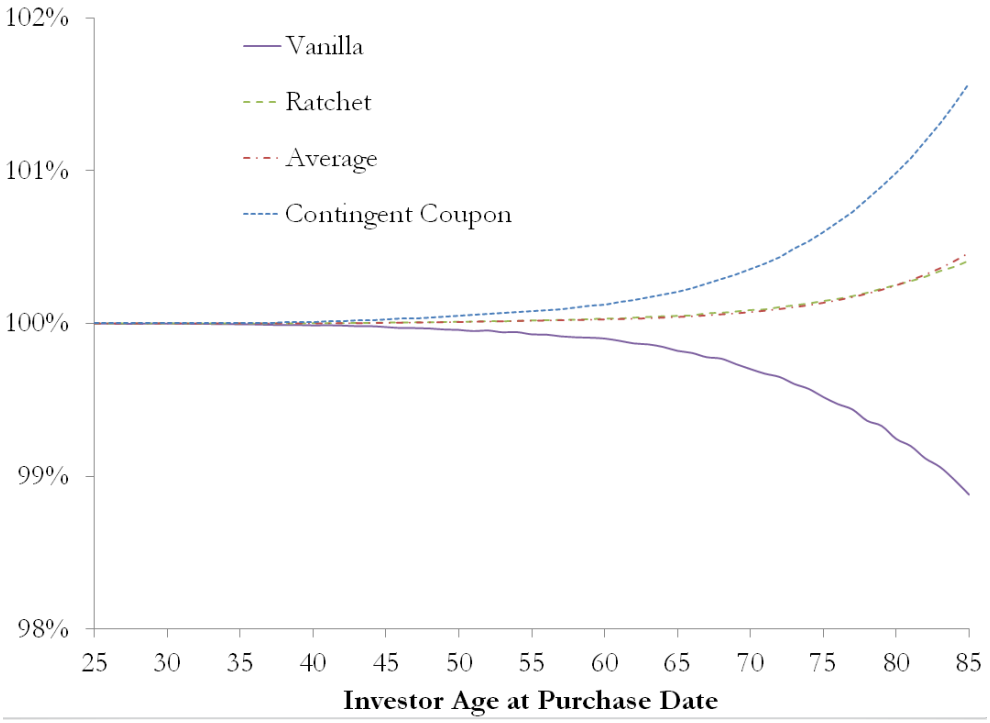
4.5 Mortality Risk and Structured CDs

Structured CDs, like traditional CDs, have defined payouts if the owner of the CD dies before maturity, which may differ from the current market value of the CD. The products in our sample simply pay the original principal amount to the investor's beneficiary,; essentially, the issuer has a binary put option to 'buy back' the CD at par upon the investor's death, known in the literature as the 'death put.' A return of principal years after the investor makes the CD will be worth less than the initial principal amount due to the time value of money. Therefore, the death put can be of negative value to the investor. However, the effect of the death put may differ between types of structured CDs.

We have modeled the death put for each of our product types using the unisex Annuity 2000 Mortality Table from the Transactions for Society of Actuaries. In our Monte Carlo simulations, for each year of the product's term we randomly select a number of simulated paths to credit with the death put based on the conditional death probabilities for an investor of an assumed age at

purchase. We then re-run our simulations for ages between 25 and 85. Figure 5 shows the average value of each of the four types of structured CDs described above for investors of varying ages.

Figure 5: Average Structured CD Value Normalized by the Average Value of the Structured CD to a 25 Year Old Investor



To clarify Figure 5, an average vanilla structured CD is worth approximately \$96.55 to a 25 year old investor. To an 85 year old investor, the average vanilla structured CD is worth approximately \$95.47 – approximately 110 basis points less. So the curve for the vanilla structured CD in Figure 5 slopes downward from the 100% value to the terminal value of 98.9%. Table 3 summarizes the average valuation (weighted by issue size), given an investor age, for each product type.

Table 3: Weighted Average Structured CD Valuation (Percentage of Face Value) by Investor Age.

	Investor Age			
Product Type	25	45	65	85
Contingent Coupon CD	92.93%	92.95%	93.12%	94.39%
Ratchet CD	96.16%	96.17%	96.21%	96.56%
Average CD	92.48%	92.48%	92.52%	92.91%
Vanilla CD	96.55%	96.53%	96.38%	95.47%

For the vanilla structured CDs, the value decreases as a function of age because the payout at death is worth less than the crediting procedure would otherwise return. However, for the ratchet, average and contingent coupon types, the value actually increases with age. Effectively, crediting formulas in these products reduce investors' value more strongly than the time value of money. Therefore, a return of principal before maturity would be a more favorable outcome from the investor's point of view. For all product types, however, the size of the effect is small.[29] Our results suggest that the death benefit is of little value to investors, and can be either positive or negative depending on product type.

4.6 Summary of Valuation Results

We have valued a total of 303 structured CDs with aggregate face value of $1.8 billion. This valuation sample accounts for roughly 15% of the structured CDs in our sample (12% by aggregate face value). Our results indicate that, on average, investors receive approximately 93.8 cents in value for each dollar invested in structured CDs.

Table 4 summarizes our valuation results across product types. The size of the valuation sample is limited both by quality of the data and the idiosyncrases of individual products. For example, many products reference proprietary indexes for which there is little or no market information, such as those noted above from JP Morgan.

[29] The value for a 25 year old investor is only 1.1% higher for the vanilla products, 0.4% lower for the ratchet products, 0.5% lower for the average products, and 1.5% lower for contingent coupon CDs when compared to the value for an 85 year old investor.

Table 4: Issue Date Weighted Average Fair Value by Product Type.

Product Type	Number	Aggregate Face Value (MM)	Average Initial Valuation	Percentage of Traditional CD
Contingent Coupon CD	230	$1,028.0	93.18%	92.44%
Ratchet CD	31	$308.2	96.23%	95.12%
Average CD	28	$338.2	92.54%	93.28%
Vanilla CD	14	$122.1	96.35%	97.03%
Total	303	$1,796.4	93.80%	93.37%

Table 4 also summarizes the structured CD valuation as a percentage of contemporaneously issued fixed-rate CDs. The rates assumed for fixed-rate CDs is the national average rate given by the FDIC for the week that the structured CDs were priced. In the event that the term of the structured CD did not match that of a traditional CD reported by the FDIC, linear interpolation was used to determine the implied CD rate. With the exception of the average CDs, the other structured CDs were priced at significant discounts to contemporaneously issued fixed-rate CDs according to our valuation results.[30]

Table 5 summarizes the valuation results for our sample of structured CDs broken down by issuing bank.[31] Average initial valuation is written as a percentage of face value. In the table, we also include the probability that an investor will realize the minimum return from investing in the products.[32]

[30] http://www.fdic.gov/regulations/resources/rates/index.html

[31] For some smaller banks (e.g. Union Bank), CDS data is unavailable as of this writing. To include the effects of credit risk for these banks, we averaged the CDS rates for all banks that issued structured CDs within our sample.

[32] For these calculations, we exclude investors who have died during the term of the notes to estimate the probability of obtaining the minimum return (since these investors do not hold the CDs to maturity).

Table 5: Issuer Structured CD Valuation Summary.

Issuer	Number	Aggregate Face Value (MM)	Initial Valuation	Probability of Minimum Return
Contingent Coupon CDs				
JP Morgan Chase Bank	194	$787.6	93.28%	69%
Barclays Bank Delaware	31	$175.3	94.10%	65%
Citibank	3	$42.2	90.77%	54%
HSBC	1	$21.5	86.86%	66%
American National Bank	1	$1.3	93.45%	66%
Total	230	$1,028.0	93.18%	68%
Ratchet CDs				
Barclays Bank Delaware	12	$64.7	94.43%	96%
SunTrust Bank	11	$114.9	97.33%	97%
Union Bank	5	$123.2	96.14%	95%
JP Morgan Chase Bank	3	$5.4	96.35%	98%
Total	31	$308.2	96.23%	96%
Average Return CDs				
SunTrust Bank	17	$230.6	93.03%	94%
JP Morgan Chase Bank	9	$26.6	89.81%	70%
Wells Fargo Bank	1	$73.2	92.83%	99%
Citibank	1	$7.8	84.81%	53%
Total	28	$338.2	92.54%	93%
Vanilla CDs				
JP Morgan Chase Bank	6	$54.9	95.48%	61%
SunTrust Bank	3	$25.6	98.65%	76%
Barclays Bank Delaware	2	$16.3	96.83%	62%
Citibank	2	$24.3	95.67%	60%
Wells Fargo Bank	1	$1.0	93.86%	98%
Total	14	$122.1	96.35%	64%

As discussed in the contingent coupon CD section, contingent coupon CDs can come in two varies: buffered and unbuffered. Table 6 decomposes the valuation results across these two types.

Table 6: Valuation results for our sample of contingent coupon structured CDs with and without buffers.

Return Type	Number	Aggregate Face Value (MM)	Initial Valuation	Probability of Minimum Return
Buffered	196	$805.1	93.02%	68%
Unbuffered	34	$222.9	93.78%	68%
Total	230	$1,028.0	93.18%	68%

Our analysis suggests that these two types of contingent coupon CDs are comparably priced and that issuers likely lower the return cap to compensate for the presence of a buffer in the buffered version of the CDs.

In sum, these results show that structured CDs are priced at significant discounts to face value. As noted in the structured products literature, the difference between the fair value and the issue price is effectively an undisclosed additional charge by the issuer. While the amount of this charge varies by product type, it is approximately as large as the discounts observed in the structured product market.[33] While structured CDs are often marketed as safe investments with additional market exposure, our results show that their unfavorable crediting formulas lead to both little market exposure and a high probability of below-market returns.

5 Discussion

In this paper, we review the market for and common features of structured CDs. We use a sample of products to provide aggregate data on this relatively obscure, yet very large financial market. We provide valuation procedures for several structured CD types included in our sample and value a variety of products based upon these procedures.

Our primary findings are that (1) structured CDs include payoffs to complex derivative positions; (2) structured CDs are worth significantly less than their issue price; (3) this mispricing is present across product types and issuers; (4) the crediting formulas in structured CDs have a high probability of crediting the minimum return; and (5) the death put can be of positive or negative value to the investor depending on product features and type. Each of these factors contribute to significant complexity in valuing these products. We find that most of the apparent benefits of structured CDs are illusory and overwhelmed by their inherent risks and embedded fees.

To our knowledge, our study is the first to examine the structured CDs market in detail, but is limited by the few publicly available sources for offering documents. In addition, there are a

[33] Bloomberg Structured Notes Brief (f)

significant number of products (even in our limited sample) that reference proprietary indexes for which there is little or no market data. This could represent an information asymmetry or conflict of interest between investors and issuers of these CDs. We have also noticed a variety of 'exotic' structured CDs that have extremely complex payout formulas and terms as long as 15 years. These may be fruitful topics for further research.

Because the structured CD market is entirely over-the-counter, customers may not be able to compare different offerings and make informed decisions about the relative value of a particular structured CD – even with information such as "comparable yields" or original issuer discounts. Structured CDs can be extremely complex investments and, in many ways, are just as complex as structured products, which are regulated much more stringently and do not enjoy taxpayer insurance. We think it worth careful consideration whether such products should be sold to retail investors, especially in an unregulated setting.

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