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"Engineering Lemons"

Doctoral Student Presentations

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Presenter: Petra Vokata, PhD student at Aalto University School of Business

Engineering Lemons*

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Abstract

Banks engineer and sell to U.S. households complex securities with attractive yields but *negative* returns. I document this in a sample of over 20,000 yield enhancement products (YEP), which became a $20 billion market after the post-crisis fall in interest rates. YEPs carry a significant downside risk and, according to regulators, are frequently missold to inexperienced investors. The products lose money both ex ante and ex post due to their largely hidden fees: on average, YEPs charge 7% in annual fees and subsequently lose 7% relative to risk-adjusted benchmarks. The fees remain large even after the SEC mandated disclosure of product values.

JEL Classification: G4, G13, G14, G18

Keywords: Financial engineering; yield enhancement; hidden prices; complexity.

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1 Introduction

Since the 2008 fall in interest rates to historic lows, banks have engineered and sold over $100 billion of yield enhancement products (YEP) to U.S. households. These products offer attractive yields—12% per annum on average—and represent the largest and fastest growing category of retail structured notes. YEPs package high-coupon bonds with short positions in put options and embed a fee that is largely undisclosed and cannot be estimated without applying option pricing techniques. For years, regulators have cautioned that the complex products may be hard for a retail investor to evaluate and that they could be misleadingly marketed as conservative fixed-income investments.[1] More recently, regulators have uncovered numerous cases of YEP misselling to thousands of inexperienced investors.[2]

Despite the growth in sales and regulatory concerns, the market for YEPs has received relatively little academic attention. In a seminal study, Henderson and Pearson (2011) document an average embedded margin of 8% in a sample of 64 YEPs, which implies that under plausible assumptions the expected return of the products is negative. Célérier and Vallée (2017) are among the first to study ex-post returns in a large sample of retail structured products and find a positive average return. Their setting, however, does not allow for a rigorous performance evaluation because the returns they use are not adjusted for risk, are restricted to the returns selectively reported by their data provider, and cover a broad mix of structured products issued in Europe, of which only some may be YEPs. Although it appears that issuers sell YEPs at a premium, which can be substantial in some cases, the fees and performance of the market for yield enhancement products as a whole have not been systematically studied. In light of the many cases of YEP misselling, it is important to know the extent of the losses incurred by investors and the ability of the market to drive out bad products. In this paper, I present evidence

[1] The Securities and Exchange Commission (SEC) identified unsuitable sales of reverse convertible notes (a class of yield enhancement products) as the most significant observation in their examination of eleven broker-dealers distributing structured securities (U.S. Securities and Exchange Commission, 2011). The Financial Industry Regulatory Authority (FINRA) and its predecessor, the National Association of Securities Dealers, have made similar arguments in their 2005 and 2010 regulatory notices, available at http://www.finra.org/sites/default/files/NoticeDocument/p014997.pdf and http://www.finra.org/sites/default/files/NoticeDocument/p120920.pdf.

[2] For example, in 2016 the SEC charged UBS Financial Services for unsuitable sales of $548 million of reverse convertibles to 8,700 inexperienced investors.

on these matters.

I use a novel database covering the U.S. market over the period 2006–15 to provide the first large-scale evidence of YEP performance. Using a sample of over 20,000 products, I find that the results of Henderson and Pearson (2011) are not confined to a few "bad apples": on average, investors pay 7% in annual fees and subsequently lose 7% per year relative to risk-adjusted benchmark returns. The average realized returns over the decade are negative and the losses are not restricted to the financial crisis of 2007–08. For instance, the bottom third of the products with the shortest maturity—and therefore with the shortest time to recoup their fees—earn negative average returns in eight out of the ten sample years. In fact, the YEP fees are large enough, and the product betas low enough, that even the expected returns of YEPs are negative.

To give a concrete example, consider the following product issued by J.P. Morgan. The product has a maturity of three months and offers a coupon of 14% per annum. Its payoff at maturity is linked to the stock of Ubiquiti Networks: the product repays the principal in full unless the stock price falls below 70% of its initial price at any time during the three months, in which case the payoff is decreased by the decline in the stock price at maturity. Assuming a 6% annual market risk premium and given the product's estimated beta (0.9 at issuance), the expected gross return of the product is less than 1.5% over its term. To assess its net expected return, one needs to estimate the product's fee—or the difference between its price and its fair value. I estimate that the fair market value of the product is 96%, implying that the net expected return is −2.5% and the embedded fee is over 15% per annum.

To help investors understand the embedded costs of YEPs, in 2012 the SEC asked issuers to disclose an estimate of the product's fair value. I examine the evolution of YEP fees around the disclosure change and find no significant decline. Even YEPs that disclose the estimated values embed fees large enough for the expected net returns to be negative. Likewise, the disclosure change is not associated with a significant drop in issuance volume. This suggests that the disclosure of product values has a limited impact on the market for YEPs.

An alternative way of evaluating YEPs as an investment—in contrast to estimating their fair values and fees—is to analyze their historical returns. But this is not an easy task either: neither the YEP returns nor their benchmark returns are easily available. There is a paucity of time-series data on YEP returns because the vast majority of the products are not listed on an exchange. One could estimate YEP returns at maturity using their payoff descriptions in prospectuses, but extracting the product terms is tedious due to their complexity and a variety of exotic options embedded in product payoffs. Even if one observes the realized returns of YEPs, it is far from trivial to evaluate their performance; one again needs option pricing techniques to derive benchmark returns for the nonlinear payoffs of YEPs.

Two features in my dataset and approach allow me to overcome these challenges. First, my data come from the most comprehensive data provider that records complete textual descriptions of the product payoffs in a semi-standardized format. Second, I develop a precise translation algorithm to convert these textual descriptions into mathematical formulas—these formulas can be evaluated to calculate the product realized returns as well as priced to estimate the product fair values. I then use the formulas to derive delta-equivalent benchmarks that dynamically hedge the product payoffs with daily adjusted positions in the underlying asset and risk-free rate. The translation algorithm is flexible enough to accommodate large heterogeneity in product payoffs and embedded exotic options as well as lexical variety of synonymous descriptions, and it covers over 85 percent of the market during the sample period. The algorithm is also highly accurate—I validate that in a sample of 12,898 products, 96 percent of the returns implied by the formulas are within one percentage point of the returns selectively reported by the data provider.

As another validity check, I compare my estimated fair values to the values disclosed by the issuers in a sample of 3,114 products. Even though the issuer estimates may rely on different valuation inputs and models, both their average and range are nearly identical to my estimates; a one basis point increase in the issuer's estimate is associated with a one basis point increase in my estimate. My sample's large size implies that idiosyncratic valuation errors are likely to cancel out. The comparison with the issuer estimates implies that any systematic errors are unlikely to be important. Moreover, I quantify the poor performance of YEPs both ex ante and ex post, and I show that their higher ex-ante fees predict lower ex-post abnormal returns. The estimated expected returns are also robust to a variety of assumptions on the expected return of the underlying.

Given the magnitude of YEP fees and their subsequent poor performance, it is natural to ask who invests in YEPs and why. YEPs are targeted at non-accredited retail investors.[3] Evidence from regulatory investigations shows that some investors do not understand the terms of the products (U.S. Securities and Exchange Commission, 2011) and that some broker-dealers are aggressively marketing the products to elderly, non-English speaking investors, and to investors with conservative investment objective, modest income or wealth, and little investing experience.[4] I find that conflicted payments—kickbacks and commissions to the brokers recommending the products—account for nearly half of all YEP fees. In a related study, Egan (2017) shows that brokers' incentives can explain the popularity of relatively inferior YEPs and that their buyers are not sophisticated enough to find "the best deal" in the market. These observations offer little support for the view that the investors are sophisticated enough to apply option pricing techniques to quantify the hidden fees of YEPs.

I argue that the most plausible interpretation of my results is that banks issue YEPs to cater to yield-seeking investors who do not understand their high fees and poor performance. An alternative explanation would be that investors understand the largely hidden costs of YEPs but invest in them for hedging or speculative purposes. While my setting does not allow me to rule out these explanations, it seems unlikely that sophisticated investors would prefer expensive YEPs over cheaper, more transparent, and more liquid exchange-traded options that offer similar exposure. For example, investors who are speculating on a relatively flat stock price may write plain vanilla put options and avoid the high costs of YEPs. It is hard to think of market expectations or hedging needs that would justify the high fees investors pay for the payoffs that YEPs offer.

To put my results into perspective, YEP fees are several times larger than fees charged by a typical mutual fund (Hortaçsu and Syverson, 2004) and about twice as large as fees charged by hedge funds, private equity funds, and venture capital funds

[3] SEC Commissioner Luis A. Aguilar estimates that 99% of investors in structured notes are retail investors (Aguilar, 2015).

[4] See SEC Risk Alert available at https://www.sec.gov/about/offices/ocie/risk-alert-bd-controls-structured-securities-products.pdf and FINRA disciplinary actions available at http://www.finra.org//industry/disciplinary-actions/finra-disciplinary-actions-online?search="reverse%20convertibles".

(Greenwood and Scharfstein, 2013). My findings echo the results of Greenwood and Scharfstein (2013) who show that investors switch to high-fee products as standard products became cheaper. However, even alternative high-fee investments seldom charge fees above their expected gross return. This is not surprising as, absent hedging motives, the expected gross return sets an upper bound on the fee financial intermediaries can reasonably charge; otherwise, investors would be better off keeping their money in mattresses. My results suggest that if the product fee is hidden, financial intermediaries may cross this upper bound and set the fee above the expected gross return.

My study adds to four strands of research. First, it contributes to the literature on retail structured products (Henderson and Pearson, 2011; Bergstresser, 2008; Henderson, Pearson, and Wang, 2018) and complex financial products (Carlin, 2009; Carlin, Kogan, and Lowery, 2013; Ghent, Torous, and Valkanov, 2017). My evidence is consistent with the catering incentives of issuing banks (Célérier and Vallée, 2017) and conflicting interests of distributing brokers (Egan, 2017), and it quantifies the transfers YEPs generate for both the issuers and the brokers.

Second, and more broadly, my results add to the literature on financial innovation and speak to the concerns about its negative social welfare implications (Lerner and Tufano, 2011; Allen, 2012; Johnson and Kwak, 2012; Gennaioli, Shleifer, and Vishny, 2012; Heidhues, Kőszegi, and Murooka, 2016) and limited ability of investors to learn about the risks of new products. Despite the significant losses caused by YEPs in 2008—23.6% on average over the term of a product—the market continued to grow through 2009 and 2010. These findings support the view that learning about new products by retail investors may be slow (Schoar, 2012).

Third, my work relates to the literature on the cost of financial intermediation and price dispersion (Philippon, 2015; Hortaçsu and Syverson, 2004). My work complements the literature documenting net-of-fee underperformance in retail financial markets (Gruber, 1996; Bergstresser, Chalmers, and Tufano, 2009; Foerster, Linnainmaa, Melzer, and Previtero, 2017) and relates to the literature on their hidden fees (Gabaix and Laibson, 2006; Anagol and Kim, 2012; Duarte and Hastings, 2012). The results on mandated value disclosure add to the literature on regulation of consumer financial products (Campbell, Jackson, Madrian, and Tufano, 2011; Beshears, Choi, Laibson, and Madrian, 2011; Agarwal, Chomsisengphet, Mahoney, and Stroebel, 2015; Campbell, 2016) and suggest that disclosure may not be enough to drive bad products out of the market.

Fourth, my paper relates to the growing literature on reaching for yield (Stein, 2013). Previous studies document reaching for yield among institutional investors (Hanson and Stein, 2015; Di Maggio and Kacperczyk, 2017) as well as in the preferences of individuals (Lian, Ma, and Wang, 2017). I focus on a sizeable market for innovative securities that appear to cater to these preferences and provide the first large-sample evidence that rather than enhancing returns to investors, the products depress the returns below zero.

The remainder of this paper is organized as follows. Section 2 describes the market for yield enhancement products. Section 3 introduces the data and translation algorithm. Section 4 describes the pricing model. Section 5 presents the results of the valuation and ex-post performance. In Section 6, I discuss the possible explanations for my results. Section 7 concludes.

2 Yield Enhancement Products

Yield enhancement products—also categorized as income products—represent the largest category in terms of the number of products of retail structured notes offered in the U.S.[5] Their issuance volume accounts for more than 40 percent of the volume of structured notes registered with the SEC. YEPs are issued by bank holding companies and distributed through affiliated broker-dealers as well as through unaffiliated broker-dealers, private banks, and registered investment advisers. Banks market the products under different names, such as reverse convertible notes, income securities, yield optimization notes, equity-linked securities, and reverse exchangeable securities. In recent years, autocallable securities—a class of YEPs that terminate early if the underlying rises above a predefined call price—have become more popular.

YEPs derive their return from the performance of the underlying asset or basket

[5]Other types of retail structured products include participation products and capital protected notes, studied, for example, by Calvet, Célérier, Sodini, and Vallée (2017). In the insurance market, structured equity-linked annuities represent more than one-third of insurers' liabilities (Koijen and Yogo, 2017). The term "structured (finance) products" is also used for structured finance vehicles that pool large numbers of economic assets and subsequently issue tranches against these collateral pools (Coval, Jurek, and Stafford, 2009). I use the term for securities that derive their payoff from a small number of underlying assets and a non-linear payoff formula.

of assets. The most common underlying is a single stock or an equity index. Their distinctive feature is the limited upside, determined by a fixed coupon rate. As the name suggests, this coupon rate—also called the headline rate—is higher than the prevailing interest rate. The higher yield is compensated by downside risk that is embedded in the product payoff through a short position in plain vanilla or exotic put options. These features result in concave payoff diagrams of the products, as shown in Figure 1.

Panel B shows a payoff diagram of the example product linked to Ubiquiti Networks. Its pricing supplement discloses fees and commissions charged by the underwriting broker-dealer of $17.50 per $1,000 issue price. On top of this explicit fee, the issuer of the product charges an implicit fee embedded in the product payoff. The payoff can be replicated with a three-month bond paying a monthly coupon of 14% per annum valued at $1,034 and a short position in a down-and-in put option valued at $73. Together, the replication price of the product amounts to $962, and the investor pays additional $21 in hidden fees.

Yield enhancement products have gained popularity in the U.S. only recently. Figure 2 plots their annual issuance volume which has grown from less than $5 billion in 2006 to around $20 billion from 2010 onwards, making it one of the largest markets for YEPs in the world.[6]

As the market grew, so did the attention of regulators who raised concerns about investors' poor understanding of the complex products and their hidden costs. Banks target the products mainly at retail investors (Aguilar, 2015) with a typical minimum investment of $1,000. Products sold to accredited investors—with income above $200,000 or net worth over $1 million—are exempt from the SEC registration and are beyond the scope of this paper. By FINRA rule 2111, broker-dealers can only sell products that are suitable for a customer based on the customer's investment profile. FINRA encourages broker-dealers to consider the recommendation of a YEP suitable only if they have a reasonable basis to believe that the investor is capable of evaluating its

[6]While the U.S. market for structured products is the most mature and complex (Qu, 2016), structured retail products are important globally. In Europe, the market is sizeable in Germany, Italy, and Switzerland. In Asia, the market is large and evolving in China, Hong Kong, South Korea, Japan, and Singapore. More recently, Chinese internet structured products (wealth management structured products provided by the internet companies) have become increasingly popular.

risks based on her knowledge and experience.[7] More strictly, the regulator considered limiting the suitability of YEPs to investors with pre-approved options trading, which could effectively limit the market only to institutional investors (Bethel and Ferrell, 2007). The internal suitability guidelines of certain broker-dealers expect investors to have at least two-year investment experience, $100,000 income, $100,000 in liquid assets, and $250,000 net worth.[8] Footnotes 2 and 4 suggest that the suitability requirements are frequently violated, echoing the general prevalence of suitability violations documented by Egan, Matvos, and Seru (2018).

Yield enhancement products are registered with the SEC under the Securities Act of 1933. Until 2012, the issuers' practice was to disclose only the underwriting discounts or commissions paid to brokers and not to disclose the embedded fees effectively charged by the issuer. In 2012, the SEC took a step towards better investor protection by asking issuers to prominently disclose their estimate of a product's fair value (U.S. Securities and Exchange Commission, 2012). A number of banks expressed reservations about the requested disclosure and argued that the valuation of products is subjective, presents a significant potential to mislead investors, and can lead to more confusion than clarity. Following discussions with the banks, the SEC issued the final instructions on value disclosure in early 2013, and the issuers began disclosing their estimates around the same time. Figure C.1 in the Appendix presents an example of a pricing supplement that includes the disclosed issuer estimated value.

The vast majority of the products are not listed on an exchange, are traded only over the counter, and are highly illiquid. In most cases, the only buyer of the notes before maturity is the issuing bank. The issuer, however, is not required to repurchase the notes nor to quote their daily prices. The notes constitute a senior unsecured debt of the issuer and are therefore subject to its credit risk. Their tax treatment is complex, often uncertain, and the products do not appear to offer any tax benefits.

[7] Financial regulators in other countries introduced stricter merit regulation of complex securities. Norway effectively banned sales of structured products to retail investors in 2008. Regulators in Belgium and Portugal have issued moratoriums on selling complex structured retail products.

[8] These criteria were described as "must" until 2009 and as "should" thereafter by RBC; http://www.finra.org/sites/default/files/fda_documents/2010022918701_FDA_JM992805.pdf.

3 Data

My data come from a commercial data provider that collects data on structured products issued all over the world. Following Célérier and Vallée (2017), I refer to it as "the platform." The platform is the most comprehensive source of data on retail structured products. At the time of data retrieval, it spanned over 50 countries, 16 years, and 11 million products.

In the U.S., the database covers 36,742 yield enhancement products issued between January 2006 and September 2015. Because of the availability of option data in OptionMetrics, I begin my sample construction with a list of 25,079 retail products with complete payoff description that are linked to a single stock or an equity index and mature before May 2016. The Data Appendix provides further details on the construction of this training sample. Since mine is the first study to use the U.S. database of the platform and the first one to use its payoff descriptions for a performance analysis, the Data Appendix also includes description of the data coverage and of the data quality checks I perform.

3.1 Payoff Translation

The key feature of the data is a complete and concise description of the product payoff—in the form of short semi-structured text—distilled from the long and complex disclosure in the prospectus. Table 1, Panel A, shows the description for the example product. The first sentence defines the underlying asset, followed by a description of the product cash flows before and at maturity. Célérier and Vallée (2017) use text analysis of these descriptions to measure the product headline rate and complexity. I develop a precise algorithm that translates the descriptions from text into mathematical formulas. The payoffs expressed in formulas can be evaluated to calculate the product payoff and fair value through decomposition into bonds and options.

The main challenge of the translation is the large variety of descriptions that reflect the heterogeneity in product payoffs and the semi-structured nature of the descriptions—the same product payoff can be described in multiple ways. To reduce the dimensionality of the translation, I first strip the numerical variables and the first sentence specifying the product underlying from the description. Next, because there are hundreds of distinct stripped descriptions, I focus on translating the most common product payoffs. I select the most frequent descriptions, screen for their synonymous descriptions, translate payoff conditions from English to the SQL language, and finally substitute back the numerical variables and compile the formulas. Panel B of Table 1 shows the formula for the example product.

I obtain underlying returns and valuation inputs from the Center for Research in Security Prices (CRSP) and OptionMetrics' IvyDB US database. To merge the data, I use the only identifier of the underlying asset available in the platform—the underlying name. For each name, I find the closest security name in OptionMetrics in terms of the Levenshtein distance and manually validate name pairs that are not perfect matches. I then merge CRSP with OptionMetrics using the CUSIP code.

The platform records the dates of initial and final valuation. I complement these dates with the dates on which the products can pay conditional coupons or terminate early (knock-out). I either extract these observation dates directly from the prospectuses or I extract the coupon and knock-out frequency from the payoff description and extrapolate the dates from the initial valuation date.

3.2 Descriptive Statistics

The translated sample covers 21,287 products ($34.4 billion)—more than 85 percent of the training sample. Table B.2 in the Appendix lists the top 15 issuers of YEPs in my sample. Many of the most frequent issuers are European banks, possibly because the market for structured products was historically larger in European countries. The three largest issuers—Barclays, Royal Bank of Canada, and UBS—account for 70% of the sample. Data on product distributors are not covered by the platform.

Table 2 presents summary statistics of the final sample. Panel A summarizes product characteristics. The average headline rate is 12%—order of magnitude higher than the prevailing interest rate. The overnight indexed swap (OIS) rate with matching maturity averages only 1.4%. The products have short maturities. Their average maximum term—if they do not terminate early—is nine months. Panel B reports the average underlying factor loadings from the single-factor and the Fama and French (2015) five-factor models and of the (high minus low) idiosyncratic volatility factor. The underlyings are typically highly volatile stocks selected systematically to support high headline rates and moderate downside protection.[9] Their average beta is over 1.5—a value common for the top beta decile of the U.S. stocks. On average, the underlyings have the highest loadings on the investment (CMA) and the idiosyncratic volatility (IVOL) factors suggesting that they comove with the stocks with aggressive investment and with high idiosyncratic volatility. In total, the sample covers 924 distinct underlying equities. Table B.3 in the Appendix lists the 40 most frequent ones.

4 Pricing Model

I now turn to an estimation of product fair values. I first decompose each product into a fixed income component and option components. In doing so, I follow the SEC fair value estimation instructions for product issuers.

The simplest products in my sample can be replicated with a bond and a plain vanilla European-style option. Table C.1 in the Appendix shows an example of such a product. The simple products are rare—only 34 products in the sample are plain vanilla. The majority of the products embed exotic options—knock-in barriers (like the example product in Table 1, $N = 13,755$) or binary options (see Table C.2 of the Appendix for an example, $N = 3,305$). I value these options using the Black-Scholes-Merton model and standard textbook formulas listed in Appendix A.

The remaining 4,193 products (autocallables) embed an early termination feature (knock-out) and may pay conditional coupons. See Table C.3 in the Appendix for an example product. The products typically terminate early if the price of the underlying is above its initial value on the observation date and pay a conditional coupon if the price is above a predefined barrier on the coupon payment date. To estimate the fair value of autocallables, I follow Deng, Mallett, and McCann (2011) and model the products as a series of options conditional on the product not being called on the previous observation dates, as described in Appendix A.

[9] See points (2) and (12) of the SEC order regarding UBS supervisory failure available at https://www.sec.gov/litigation/admin/2016/34-78958.pdf.

For all products, the estimated fair values are based on the assumption of flat volatility, which does not capture the volatility skew. The advantage of this simple approach over more advanced approaches, such as local stochastic volatility models, is the availability of closed-form valuation formulas and computational efficiency. In total, I estimate the fair value or product delta for nearly 3.5 million day-product combinations—orders of magnitude larger number than in previous studies. This makes alternative approaches, such as one-by-one product pricing using commercial pricing tools (as in Célérier and Vallée 2017), impractical. On the other hand, the advantage of having a large sample is that idiosyncratic errors in valuation tend to cancel out. In Section 5.4, I address the concern of potential systematic errors by comparing my estimates to the ones disclosed by the issuers.

4.1 Valuation Inputs

I obtain data on implied volatility from the option price file of OptionMetrics. For each option, I bi-linearly interpolate implied volatility from the four options with the closest expiry dates before and after the option expiry date and the closest strike prices above and below the option strike price. In cases where one or more of the four options are not available, I follow Henderson and Pearson (2011) and take the implied volatility of the option with the closest expiry date and the nearest strike price.

Consistent with Hull and White (2013), I use the OIS rate as a proxy for the risk-free rate. Specifically, I linearly interpolate the rate from the two rates with the nearest maturities. I obtain the OIS rates from Bloomberg.

To estimate the dividend yield of stocks, I follow the methodology of OptionMetrics. I consider the dividend yield to be constant and equal to the most recent dividend payment divided by the most recent closing price. Unless a dividend payment date is already declared, I project the ex-dividend dates by extrapolating from the past dates and the most recent dividend payment frequency. The predicted dates extend up to the maximum maturity of a product. Dividend yields for the underlying indices are from the index dividend table of OptionMetrics.

Table 2, Panel C, presents the summary statistics of the valuation inputs. The average implied volatility is above 40% and reflects the higher volatility of the underlyings in my sample. The average dividend yield is less than 1% and, therefore, any inaccuracies in projected ex-dividend dates are unlikely to be important. The table also presents the average delta of the options embedded in the product at issuance. All the products have a positive delta, implying that their returns covary positively with the returns of the underlying equities.

Because the products expose investors to the default risk of the issuer, their values should be adjusted for credit risk. A common proxy for the issuer credit risk is the CDS spread, which is not available for one-third of the products in my sample—mainly because the issuer does not have traded CDS contracts. For this reason, I estimate the value of the products without the credit value adjustment, but discuss how large is the impact of the adjustment for products with available CDS spread. I obtain CDS data from (in order of priority) CMA Datavision, Thomson Reuters, and Bloomberg by linearly interpolating from the two nearest maturities.

5 Results

In this section, I present the estimation results. I first discuss the estimated ex-ante measures—embedded margins, fees, and implied expected returns—and then turn to the ex-post evidence on YEP performance.

5.1 Margins and Embedded Fees

Table 3, Panel A, reports the estimated product margins at issuance. I define the margin as

$$margin = \frac{price - fair\ value}{price}. \tag{1}$$

The average margin before adjusting for the credit risk is 4%, that is a product sold for \$1,000 is on average worth only \$960. The disclosed commissions explain about 45 percent of the estimated margins. In a sample of 19,431 products for which the platform reports the commissions, the average commission is 1.79%. Less than 3% of the products have a negative estimated margin. This may be because the fair product values may be estimated with error, are not adjusted for the credit risk, and can be affected by market movements against the issuing bank during the offering period. Table C.4 in the Appendix lists the estimated margins for a sample of 100 products.

In the second and third columns, I estimate the margins only for the subsample of products with available CDS spread data. The difference between the unadjusted ($r = r_f$) and the credit-risk-adjusted ($r = r_f + CDS$) margins is on average only about 0.2 percentage points. Because the effect of credit value adjustment is small and the CDS data are not available for a significant fraction of the products, I focus on the unadjusted values in the rest of the paper. These fair values, therefore, represent lower bound estimates and the expected returns derived from them upper bound estimates.

In Panel B, I convert the margins into monthly embedded fees. For products with a fixed maturity, I calculate the fees as the margin divided by the term of the product. For products that can terminate early, I use the risk-neutral probabilities of early termination on observation dates (Equation 11 in the Appendix) and calculate their monthly fee as

$$fee = \sum_{m=1}^{M} q_{f,m} \frac{margin}{t_m}, \tag{2}$$

where $m = 1, ..., M$ denote the observation dates, $q_{f,m}$ is the risk-neutral probability of termination on date m, t_m is the time between the initial and the observation date in months, and $margin$ is the product margin at issuance. On (volume-weighted) average, investors pay 61 basis points in monthly fees. As a point of reference, YEPs are nearly four times as expensive as the typical mutual fund and nearly three times as expensive as the most expensive retail S&P 500 index fund reported in Hortaçsu and Syverson (2004).

5.2 Expected Returns

I now test how the fees reported in the previous section affect the net-of-fee expected returns of YEPs and show that under various measures of the expected return on the underlying, the majority of the products in my sample have a negative expected return. To this end, I extend the pricing model described in Section 4 and calculate the expected undiscounted product payoffs under the objective ("real-world") expected return on the underlying, μ. I substitute the risk-neutral process for the stock with:

$$dS = (\mu - q)Sdt + \sigma Sdz, \tag{3}$$

where S denotes the underlying price, q the dividend yield provided by the underlying, and σ the volatility of the underlying.

The estimated product payoff expressed as a percentage of the issue price equals to the product expected return net of fees. In my preferred specification, I estimate the expected return on the underlying asset using the CAPM β estimated over the past 60 months and a 6% p.a. market risk premium. The first column of Table 4 reports the results and shows that the sample average, the volume-weighted average, as well as the median, are negative, ranging from a return of -0.5% to -1.5% over the term of a product (holding period). The estimated returns are higher with the market premium equal to 8% p.a. (second column) or to the value-weighted CRSP average (third column), but even in these specifications the median expected return is negative and the average is not significantly different from zero.

In the previous analysis, I assume that the market risk premium is constant or equal to the historical average. Martin (2017) shows that his measure of expected market return (SVIX) derived from option prices implies a large time-series variation in expected market return, which exceeds 20% in the peak months of 2008. I estimate product expected returns using SVIX for a sample of products issued before February 2012 (due to data availability). Column 4 confirms that the average expected return is negative even under SVIX. The individual averages of expected returns in the ten years of my sample estimated with a 6% p.a. market risk premium are negative as well. My results are, therefore, not driven by the unusual market conditions in the fall of 2008.

In the last column of Table 4, I use the Fama and French (2015) five-factor model instead of the single-factor model. A large empirical literature dating back to Black (1972) documents underperformance of high-beta stocks relative to the CAPM predictions. Given that high-beta stocks are overrepresented in the sample of underlying equities, the single-factor model likely overestimates the expected returns of the underlying stocks. This is consistent with the expected returns estimated using the five-factor model, which are significantly lower than in the previous specifications. The volume-weighted average expected return in this specification is −1.73% over the holding period, and for three-quarters of YEPs, I estimate a negative expected return.

In Panel B of Table 4, I report the estimated expected returns on a monthly basis compounded using the expected term of a product under the risk-neutral measure. Both the holding period and monthly returns illustrate economically important dispersion in expected product returns. Moving from the 25$^{\text{th}}$ percentile to the 75$^{\text{th}}$ percentile of the expected monthly return distribution corresponds to an increase of 60 basis points in monthly expected returns. In the next section, I analyze the determinants of the variation in expected returns and their relationship with product expected term.

5.3 Determinants of Expected Returns and Fees

I first explore the relationship between product margin and expected term. If margins scale linearly with product expected terms, embedded monthly fees do not vary across expected terms. On the other hand, if margins include a fixed component, monthly fees are negatively related to expected terms. This is what Table 5 shows. In Panel A, I report the average margins for product portfolios sorted by the expected term. While the margins increase with product expected term, they scale less than proportionally and include a fixed component. Consequently, the monthly embedded fees, reported in Panel B, are the highest for the products with the shortest expected term of up to four months—on average 1.1% per month. These products are nearly three times as expensive as the products with an expected term of over eight months.

Regressions of margins and fees on product characteristics reported in Panel C show the same pattern. In the first column, I estimate a fixed component of the margin of 2.9%. Both the margins and monthly fees decrease with the product volume and increase with the headline rate (column 2 and 4). As a consequence, the net-of-fees monthly expected returns (column 6) increase with the product term and volume, and decrease with the headline rate. Columns 3, 5, and 7 show that these relationships are robust to the inclusion of the squared expected term and show that the relationship between margins or monthly expected returns (monthly fees) and expected term is concave (convex).

The fees I estimate are in line with the YEP margins documented by Henderson and Pearson (2011) and Egan (2017) in the U.S. market. My estimates are, however, higher than those documented for structured products issued in Europe (Célérier and Vallée, 2017; Baule, 2011; Szymanowska, Horst, and Veld, 2009; Burth, Kraus, and Wohlwend, 2003). The negative relationship between expected term and fees may be one reason why the results differ. For example, the 141 products valued by Célérier and Vallée (2017) have an average maturity of over four years. Moreover, products issued in Europe are more likely to be listed on exchanges, sold through different distribution channels, and the European markets tend to have a larger number of competing product providers, which may explain their lower fees. For another comparison, in the next section I relate my estimates to the product value estimates disclosed by the issuers.

5.4 Comparison of Model Estimates with Issuer Estimates

The product value estimates disclosed by the issuers provide an opportunity to test the robustness of my estimates to alternative valuation models. Issuers began disclosing their estimated values of products following the SEC requirement in 2013. I observe the disclosed estimates for 3,114 products in my sample.

Table 6, Panel A, shows that my estimates are very similar to the issuer estimates on average. The volume-weighted averages of both estimates are nearly identical and equal to 97.13–97.15% of the issue price. In addition, both estimates show similar value ranges between 88–101%. The estimates disclosed by the issuers, however, display lower standard deviation, possibly due to a smaller modelling error. Panel B reports the results from a regression of the model estimates on issuer disclosed estimates. The intercept is not statistically different from zero, and the slope coefficient is not statistically different from 1. The model's R^2 implies that the correlation between the two estimates is more than 0.4.

There are two important differences between the issuers' estimates and mine. First, the model fair value estimates ignore the default risk of the issuer and, therefore, represent an upper bound of the fair value. Second, issuers use their internal funding rate which is typically lower than their secondary market credit spread to estimate the values and therefore overestimate the fair value as well (Hull and White, 2014). The results in Table 6 suggest that the bias introduced by the issuers when using their funding rate may be of a similar magnitude as the credit value adjustment ignored by my model.

Together with the fact that my estimates are conservative because they are not adjusted for the credit risk, the results of this robustness exercise suggest that any valuation errors in my estimates are unlikely to be important.

5.5 Fees and Expected Returns After Mandatory Value Disclosure

The motivation behind the mandated value disclosure was to give investors a chance to understand the undisclosed costs of YEPs. To the extent that the disclosure successfully unshrouds the hidden costs of YEPs to uninformed investors, it could drive expensive products out of the market; it could cause a decline in embedded fees or issuance volume.

To test this conjecture, I examine the evolution of the YEP fees, expected returns, and product characteristics between 2007 and 2014 in Figure 3. Because the mandatory value disclosure was gradually implemented in 2013 with no exact date marking the change, I compare the market between 2014 and 2011—the year before the SEC announced the intended change. The average monthly fees have declined from 0.89% to 0.65% between the years 2011 and 2014, which led to an increase in the expected returns from -0.5% to -0.2% relying on the single-factor model and a 6% market risk premium. Neither of the differences, however, is statistically significant at the 5% level. In addition, the decrease in fees may be a result of the decline in implied volatility presented in Panel E. Both the average monthly VIX index and the average implied volatility of product options declined between 2011–14 which, all else equal, leads to lower embedded fees. Figure 2 shows that there was no significant drop in issuance volume around the disclosure change either.

While my setting does not allow for a causal interpretation, it allows me to conclude that the unshrouding policy was not associated with a statistically significant decline in fees and it did not eliminate the issuance of products with negative expected returns.

5.6 Ex-Post Returns

The evidence presented so far focuses on ex-ante costs and returns. In the rest of this section, I analyze YEP performance ex post.

Due to the paucity of secondary market trading of YEPs, there is lack of time-series data on their returns. For this reason, I focus on their returns at maturity. While the platform records realized returns provided by the issuers or calculated by the platform analysts, its coverage is only about 60 percent of my sample. To get a comprehensive record of YEP performance, I calculate their returns using the translated payoff formulas combined with the ex-post prices of the underlying assets.[10]

To calculate the product realized return, which represents the net-of-fee return, I sum the payoff at maturity and the coupons reinvested until maturity at the risk-free rate and divide the sum by the issue price.[11] This approach does not take into account the possibility of issuer default, which is rare but applied, e.g., to the products issued by Lehman Brothers. On top of the holding period return, I also calculate the monthly return using the effective term of a product.

The first column of Table 7 presents the results. Over the sample period, investors in YEPs lost money on average. The volume-weighted average return is -4.55% over the holding period, or -0.72% monthly. Over a quarter of the products paid back less than the invested capital. The return averages for portfolios of products issued in a given year show that YEPs comove with the broad market index. Products issued in the years 2007 and 2008 earn the lowest average returns. Negative returns, however, are not confined to the crash period. Investors lost money on average even in the years 2011, 2014, and 2015, when the market earned positive returns.

For comparison, columns 4 and 5 report the average return of the underlying and value-weighted CRSP return over the term of the product. On average, both the average returns on the underlying and on the market are above the product returns and, except for the volume-weighted average underlying return, they are positive. Figure 4 illustrates the patterns between product, underlying, and market returns. I sort the products based

[10] Another paper that studies the ex-post performance of structured products is Deng, Dulaney, Husson, McCann, and Yan (2015). The authors derive the fair value of the products after the initial valuation date and construct an index of hypothetical product returns. The aim of my approach is to estimate returns likely realized by the investors and compare them to appropriate benchmarks. For this reason, I focus on the returns at maturity because YEPs are intended to be held until maturity and have little secondary market activity.

[11] I cross-validate the calculated returns using the returns reported by the platform for a subsample of 12,898 products. The holding period returns I calculate are close to the returns estimated by the platform ($\overline{HPR}_{calculated} = -4.75$ and $\overline{HPR}_{platform} = -4.28$), and 96% of the calculated returns are within one percentage point of the return reported by the platform.

on their expected term into three groups displayed in the first three panels. Each dot represents the equally weighted average of a portfolio of YEPs issued in a given year. Consistent with the payoff diagrams in Figure 1, I plot the underlying return on the x-axis and the product or market return on the y-axis. The shape of the product returns follows the concave shape of their payoff diagrams—the positive returns are limited, while the negative returns closely follow the negative returns of the portfolios of underlying assets.

For most of the portfolios, the YEP returns are lower than the underlying portfolio return as they lie below the 45-degree line. Similarly, for most of the portfolios, the underlying portfolio return is lower than the market return as the market returns lie mostly above the 45-degree line. The YEP returns are, therefore, also lower than the market return for all but one portfolio. Consistent with the expected net-of-fees returns being negatively related to the expected product term, the YEP returns for products with an expected term of up to four months (Panel A) are the lowest. Their average returns are negative in eight out of the ten years.

Of course, neither the market nor the underlying return is an optimal benchmark because of the non-linear payoffs of YEPs. In the next section, I derive the product-specific benchmarks and investigate the abnormal returns of YEPs.

5.7 Benchmark Returns

Issuers, or more precisely hedge providers, of yield enhancement products can hedge their exposure statically by buying derivatives that replicate the product's payoff. Alternatively, they can hedge the position dynamically by frequently trading in the underlying market. I use such a dynamic strategy, which generates a delta-equivalent daily adjusted return, as a benchmark.

To this end, I use the pricing model described in Section 4 to calculate product daily delta as $\Delta_{i,t}(S_{i,t}, \sigma_{i,t}, r_t, q_{i,t}) = \frac{\partial fair\ value_{i,t}}{\partial S_{i,t}}$, where I interpolate $\sigma_{i,t}$ and r_t from option prices and swap rates on day t. I cap the absolute product delta at 2 to avoid extreme positions. For each product i and trading day t, I calculate the daily benchmark return, $r^b_{i,t}$, as

$$r^b_{i,t} = r_t + \Delta_{i,t}(r_{S_{i,t}} - r_t), \tag{4}$$

where $r_{S_i,t}$ is the return on the underlying stock on day t. The benchmark return at maturity is then the cumulative return from this delta-equivalent strategy

$$benchmark_i = \prod_{t=1}^{T}(1 + r^b_{i,t}). \tag{5}$$

Figure 5 plots kernel regressions of product returns on benchmark returns and shows that these first-order approximations track the product returns fairly well. In certain cases when the underlying performs well, the benchmark strategy outperforms the fixed maximum return of the product. These cases lead to the departure of product returns from benchmark returns in the segment of positive product returns. On the other hand, in cases where the underlying drops below the initial price but does not cross the barrier, the return from the benchmark strategy is below the return of the product. These cases manifest themselves in the kernel regression estimates crossing through the 45-degree line. Such cases are, however, less frequent since over 75 percent of the benchmark returns outperform the product returns.

Columns 2 and 3 of Table 7 report the average benchmark return as well as the abnormal return defined as the difference between the benchmark and the product return. While the benchmark returns are not statistically different from zero, the abnormal returns are negative and both statistically and economically significant. The volume-weighted average monthly abnormal return is -0.56% and therefore of a similar magnitude as the estimated monthly fee.

In Table 8, I estimate regressions explaining the ex-post returns. In columns 1–3, I regress the product return on the benchmark return and product characteristics. The coefficients on the benchmark returns are close to 1 and the constant from the regression reported in the first column is statistically significant and equal to the average abnormal return. Consistent with the regressions of YEP expected returns, their ex-post returns are positively related to the product expected term and volume, and negatively related to the headline rate, although the coefficients on headline rate are not statistically significant at the 5% level. Regressions of the abnormal return on the fees show that most of the underperformance of YEPs relative to the benchmark returns can be explained by their fees. The coefficients on monthly fees are around -0.8. Moreover, these estimates likely suffer from the attenuation bias as the abnormal returns are estimated with error due to the difficulties in delta-hedging discontinuous payoffs.

The results in Table 7 and Figure 4 show that the underlying equities earn lower returns compared to the market despite their high betas. Given that the majority of YEPs constitute undiversified bets on a single stock, the poor performance of the underlyings is in line with Bessembinder (2017), who shows that the majority of CRSP stocks have buy-and-hold returns below Treasury bills. Panel B of Table 8 shows that even the portfolio of underlying stocks underperforms relative to the single-factor model, the Fama-French three- and five-factor models, and the addition of the (high minus low) idiosyncratic volatility factor (IVOL). I form a portfolio of the underlying stocks in each month by taking a volume-weighted average return of the stocks used as an underlying in outstanding YEPs issued before the beginning of the month. I find that this portfolio delivers negative and significant alpha with respect to the models and that it has a significant loading only on the market and the IVOL factor. The positive loadings on the IVOL factor explain part of the underperformance of the underlying portfolio, as high idiosyncratic volatility stocks tend to underperform low idiosyncratic volatility stocks (Ang, Hodrick, Xing, and Zhang, 2006).

Taken together, issuers are more likely to select as the underlying: stocks with historically high market sensitivity and stocks that comove with high idiosyncratic volatility stocks during the term of the product. All else equal, selecting these stocks increases the embedded fees and decreases the returns of YEPs.

In summary, I provide a large set of evidence of the negative returns of YEPs both ex ante and ex post. Over the 2006–15 period, investors in YEPs lost more than \$1.5 billion. This number is likely to be conservative as it does take into account losses on YEPs not covered in my sample. I quantify a lower bound of the hidden costs of YEPs, which accounts for \$1.19 billion of the realized losses. My estimates do not capture the compensation for issuer credit risk as well as possible market manipulation by the issuer that negatively affects investors, as documented by Henderson, Pearson, and Wang (2018). As a result, my estimates of hidden costs of YEPs are biased downward.

6 Discussion

The previous section documents that YEPs charge embedded fees large enough for their expected returns to be negative. Fees of this magnitude are rarely observed in financial markets. In this section, I discuss the possible explanations for this puzzling finding. I organize the discussion around two basic questions. First, do investors observe and understand the costs of yield enhancement products? Second, what are the motives for buying the products? I start with the explanations that are consistent with no information asymmetry between the investors and issuers about the embedded costs of the products. I then explore the explanations that fall under the economics of hidden prices.

6.1 No Information Asymmetry

6.1.1 Traditional motives

In standard portfolio choice theory, investors buy an asset with a negative expected return only if it allows them to hedge against "bad" states with high marginal utility. YEPs provide positive returns in states where the underlying performs well and stays above a predefined threshold. To the extent that investors' consumption covaries with the broad market index and thus with the prices of the underlying, YEPs do not seem to hedge states with low consumption.

While YEPs may offer payoffs that are not perfectly spanned by the traditional instruments available to retail investors—for example, barrier options and callable features embedded in YEPs—it is hard to think of background risks or portfolios likely held by retail investors that can be hedged with these payoffs. Even if one accepts the view that YEPs may allow investors to hedge some risks, it seems hard to justify the high premiums of YEPs over static or dynamic strategies in the underlying asset or exchange-traded options that approximately replicate the exotic features of YEPs. One could reconcile the high premiums when investors lack the skill to carry out such strategies. However, in that case, investors also likely lack the skill to understand the embedded costs of YEPs.

Moreover, it is not clear why the hedging demand for YEPs would grow in the low interest rate environment and why there would be little hedging demand for similar payoffs linked to low-volatility assets, which are less likely to be chosen as an underlying.

YEPs are unlikely to offer any tax benefits; in fact, their taxation is often uncertain. They also do not reduce transaction costs, nor do they increase liquidity. On the contrary, they are highly illiquid. Neither do YEPs reduce agency costs or change prices of assets that would favor the investors. Changes in the prices of the underlying due to pre-trade hedging rather favor the issuing banks, and the changes reverse soon after the issue date (Henderson, Pearson, and Wang, 2018). In sum, the evidence on YEPs is hard to reconcile with the standard motives for financial innovation (as listed in Allen and Gale 1994).

6.1.2 Speculation

Simsek (2013) provides an alternative view of financial innovation driven by investor disagreement. In this view, profit-seeking financial intermediaries introduce new assets that allow investors to bet on their disagreement. Note that although belief disagreement may cause investors to overestimate the expected returns of YEPs, it does not influence the observed price difference between YEPs and their static replicating strategies. Investors agree to disagree in the sense that they correctly observe market prices, but overestimate the precision of their own information—possibly because of overconfidence (Barber and Odean, 2001; Grinblatt and Keloharju, 2009).

Some of the evidence on YEPs is consistent with this interpretation. First, YEPs allow investors to bet on the price of the underlying staying flat. Second, YEPs became popular after 2009, coinciding with the period of elevated aggregate disagreement (Hong and Sraer, 2016). Third, the stocks that issuers select as underlyings have high betas and therefore are more sensitive to disagreement and speculative overpricing (Hong and Sraer, 2016). Fourth, investor suitability disclosure presented in Figure C.2 in the Appendix suggests that the issuers target investors who believe that the probability of the downside risk is small.

On the other hand, the high premium of YEPs over their replicating strategies seems difficult to reconcile with simple disagreement models. In particular, investors with heterogeneous beliefs about the fundamental value of the underlying and sophisticated enough to estimate the product fees with option pricing techniques may as well write better-priced plain-vanilla put options and avoid the high costs of YEPs. In fact, if investors prefer exotic features of YEPs over plain vanilla payoffs, one needs to assume that investors disagree not only about the value of the underlying but also about its future price path. It is not clear what source of disagreement would lead to such beliefs.

6.2 Hidden Prices

The second category of explanations falls under the economics of hidden prices (Gabaix and Laibson, 2006; Ellison and Ellison, 2009; Carlin, 2009; Carlin and Manso, 2010; Heidhues, Kőszegi, and Murooka, 2016, 2017). Specifically, investors may not understand the large fees of yield enhancement products either because they do not possess the skill or market data to estimate the fees with option pricing methods, or because they do not know how to interpret the issuer's product value estimates. For example, issuer value estimates are not sufficient to derive the annual costs of autocallable products that may terminate early.

Several pieces of evidence support the view that at least some investors do not understand the opaque terms of the products. First, SEC's interviews with some investors provide direct evidence that these investors did not understand the terms of the products they bought (U.S. Securities and Exchange Commission, 2011).[12] Second, the evidence on brokers targeting YEP sales to elderly investors—for whom YEPs are less likely to be suitable—is consistent with broker efforts to exploit investors' cognitive limitations. Third and importantly, thousands of investors in YEPs have very little investing experience and modest wealth. These investors are less likely to possess the skills to estimate the embedded costs of YEPs and they are also more likely to make investment mistakes (Vissing-Jørgensen, 2004).

In addition, there is little reason to believe that the misselling cases documented by regulators capture the full extent of inappropriate sales of YEPs. Since YEP returns are negatively skewed, most investors may never understand the downside risks embedded

[12] Similarly, a recent investigation by the British regulator, the Financial Conduct Authority, concluded that the surveyed investors in structured products do not understand product performance given the performance of the underlying and, consequently, overestimate the product expected returns (Financial Conduct Authority, 2015).

in the products and may therefore never file complaints with regulators. Regulatory investigations may be ad hoc (Okat, 2016) and they may rely on technologies that do not catch all misselling cases. For example, thousands of misselling cases dating back to 2011 went undetected until 2016, when the SEC adopted big data approach in its investigations.[13]

6.2.1 Reaching-for-yield

Ignoring the high costs of YEPs, the products may be attractive for investors who "reach for yield"—in the sense of seeking higher yields when interest rates are low. A similar argument has been made by Célérier and Vallée (2017) and Bordalo, Gennaioli, and Shleifer (2012).

This interpretation is consistent with the higher popularity of YEPs in the low interest environment in which investors show a greater appetite for higher returns (Lian, Ma, and Wang, 2017). It is also easy to reconcile with the strategic choice of highly volatile stocks as underlyings to support the high headline rates of YEPs.

The underlying psychological mechanism of reaching-for-yield may be salient thinking (Bordalo, Gennaioli, and Shleifer, 2012; Lian, Ma, and Wang, 2017). Consistent with my results, Inderst and Obradovits (2016) show that the combination of salient thinking and shrouded fees leads to the issuance of low-quality products. The average headline rates of YEPs appear highly salient—on average 12% per year. These headline rates are also saliently advertised in the names of the products.[14] Moreover, the headline rates are typically disclosed on an annual basis, although the applicable coupons are lower due to short maturities.

Reaching-for-yield may also be related to reference dependence (Lian, Ma, and Wang, 2017). In particular, past experiences may influence investor preferences and

[13] See SEC press release available at https://www.sec.gov/news/pressrelease/2016-197.html.

[14] See, e.g., the following prospectuses:
"20.0% (per annum) Reverse Exchangeable Notes due April 30, 2007" available at https://www.sec.gov/Archives/edgar/data/19617/000089109206003303/e25427_424b2.pdf,
"10.00% Knock-in Reverse Exchangeable(SM) Securities due April 26, 2007" available at https://www.sec.gov/Archives/edgar/data/897878/000089787806000059/slbfinal.txt,
or "13.25% Reverse Exchangeable Notes Linked to the Common Stock of Champion Enterprises, Inc. (CHB)" available at https://www.sec.gov/Archives/edgar/data/806085/000119312507134059/d424b2.htm.

portfolio choice (Malmendier and Nagel, 2011; Knüpfer, Rantapuska, and Sarvimäki, 2017) and lead to adaptation of history-dependent reference points (Bordalo, Gennaioli, and Shleifer, 2017). Panel F of Figure 3 shows that the average headline rate offered by YEPs remained relatively stable throughout my sample period. Consistent with the findings from the European markets (Célérier and Vallée, 2017), I find no significant drop in the headline rate following the fall of interest rates to near zero at the end of 2008. This pattern is consistent with catering to investor preferences for a history-dependent reference rate.

6.2.2 Conflicted advice

Investor decisions do not occur in a vacuum and may be shaped by the recommendations of financial advisers. In the context of YEPs, financial advice is likely to be conflicted because advisers receive kickbacks and commissions for recommending YEPs. The numerous cases of YEP misselling provide direct evidence of brokers acting against the best interest of their clients. I find that nearly half of the large fees of YEPs can be explained by conflicted payments to the distributor recommending the product. Egan (2017) provides further evidence that brokers steer clients to inferior YEPs that generate higher conflicted compensation. In sum, the evidence is consistent with the view that conflicted advice is an important factor in the market for YEPs.

In discussing the potential explanations of my findings, I recognize that investor heterogeneity makes it hard to pin down a single explanation and gives little reason to believe that only one channel plays a role. Nevertheless, the evidence from regulatory examinations on some investors as well as Occam's razor favor a simple interpretation: investors buy the products because of their high yields and lack of understanding of their high fees and low returns.

7 Conclusion

In the aftermath of the financial crisis of 2007–08, the Federal Reserve set the interest rates to historic lows. This paper investigates the U.S. market for yield enhancement products—securities designed to offer yield above the prevailing interest rates—that flourished during the same period. Regulators expressed concerns over investors' understanding of the product risks and embedded fees because the market is complex and opaque. Financial economists have remained largely silent on the topic possibly for the same reasons. I agree with Zingales (2015) that "our primary contribution as researchers is to expose the [financial market] distortions" and uncover the ex-ante and ex-post returns of YEPs.

I estimate that investors in YEPs pay on average 7% in annual fees and subsequently lose 7% per year relative to risk-adjusted benchmarks. Net of fees, the expected returns of YEPs are negative. The issuance of products with negative expected returns persists even after the mandatory product value disclosure required by the SEC.

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Figures and Tables

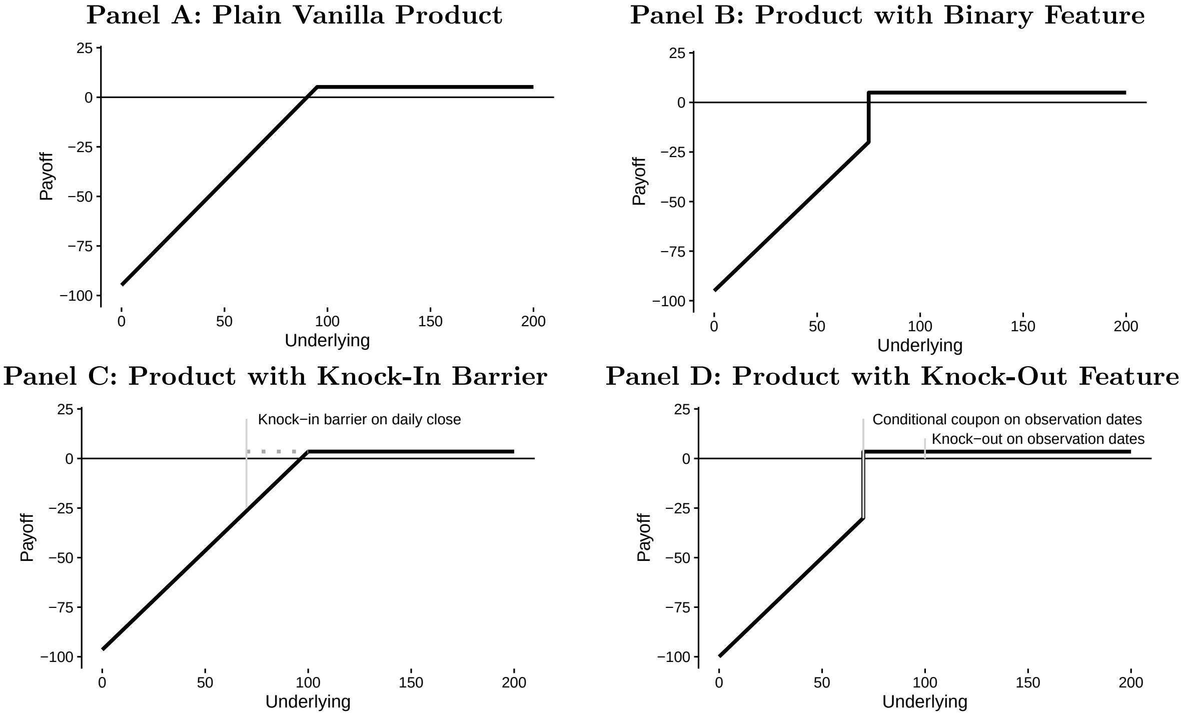


Figure 1: Payoff examples

The figure shows examples of product payoff diagrams. The horizontal axis measures the return of the underlying at maturity. The vertical axis measures the product holding period return equal to the sum of the payoff at maturity and the coupon payments. Panel A shows the payoff diagram for the plain vanilla product described in Table C.1 in the Appendix. Panel B shows the payoff diagram for the product with binary feature described in Table C.2 in the Appendix. Panel C shows the payoff diagram for the product with down-and-in barrier described in Table 1. Panel D shows a simplified payoff diagram for the product with knock-out feature and conditional coupons described in Table C.3 in the Appendix.

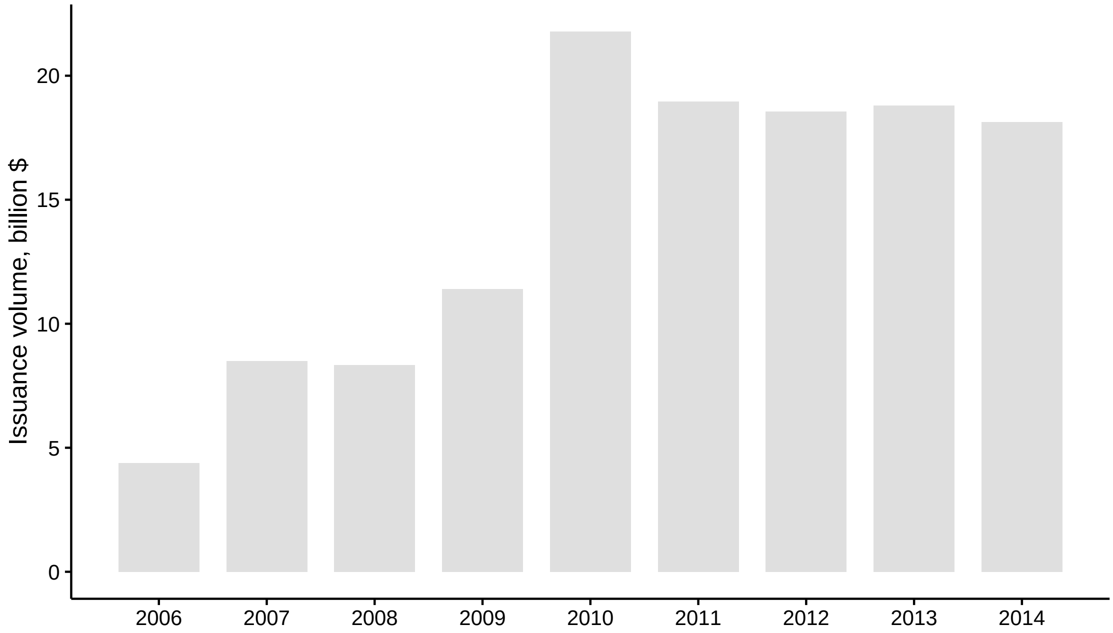


Figure 2: Issuance volume

The figure shows annual issuance volume of yield enhancement structured notes issued between January 2006 and December 2014, the last year for which complete volume data are available. The sample covers U.S. registered structured notes categorized as yield enhancement ("income") products by the platform.

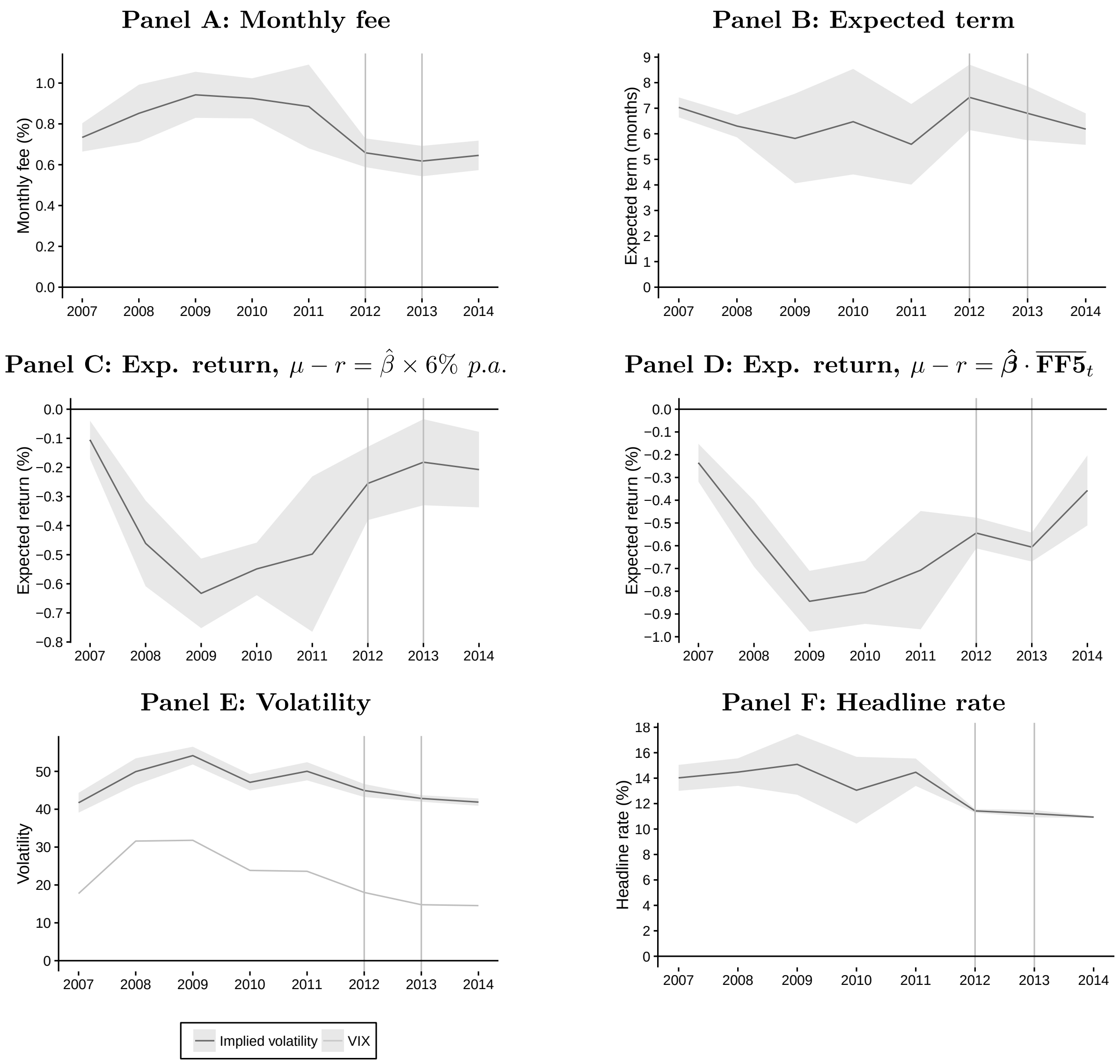


Figure 3: Fees, expected returns, and product characteristics around mandatory value disclosure

The figure shows the evolution of monthly fees (Panel A), expected term (Panel B), monthly expected returns (Panel C and D), volatility (Panel E), and headline rate (Panel F). The figures display averages of the variables over products issued in a given year and 95-percent confidence intervals based on standard errors clustered at the issuer level. Monthly fees are estimated using the pricing model described in Section 4 and are not adjusted for the credit risk of the issuer. To estimate the expected returns, I assume the expected excess return on the underlying equals $\mu - r = \hat{\beta} \times 6\%$ *p.a.* (Panel C) or the product of the factor loadings and their respective mean factor values from the Fama and French (2015) five-factor model: $\mu - r = \hat{\boldsymbol{\beta}} \cdot \overline{\mathbf{FF5}}_t$ (Panel D). Panel E shows the average implied volatility over the options of a product at issuance and the average monthly VIX index. The sample consists of 20,659 yield enhancement products issued between January 2007 and December 2014. The first vertical line depicts the year when the SEC announced the requirement to disclose the issuer estimated fair value. The second vertical line indicates the year when the mandatory disclosure was implemented.

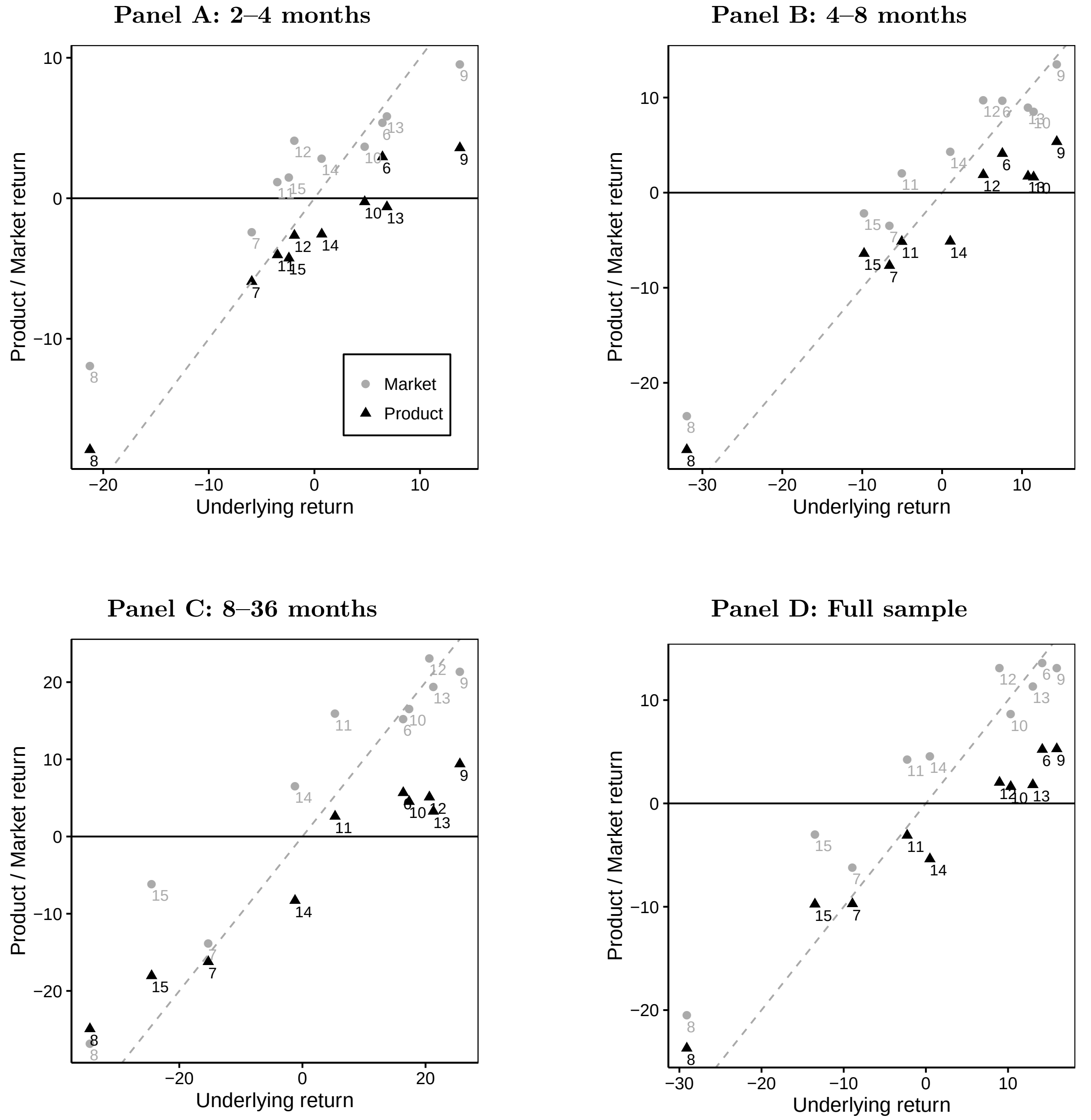


Figure 4: Product, market, and underlying ex-post returns by expected term
The figure shows the scatter plots of ex-post product, underlying, and market returns over the product holding period. Each point represents an equal weighted return of a portfolio of products issued in a calendar year and sorted by their expected term: less than 4 months (Panel A, $N = 6,159$), 4–8 months (Panel B, $N = 9,627$), and more than 8 months (Panel C, $N = 5,501$). Panel D covers the full sample of 21,287 products. Expected term is calculated using risk-neutral probabilities of product early terminations estimated using the pricing model described in Section 4. Underlying and market return are the underlying and value-weighted CRSP return over the term of the product. The dashed line is a 45-degree line. The point labels indicate the years.

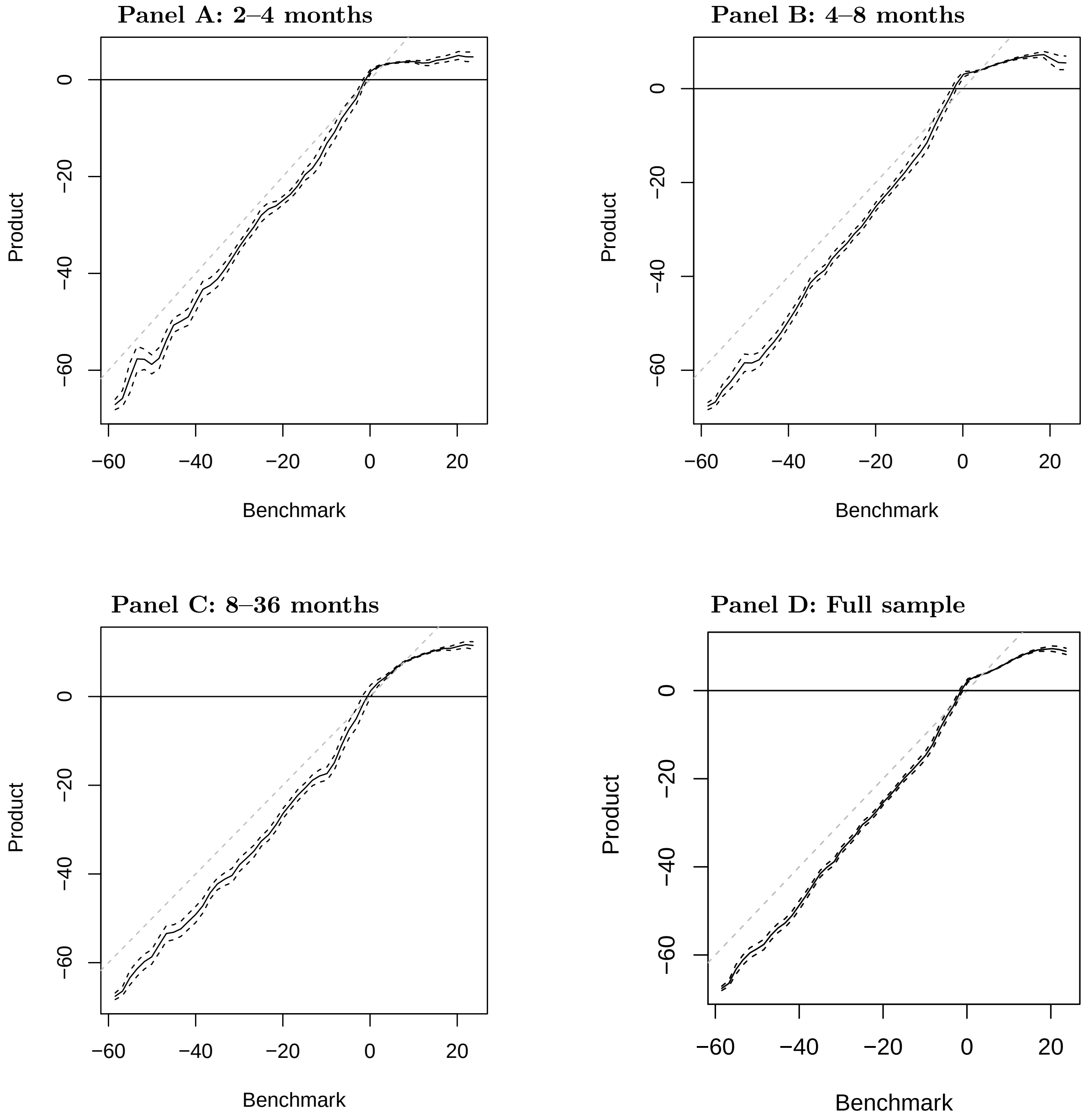


Figure 5: Product and benchmark returns by expected term

The figure plots point estimates and 95-percent confidence intervals from kernel regressions of product returns on benchmark returns. *Product return* is the sum of the payoff at maturity and coupon payments rolled over at the risk-free rate until maturity. *Benchmark return* is the delta equivalent dynamically adjusted positions in the underlying stock and the risk-free rate. For each product i, the delta-equivalent daily adjusted position in the underlying stock is modeled as:

$$r^b_{i,t} = r_t + \Delta_{i,t}(r_{S_{i,t}} - r_t),$$

where $\Delta_{i,t}(S_{i,t}, \sigma_{i,t}, r_t, q_{i,t}) = \frac{\partial fair\ value_{i,t}}{\partial S_{i,t}}$ is the ratio of the change in the value of the product to the change in the price of the underlying stock, $r_{S_{i,t}}$ is the return on the underlying stock on day t, and r_t is the riskless rate. The benchmark return at maturity is the cumulative return from this delta-equivalent strategy, $\prod_{t=1}^{T}(1 + r^b_{i,t})$. Products are sorted by their expected term: less than 4 months (Panel A, $N = 6,159$), 4–8 months (Panel B, $N = 9,627$), and more than 8 months (Panel C, $N = 5,501$). Panel D covers the full sample of 21,287 products. The dashed lines are 45-degree lines.

Table 1: Product Example

The table presents an example of a product, its payoff description, translation into a mathematical formula, and decomposition into a bond and an option. Prices of the underlying are normalized to 1 at issuance.

Panel A: Product characteristics

Name	3.50% (equivalent to 14.00% per annum) Reverse Exchangeable Notes due August 29, 2014 Linked to the Common Stock of Ubiquiti Networks, Inc.
Issuer	JPMorgan Chase & Co.
CUSIP	48127DKN7
Volume	$1.305 million
Year	2014
Term	3 months
Headline rate	14%
Underlying	Ubiquiti Networks
Payoff description	This is an income product linked to the share of Ubiquiti Networks. The product offers a coupon of 14% p.a., paid monthly throughout the investment period. At maturity, the product offers a capital return of 100%, if the final share level is equal to or greater than the initial level or if the underlying does not fall by more than 30% from its initial level at any time during the investment. If the underlying does fall by more than 30% from its initial level at any time during the investment and the final share level is lower than the initial level, the capital return equals 100%, minus 1% for every 1% fall, paid in cash or in shares.

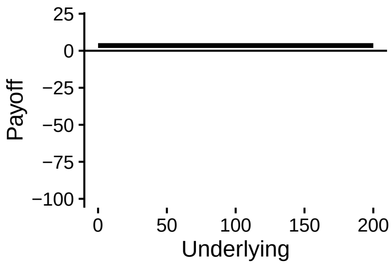
Panel B: Payoff translation, decomposition and evaluation

Translated formula

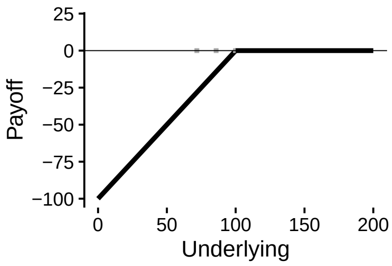
$$P_T = \begin{cases} 1 & \text{if } S_t \geq 0.7 \quad \forall t = 1, ..., T \\ S_T & \text{otherwise} \end{cases}$$

$$P_m = 0.14 \times \Delta t \quad \text{for monthly observation dates } m = 1, ..., M$$

Decomposition



Long bond, 14% monthly coupon



Short down-and-in put, 30% barrier

Table 2: Summary Statistics

The table reports summary statistics of product characteristics at issuance (Panel A), underlying factor loadings (Panel B), and inputs to the pricing model (Panel C). *Volume* is issuance volume in million \$. *Headline rate* is the product annual coupon rate extracted from its payoff description. *Maximum term* (in months) is the maximum maturity of a product if it does not terminate early. Underlying factor loadings are estimated using 60 monthly returns preceding the initial valuation date. $\hat{\beta}$ is the CAPM beta. $\hat{\beta}_{SMB}$, $\hat{\beta}_{HML}$, $\hat{\beta}_{RMW}$, $\hat{\beta}_{CMA}$ are from the Fama and French (2015) five-factor model. $\hat{\beta}_{IVOL}$ is from the two-factor model of CRSP value-weighted return and the (high minus low) idiosyncratic volatility factor. Valuation inputs (in %) are reported as averages over the options embedded in a product on the initial valuation date and their measurement is described in Section 4. r is the risk-free rate, q is the dividend yield, σ is the implied volatility, CDS is the issuer's credit default spread. $\Delta_{i,0}$ is the product delta on the initial valuation day. The sample consists of 21,287 yield enhancement products issued between January 2006 and September 2015.

Panel A: Product characteristics

	Mean	Vol.-wtd. average	Std. Dev.	Min	p25	p75	Max	Observations
Volume	1.6	-	5.3	0.0	0.2	1.5	204.6	21,287
Headline rate	13.0	12.0	4.7	2.6	9.9	15.0	67.0	21,287
Maximum term	8.3	9.2	4.6	1.9	3.1	12.0	36.1	21,287

Panel B: Underlying factor loadings

	Mean	Vol.-wtd. average	Std. Dev.	Min	p25	p75	Max	Observations
$\hat{\beta}$	1.6	1.6	0.8	0.3	1.2	2.0	3.9	21,287
$\hat{\beta}_{SMB}$	0.5	0.4	1.0	-11.6	-0.1	1.0	9.5	21,287
$\hat{\beta}_{HML}$	0.1	0.1	1.5	-8.0	-0.8	0.8	7.5	21,287
$\hat{\beta}_{RMW}$	-0.2	-0.1	1.6	-14.1	-1.0	0.6	7.2	21,287
$\hat{\beta}_{CMA}$	-0.9	-0.9	1.9	-9.6	-2.0	0.1	9.0	21,287
$\hat{\beta}_{IVOL}$	0.8	0.7	1.0	-3.1	0.1	1.2	6.6	21,287

Panel C: Valuation inputs

	Mean	Vol.-wtd. average	Std. Dev.	Min	p25	p75	Max	Observations
r	1.1	1.4	1.7	0.0	0.1	1.4	5.7	21,287
q	0.9	1.0	1.3	0.0	0.0	1.3	6.6	21,287
σ	46.2	42.4	13.2	14.2	37.5	52.2	209.0	21,287
CDS	0.5	0.6	0.5	0.0	0.2	0.8	7.8	14,555
$\Delta_{i,0}$	41.9	42.3	4.7	23.9	39.3	45.4	50.1	21,287

Table 3: Margins and Embedded Fees

The table reports estimates of product margins and monthly fees obtained from the pricing model described in Section 4. The first two columns present the values not adjusted for credit risk for the whole sample (first column) and for the subsample with available CDS spreads (second column). The third column presents values adjusted for credit risk. *Margin* (in %, Panel A) is the difference between the fair product value and the issue price as a percentage of the issue price. I winsorize the estimated margins at the 1 percent level. *Monthly embedded fees* (in basis points, Panel B) are defined as:

$$fee = \sum_{m=1}^{M} q_{f,m} \frac{margin}{t_m},$$

where $margin$ is the estimated product margin, $q_{f,m}$ is the risk-neutral probability of termination on date m, and t_m is the difference in months between the observation date m and the initial valuation date. Standard errors are clustered at the issuer level and reported in brackets.

Panel A: Margins

	Adjusted for credit risk		
	No	No	Yes
	Full Sample	CDS available	CDS available
Mean	4.16	4.31	4.47
	(0.20)	(0.27)	(0.29)
Vol.-wtd. average	3.95	4.08	4.30
p25	5.49	5.72	5.94
p50	4.01	4.23	4.37
p75	2.66	2.74	2.84
Observations	21,287	14,555	14,555

Panel B: Monthly embedded fees

	Adjusted for credit risk		
	No	No	Yes
	Full Sample	CDS available	CDS available
Mean	0.77	0.71	0.73
	(0.06)	(0.06)	(0.06)
Vol.-wtd. average	0.61	0.58	0.61
p25	0.42	0.41	0.43
p50	0.64	0.59	0.62
p75	1.01	0.90	0.93
Observations	21,287	14,555	14,555

Table 4: Expected Returns

The table reports estimates of net-of-fees expected returns of the products. The column labels indicate the model used to estimate the expected return on the underlying. $\hat{\beta}$ is the CAPM beta. $\overline{CRSP}_t$ is the value-weighted average. $SVIX$ is the 1 year equity premium based on the SVIX index (Martin, 2017). $\hat{\boldsymbol{\beta}}$ is a vector of Fama and French (2015) factor loadings, and $\overline{\mathbf{FF5}}_t$ is a vector of the respective mean factor values. Betas are estimated using 60 monthly returns preceding the initial valuation date. Average factor returns are over the period from January 1996 until the last month before the initial valuation date of the product. Panel A reports holding period returns. Panel B reports monthly returns calculated using the expected term of the product under the risk-neutral probabilities of early termination. The sample consists of 21,287 products issued between January 2006 and September 2015. The expected returns based on SVIX are for the subsample of 13,595 products issued until February 2012. Standard errors are clustered at the issuer level and reported in brackets.

Panel A: Holding period expected returns

	Expected excess underlying return				
	$\hat{\beta} \times 6\%$ *p.a.*	$\hat{\beta} \times 8\%$ *p.a.*	$\hat{\beta} \times \overline{CRSP}_t$	$\hat{\beta} \times SVIX_t$	$\hat{\boldsymbol{\beta}} \cdot \overline{\mathbf{FF5}}_t$
Mean	-1.45	-0.85	-0.62	-1.90	-2.76
	(0.20)	(0.24)	(0.27)	(0.23)	(0.19)
Vol.-wtd. average	-0.57	0.13	0.40	-1.11	-1.73
p25	-2.97	-2.43	-2.33	-3.35	-4.90
p50	-1.46	-0.88	-0.68	-1.82	-2.50
p75	0.60	0.70	0.99	-0.25	-0.13
Observations	21,287	21,287	21,287	13,595	21,287

Panel B: Monthly expected returns

	Expected excess underlying return				
	$\hat{\beta} \times 6\%$ *p.a.*	$\hat{\beta} \times 8\%$ *p.a.*	$\hat{\beta} \times \overline{CRSP}_t$	$\hat{\beta} \times SVIX_t$	$\hat{\boldsymbol{\beta}} \cdot \overline{\mathbf{FF5}}_t$
Mean	-0.34	-0.24	-0.21	-0.46	-0.56
	(0.08)	(0.08)	(0.09)	(0.06)	(0.06)
Vol.-wtd. average	-0.17	-0.08	-0.05	-0.25	-0.35
p25	-0.60	-0.50	-0.47	-0.73	-0.97
p50	-0.23	-0.14	-0.11	-0.32	-0.44
p75	0.01	0.11	0.15	-0.04	-0.02
Observations	21,287	21,287	21,287	13,595	21,287

Table 5: Margins, Embedded Fees, and Product Characteristics

Panel A and B report present values and embedded fees for the portfolios of products sorted by expected term. *Expected term* is estimated using risk-neutral probabilities of early termination. Panel C reports estimates from regressing the margin (columns 1–3), the monthly embedded fees (columns 4–5), and the monthly expected returns (columns 6–7) on product characteristics. Margins, fees, and expected returns are estimated using the option pricing methods described in Section 4. To estimate the expected returns I assume that the expected excess return on the underlying equals $\mu - r = \hat{\beta} \times 6\%$ *p.a.*. The sample consists of 21,287 yield enhancement products issued between January 2006 and September 2015. Standard errors are clustered at the issuer level and reported in brackets.

Panel A: Margins by expected term

	2–4 months	4–8 months	> 8 months
Mean	3.58	3.94	5.45
	(0.18)	(0.37)	(0.29)
Vol.-wtd. average	3.42	3.92	4.58
p25	2.24	2.56	4.25
p50	3.43	3.76	5.35
p75	4.73	5.19	6.55
Observations	6,159	9,627	5,501

Panel B: Monthly embedded fees by expected term

	2–4 months	4–8 months	> 8 months
Mean	1.20	0.69	0.44
	(0.04)	(0.04)	(0.02)
Vol.-wtd. average	1.10	0.67	0.35
p25	0.75	0.47	0.33
p50	1.15	0.67	0.43
p75	1.58	0.90	0.53
Observations	6,159	9,627	5,501

Panel C: Regressions on product characteristics

Dependent variable	Margin			Monthly fee		Monthly expected return	
Constant	2.863						
	(0.394)						
Expected term	0.196	0.232	0.403	-0.045	-0.112	0.034	0.090
	(0.042)	(0.035)	(0.101)	(0.011)	(0.025)	(0.017)	(0.041)
Expected term^2			-0.009		0.003		-0.003
			(0.003)		(0.001)		(0.001)
log(Volume)		-0.337	-0.338	-0.073	-0.073	0.078	0.077
		(0.022)	(0.020)	(0.007)	(0.008)	(0.010)	(0.010)
Headline rate		0.055	0.063	0.022	0.019	-0.017	-0.014
		(0.024)	(0.020)	(0.006)	(0.006)	(0.008)	(0.008)
Year FE	No	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	No	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.11	0.20	0.21	0.27	0.30	0.24	0.25
Observations	21,287	21,287	21,287	21,287	21,287	21,287	21,287

Table 6: Model Fair Values vs Issuer Estimated Values

The table reports comparison of the fair product values estimated using the pricing model described in Section 4 (*model value*) with the estimated values disclosed by the issuers (*issuer value*) following the 2013 introduction of fair value disclosure. Both values are reported as a fraction of the issue price in %. The sample consists of 3,114 yield enhancement products for which both the model value and the issuer value are available. Panel A reports the summary statistics of the sample. Panel B reports the estimates from regressing the model value on the issuer value. Standard errors are clustered at the issuer level and reported in brackets.

Panel A: Summary statistics of estimated values

	Mean	Vol.-wtd. average	S. D.	Min	p25	p75	Max	Observations
Model value	96.42	97.13	2.273	88.39	96.15	97.06	101.30	3,114
Issuer value	96.59	97.15	0.876	88.90	95.26	97.84	101.40	3,114

Panel B: Regression of model values on issuer values

Constant	-0.051	
	(0.090)	
Issuer value	1.051	1.079
	(0.094)	(0.085)
Issuer FE	No	Yes
Observations	3,114	3,114
R^2	0.164	0.175

Table 7: Ex-Post Returns

The table reports estimates of ex-post returns. *Product return* is the sum of the payoff at maturity and all coupon payments rolled over at the risk-free rate until maturity. *Benchmark return* is the cumulative return of delta equivalent daily adjusted positions in the underlying equity and risk-free rate at maturity. *Abnormal return* is the difference between product return and benchmark return. *Underlying return* and *Market return* are the underlying and value-weighted CRSP returns over the effective term of the product. The table reports average returns by the year of initial valuation date and summary statistics for the full sample. Panel A reports holding period returns. Panel B reports monthly returns calculated using the effective term of a product. The sample consists of 21,287 products issued between January 2006 and September 2015. Standard errors are clustered at the issuer level and reported in brackets.

Panel A: Holding period returns

Year	Product	Benchmark	Abnormal	Underlying	Market	Observations
2006	5.22	7.82	-2.60	14.17	13.59	417
2007	-9.72	-4.24	-5.47	-8.94	-6.22	2,616
2008	-23.70	-14.77	-8.93	-29.10	-20.52	2,479
2009	5.28	7.10	-1.82	15.93	13.11	1,827
2010	1.62	4.78	-3.16	10.33	8.63	2,903
2011	-3.09	-0.51	-2.58	-2.27	4.25	2,717
2012	2.03	2.72	-0.69	8.96	13.11	3,446
2013	1.80	3.94	-2.13	13.02	11.31	2,536
2014	-5.38	-1.57	-3.81	0.49	4.54	2,135
2015	-9.75	-6.35	-3.41	-13.50	-3.00	211
Mean	-3.66	-0.20	-3.46	1.19	3.85	21,287
	(1.44)	(0.89)	(0.68)	(2.37)	(2.52)	
Vol.-wtd. average	-4.55	-1.08	-3.47	-1.80	1.43	
p25	-5.03	-0.96	-5.81	-18.36	-2.21	
p50	4.00	5.70	-2.60	3.20	4.92	
p75	7.00	9.60	-0.29	19.22	12.75	

Panel B: Monthly returns

Year	Product	Benchmark	Abnormal	Underlying	Market	Observations
2006	0.55	0.80	-0.26	1.41	1.37	417
2007	-1.46	-0.58	-0.88	-1.35	-0.79	2,616
2008	-4.46	-2.85	-1.61	-5.37	-3.58	2,479
2009	1.00	1.45	-0.45	3.25	2.54	1,827
2010	0.15	0.77	-0.62	1.66	1.32	2,903
2011	-0.81	-0.03	-0.78	-0.37	0.65	2,717
2012	0.14	0.40	-0.25	1.31	1.52	3,446
2013	0.42	0.89	-0.47	2.74	1.70	2,536
2014	-0.11	0.48	-0.59	1.69	0.83	2,135
2015	-0.65	-0.18	-0.47	-0.42	0.06	211
Mean	-0.63	0.05	-0.69	0.40	0.53	21,287
	(0.34)	(0.24)	(0.11)	(0.59)	(0.34)	
Vol.-wtd. average	-0.72	-0.15	-0.56	-0.20	0.12	
p25	-0.66	-0.16	-1.09	-2.86	-0.37	
p50	0.84	1.04	-0.48	0.58	1.05	
p75	1.11	1.72	-0.04	3.65	1.93	

Table 8: Regressions Explaining Ex-Post Returns

Panel A reports results from regressions of product ex-post returns on benchmark returns and product characteristics (columns 1–3), and regressions of abnormal returns on monthly fees (column 4–5). The returns are monthly and the sample consists of 21,287 products issued between January 2006 and September 2015. Standard errors are clustered at the issuer level and reported in brackets. Panel B reports results from regressions of monthly returns of a portfolio of underlying stocks on benchmark returns from February 2006 through March 2016. Each month, the portfolio consists of volume-weighted average returns of underlying stocks of products outstanding at the beginning of the month and issued before the beginning of the month. MKT is value-weighted CRSP return, $IVOL$ is calculated as high minus low quintile of idiosyncratic volatility from the three-factor model, and the remaining factors are from Ken French's website. Newey-West adjusted standard errors are reported in brackets.

Panel A: Ex-post product returns

Dep. var.	Product return			Abnormal return	
Constant	-0.686			-0.063	
	(0.111)			(0.054)	
Benchmark return	1.004	0.960	0.960		
	(0.009)	(0.007)	(0.006)		
Expected term		0.051	0.133		
		(0.010)	(0.018)		
Expected term^2			-0.004		
			(0.001)		
log(Volume)		0.082	0.082		
		(0.022)	(0.023)		
Headline rate		-0.008	-0.004		
		(0.005)	(0.005)		
Monthly fee				-0.807	-0.772
				(0.062)	(0.083)
Year FE	No	Yes	Yes	No	Yes
Issuer FE	No	Yes	Yes	No	Yes
R^2	0.87	0.89	0.89	0.12	0.20
Observations	21,287	21,287	21,287	21,287	21,287

Panel B: Returns of portfolio of underlying stocks

Dep. var.	Volume-weighted return of underlying stocks					
Constant	-0.725	-0.537	-0.728	-0.550	-0.781	-0.656
	(0.214)	(0.201)	(0.195)	(0.206)	(0.243)	(0.241)
MKT_t	1.374	1.182	1.355	1.190	1.373	1.218
	(0.069)	(0.090)	(0.063)	(0.093)	(0.066)	(0.096)
$IVOL_t$		0.319		0.309		0.334
		(0.080)		(0.088)		(0.093)
SMB_t			0.176	0.034	0.204	0.064
			(0.092)	(0.084)	(0.103)	(0.096)
HML_t			-0.092	-0.048	-0.042	-0.040
			(0.133)	(0.123)	(0.159)	(0.130)
RMW_t					0.200	0.288
					(0.224)	(0.233)
CMA_t					-0.132	0.034
					(0.213)	(0.200)

Appendix

A Pricing Formulas

The risk-neutral process for the underlying asset is

$$dS = (r - q)Sdt + \sigma S dz, \tag{6}$$

where S denotes the underlying asset price, r the risk-free rate of return, q the dividend yield provided by the stock, and σ the volatility of the stock.

Products without a knock-out feature can be valued using standard textbook (e.g. Hull 2018) formulas for option valuation. The price of a *plain vanilla* put option with strike price K is calculated as

$$p = Ke^{-rT}N(-d_2) - S_0e^{-qT}N(-d_1), \tag{7}$$

where

$$d_1 = \frac{ln(S_0/K) + (r - q + \sigma^2/2)T}{\sigma\sqrt{T}}$$

$$d_2 = \frac{ln(S_0/K) + (r - q - \sigma^2/2)T}{\sigma\sqrt{T}}.$$

The *down-and-in* put option with barrier H is valued as

$$\begin{aligned} p_{di} = \quad & -S_0N(-x_1)e^{-qT} + Ke^{-rT}N(-x_1 + \sigma\sqrt{T}) + S_0e^{-qT}(H/S_0)^{2\lambda}[N(y) - N(y_1)] \\ & -Ke^{-rT}(H/S_0)^{2\lambda-2}[N(y - \sigma\sqrt{T}) - N(y_1 - \sigma\sqrt{T})], \end{aligned}$$

where

$$\lambda = \frac{r - q + \sigma^2/2}{\sigma^2}$$

$$x_1 = \frac{ln(S_0/H)}{\sigma\sqrt{T}} + \lambda\sigma\sqrt{T}$$

$$y = \frac{ln(H^2/(S_0K))}{\sigma\sqrt{T}} + \lambda\sigma\sqrt{T}$$

$$y_1 = \frac{ln(H/S_0)}{\sigma\sqrt{T}} + \lambda\sigma\sqrt{T}.$$

The above formula for continuous barrier monitoring holds only approximately as the barrier monitoring frequency for most of the products is at daily market close.

The price for an *asset-or-nothing* option equals to

$$p_a = S_0e^{-qT}N(-d_1). \tag{8}$$

Cash-or-nothing call and put options are priced as

$$c_c = Qe^{-rT}N(d_2) \tag{9}$$

and

$$p_c = Qe^{-rT}N(-d_2). \tag{10}$$

To estimate the values of products with a knock-out feature, I decompose their payoff into a series of options conditional on the product not being called on the preceding observation dates. The coupons and face value payments in case of early termination can be valued as conditional cash-or-nothing call options. Letting $m = 1, ..., M$ denote the observation dates, S_m price of the underlying asset on the observation date m, and t_m the time between the initial and the observation date, the risk-neutral probability of termination on date m is given by the equation

$$q_{f,m} = Prob^{\mathbb{Q}}(S_n < K, \forall n = 1, ..., m-1, \text{ and } S_m \geq K), \tag{11}$$

where $Prob^{\mathbb{Q}}$ is the risk-neutral probability measure and K is the knock-out barrier price. In case of face value repayment at maturity the last condition becomes $S_M > C$, where C is the knock-out barrier price applicable at maturity.

Similarly, the risk-neutral probability of coupon payment is given by the equation

$$q_{c,m} = Prob^{\mathbb{Q}}(S_n < K, \forall n = 1, ..., m-1, \text{ and } S_m > C), \tag{12}$$

where C is barrier strike price for coupon payments.

On top of the coupons and face value payments, the payoff embeds a conditional long position in an asset-or-nothing put option, whose price is given by

$$p = \mathbb{E}^{\mathbb{Q}}\left[S_T | S_n < K, \forall n = 1, ..., M-1, \text{ and } S_T \leq C\right] e^{-rT}, \tag{13}$$

where $\mathbb{E}^{\mathbb{Q}}$ denotes the expectation under the risk-neutral probability.

Since the asset price on any observation date, conditional on its price on any previous observation date, is assumed to be lognormally distributed and to follow a Markov process, changes in asset prices between the observation dates are pairwise independent. I can therefore follow Deng, Mallett, and McCann (2011), compute the corresponding multivariate standard normal cumulative probability function, and evaluate the equations 11-13. The value of the product at issuance, v_0, is then given by the sum of the discounted expected cash flows

$$v_0 = \sum_{m=1}^{M} q_{f,m} Q_F e^{-rt_m} + \sum_{m=1}^{M} q_{c,m} Q_C e^{-rt_m} + p, \tag{14}$$

where Q_F is the principal amount and Q_C is the coupon.

B Data Appendix

B.1 Platform Coverage

To confirm that the database is comprehensive, I validate its coverage with the filings in the EDGAR system. I download all prospectuses filed as 424B2 forms between January 2002 and September 2015 and select all files that contain a CUSIP code, the keyword "linked", and that do not include the keyword "ETN". I search the prospectuses for the list of CUSIP codes recorded by the platform. Table B.1 shows the results of this exercise and indicates that the platform has lower coverage before the year 2006 and excellent coverage thereafter. Closer examination reveals that the prospectuses that do not match with any CUSIP code are not prospectuses of structured products but mostly of fixed rate notes. The sum of the issuance volume reported by the platform for products issued in 2014 aligns with the aggregate volume of structured notes reported by Bloomberg. Therefore, I believe that the platform coverage of yield enhancement products from 2006 onwards is exhaustive.

Table B.1: Platform Coverage

The table reports the estimated coverage of the platform. I start with all prospectuses filed as 424B2 forms in the EDGAR system between January 2002 and September 2015 and select all prospectuses that contain a CUSIP code and the keyword "linked" and that do not include keyword "ETN". Column *All prospectuses* reports the number of files that fit this criteria each year. Next, I search these prospectuses for a list of all CUSIP codes recorded by the platform. Column *Matched with platform* reports the number of these matched files. Estimated coverage is the number of matched files divided by the total number of files.

Year	All prospectuses	Matched with platform	Estimated coverage (%)
2002	46	3	7
2003	95	1	1
2004	131	-	
2005	136	13	10
2006	1,201	840	70
2007	3,893	2,840	73
2008	4,500	3,699	82
2009	3,176	2,923	92
2010	5,073	4,440	88
2011	7,571	6,959	92
2012	9,250	8,941	97
2013	9,729	9,386	96
2014	10,804	10,487	97
2015	8,854	8,266	93
2006–15	64,051	58,781	92

B.2 Sample Selection

The platform covers 36,742 structured products ($124.841 billion) issued in the U.S. as a registered note between January 2006 and September 2015 (time of data retrieval) and categorized as "income" products. The list below describes the criteria applied to construct the dataset of YEPs and the number of product and issuance volume dropped due to each criterion.

(a) (8 products, $0.119 bn) I exclude products categorized by the platform as "Private Banking" products.

(b) (8,554 products, $66.558 bn) I drop products with a final valuation date, i.e. maximum maturity, after April 2016 because of option data availability and the need to estimate product deltas over the term of a product.

(c) (1,235 products, $11.229 bn) A small fraction of the products are linked to non-equity asset classes for which data on returns and implied volatilities are not available.

(d) (696 products, $2.319 bn) Products linked to an equity index or stock that are not covered in OptionMetrics IvyDB US are dropped.

(e) (692 products, $1.459 bn) I drop products that are callable by the issuer. Their termination date—and the realized return derived from it—is at the discretion of the issuer and cannot be unequivocally derived from the payoff formula.

(f) (478 products, $2.910 bn) I drop products with incomplete payoff information, such as descriptions including numerical variables defined within a range.

I use the resulting sample of 25,079 products ($40.246 billion) to train the translation algorithm. The translated sample covers the most frequent payoffs, 21,287 products, and $34.4 billion of issuance volume. Tables B.2 and B.3 present the most frequent issuers and underlyings covered by the sample.

B.3 Quality Assurance of Platform's Payoff Description

To validate the accuracy of the descriptions, I manually cross-validate a random sample of 100 products with the product terms disclosed in their prospectuses. While this is a small sample, this careful validation confirms that the descriptions are highly accurate.

As a second check, I manually validate products in the top and the bottom percentiles of each numerical payoff characteristic (e.g. the headline rate, the participation rate, and the barrier level) and correct occasional typos.

Note that the comparison of returns implied from the translated formulas with the returns reported by the platform provides another indirect test of the accuracy of the payoff descriptions as well as of the translation algorithm. In a sample of 12,898 products, 96 percent of the calculated returns are within one percentage point of the returns reported by the platform.

Table B.2: Issuers

The table reports the 15 largest issuers in the sample, the number of products they issued, and issuance volume. The sample consists of 21,287 yield enhancement products issued between January 2006 and September 2015.

Issuer	Number of products	Issuance volume (million $)
Barclays Bank	4,280	10,367
RBC	4,030	3,887
UBS	6,667	3,700
Citigroup Funding	129	3,441
JPMorgan Chase	2,267	2,861
ABN Amro Bank	1,655	2,131
Bank of America	56	1,810
Morgan Stanley	174	1,692
HSBC Bank	436	1,557
Eksportfinans ASA	248	716
Svensk Exportkredit	24	613
Deutsche Bank	157	575
Bank of Montreal	650	257
Credit Suisse	143	228
Lehman Brothers	172	205

Table B.3: Underlying Equities

The table reports the 40 most frequent underlying assets in the sample, the number of products that are linked to them, and their total issuance volume. The sample consists of 21,287 yield enhancement products issued between January 2006 and September 2015.

Underlying	Number of products	Issuance volume (million $)
Apple	906	1,629
UnitedStatesSteel	626	545
FreeportMcMoran	590	803
BankofAmerica	373	820
PeabodyEnergy	332	373
Ford	315	1,350
JPMorganChase	307	890
LasVegasSands	287	440
Caterpillar	279	393
GeneralElectric	264	1,025
ChesapeakeEnergy	246	449
Halliburton	211	599
Citigroup	204	242
Alcoa	203	427
MetLife	199	392
AlphaNaturalResources	193	95
BlackBerry	190	233
ValeroEnergy	189	429
MicronTechnology	188	158
GenworthFinancial	185	96
PulteGroup	178	57
Amazon	175	251
Netflix	175	182
Deere&Company	167	387
UnitedRentals	167	96
JoyGlobal	166	158
WellsFargo	166	473
GeneralMotors	165	444
Facebook	161	98
SilverWheaton	161	168
Yahoo	160	317
Cummins	159	134
FirstSolar	158	113
ArchCoal	154	257
DeltaAirLines	153	339
DowChemical	151	317
MorganStanley	151	102
Schlumberger	146	466
Tesoro	138	152
MGM	133	193

B.4 Sources and Variable Definitions

Table B.4: Variable Definitions

Variable	Construction	Source
Issuer	provider	Platform, Product table
Year	calendar year of initial_strike date	Platform, Product table
Volume	volume_amount	Platform, Market table
Maximum term	(final_index − initial_strike) $\cdot \frac{12}{365}$	Platform, Product table
Issuer value	est_initial_value	Platform, Product table
$\hat{\beta}$	CAPM beta estimated over past 24–60 months	CRSP
Risk-free rate, r	OIS rate linearly interpolated from two nearest maturities	Bloomberg
Dividend yield, q	following OptionMetrics methodology	OptionMetrics IvyDB US, Distribution/Index dividend table
Implied volatility, σ	implied volatility bi-linearly interpolated from four options with the closest expiry date before and after the option expiry date and the closest strike prices above and below the option strike price or implied volatility of the option with the closest expiry date and the closest strike price	OptionMetrics IvyDB US, Option price table
CDS	linearly interpolated from two nearest maturities	CMA datavision, Thomson Reuters, Bloomberg
MKT	value-weighted CRSP return	CRSP
SMB, HML, RMW, CMA		Ken French's website
IVOL	high − low quintile of idiosyncratic volatility from Fama-French three-factor model	CRSP
SVIX	annual horizon	Ian Martin's website
Expected term	$\sum_{m=1}^{M} q_{f,m} t_m$	Pricing model
Margin	(price − fair value) / price	Pricing model
Commission	commission	Platform, Product table
Monthly embedded fee	$\sum_{m=1}^{M} q_{f,m} \frac{margin}{t_m}$	Pricing model
Expected net return	(future value − price) / price	Pricing model
Expected gross return	(future value − fair value) / fair value	Pricing model
Monthly expected return	holding period expected return / expected term	Pricing model
Model value	fair value / price	Pricing model
Product delta, $\Delta_{i,t}$	$\frac{\partial \text{fair value}_{i,t}}{\partial S_{i,t}}$	Pricing model
Benchmark return	$\prod_{t=1}^{T}(1 + r_t + \Delta_{i,t}(r_{S_{i,t}} - r_t))$	Pricing model
Abnormal return	product return − benchmark return	Pricing model
Headline rate	maximum coupon or call premium in % $p.a.$	Translated formula
Effective term	(effective_maturity − initial_strike) $\cdot \frac{12}{365}$	Evaluated formula
Product return	payment at maturity + coupon payments rolled over until maturity at the risk-free rate	Evaluated formula
Monthly return (product/benchmark/abnormal)	holding period return / effective term	

C Additional Figures and Tables

UBS AG Trigger Phoenix Autocallable Optimization Securities

UBS AG $132,000.00 Securities Linked to the common stock of Cornerstone OnDemand, Inc. due on February 11, 2016

Final Terms	
Issuer	UBS AG, London Branch
Principal Amount	$10.00 per security. The Securities are offered at a minimum investment of 100 Securities at $10.00 per Security (representing a $1,000 investment) and integral multiples of $10.00 in excess thereof.
Term	Approximately 12 months, unless called earlier.
Underlying Equity	The common stock of Cornerstone OnDemand, Inc.
Contingent Coupon	If the closing price of the underlying equity is equal to or greater than the coupon barrier on any observation date, UBS will pay you the contingent coupon applicable to such observation date. If the closing price of the underlying equity is less than the coupon barrier on any observation date, the contingent coupon applicable to such observation date will not be payable and UBS will not make any payment to you on the relevant coupon payment date. The contingent coupon will be a fixed amount based upon equal quarterly installments at the per annum contingent coupon rate. Contingent coupons are not guaranteed and UBS will not pay you the contingent coupon for any observation date on which the closing price of the underlying equity is less than the coupon barrier. The table below reflects the contingent coupon rate of 13.24% per annum. Amounts in the table below may have been rounded for ease of analysis. Observation Date* — Contingent Coupon (per security) 04-May-2015 — $0.3310 04-Aug-2015 — $0.3310 04-Nov-2015 — $0.3310 04-Feb-2016 — $0.3310 *Observation dates are subject to the market disruption event provisions set forth in the Trigger Phoenix Autocallable Optimization Securities product supplement ("TPAOS product supplement").
Contingent Coupon Rate	13.24% per annum (or approximately 3.310% per outstanding quarter).
Automatic Call Feature	The Securities will be called automatically if the closing price of the underlying equity on any observation date is equal to or greater than the initial price. If the Securities are called on any observation date, UBS will pay you on the corresponding coupon payment date a cash payment per Security equal to your principal amount plus the contingent coupon otherwise due on such date pursuant to the contingent coupon feature. No further amounts will be owed to you under the Securities.
Payment at Maturity (per Security)	If the Securities are not called and the final price is equal to or greater than the trigger price and coupon barrier, UBS will pay you a cash payment per Security on the maturity date equal to your principal plus the contingent coupon otherwise due on the maturity date. If the Securities are not called and the final price is less than the trigger price, UBS will pay you a cash payment on the maturity date of significantly less than the principal amount, if anything, resulting in a loss of principal that is proportionate to the decline of the underlying equity, for an amount equal to $10 + ($10 x underlying return).
Underlying Return	$\frac{\text{Final Price} - \text{Initial Price}}{\text{Initial Price}}$
Closing Price	On any trading day, the last reported sale price (or, in the case of NASDAQ, the official closing price) of the underlying equity during the principal trading session on the principal national securities exchange on which it is listed for trading, as determined by the calculation agent.
Initial Price	$32.54, which is the closing price of the underlying equity on the trade date. The initial price is subject to adjustments in the case of certain corporate events, as described in the TPAOS product supplement.
Trigger Price/Coupon Barrier	$22.78, which is 70.00% of the initial price of the underlying equity. The trigger price and coupon barrier are subject to adjustments in the case of certain corporate events, as described in the TPAOS product supplement.
Final Price	The closing price of the underlying equity on the final valuation date. The final price is subject to adjustment in the case of certain corporate events, as described in the TPAOS product supplement.
Trade Date	February 4, 2015
Settlement Date	February 9, 2015
Final Valuation Date	February 4, 2016 (subject to postponement in the event of a market disruption event, as described in the TPAOS product supplement)
Maturity Date	February 11, 2016 (subject to postponement in the event of a market disruption event, as described in the TPAOS product supplement)
Coupon Payment Dates	Five business days following each observation date, except the coupon payment date for the final valuation date will be the maturity date.
CUSIP	90274L673
ISIN	US90274L6737
Valoren	26948314

The estimated initial value of the Securities as of the trade date is $9.25 for Securities linked to the underlying equity. The estimated initial value of the Securities was determined as of the close of the relevant markets on the date of this final terms supplement by reference to UBS' internal pricing models, inclusive of the internal funding rate. For more information about secondary market offers and the estimated initial value of the Securities, see "Key Risks - Fair value considerations" and "Key Risks - Limited or no secondary market and secondary market price considerations" in this final terms supplement.

Figure C.1: Pricing supplement with disclosed issuer estimated value

Investor Suitability

The suitability considerations identified below are not exhaustive. Whether or not the Notes are a suitable investment for you will depend on your individual circumstances, and you should reach an investment decision only after you and your investment, legal, tax, accounting and other advisors have carefully considered the suitability of an investment in the Notes in light of your particular circumstances. You should also review "Key Risks" on page 4 of this pricing supplement and "Risk Factors" on page 8 of the accompanying product supplement.

The Notes may be suitable for you if:

- You fully understand the risks inherent in an investment in the Notes, including the risk of loss of your entire initial investment.
- You can tolerate a loss of all or a substantial portion of your initial investment and are willing to make an investment that may have the full downside market risk of an investment in the Reference Underlying.
- You believe the Final Price of the Reference Underlying is not likely to be below the Conversion Price and, if it is, you can tolerate receiving shares of the Reference Underlying at maturity that are worth less than your initial investment or may have no value at all.
- You understand and accept that you will not participate in any appreciation in the price of the Reference Underlying and that your return at maturity is limited to the Coupon Payments.
- You are willing to accept the risks of owning equities in general and the Reference Underlying in particular.
- You can tolerate fluctuations in the price of the Notes prior to maturity that may be similar to or exceed the downside price fluctuations of the Reference Underlying.
- You are willing to invest in the Notes based on the Coupon Rate set forth on the cover of this pricing supplement.
- You are willing and able to hold the Notes to maturity, a term of approximately 6 months, and accept that there may be little or no secondary market for the Notes.
- You are willing to accept the credit risk associated with Deutsche Bank AG, as Issuer of the Notes, and understand that if Deutsche Bank AG defaults on its obligations you may not receive any amounts due to you, including any repayment of your initial investment at maturity.

The Notes may *not* be suitable for you if:

- You do not fully understand the risks inherent in an investment in the Notes, including the risk of loss of your entire initial investment.
- You require an investment designed to provide a full return of your initial investment at maturity.
- You are not willing to make an investment that may have the full downside market risk of an investment in the Reference Underlying.
- You believe the Final Price of the Reference Underlying is likely to be below the Conversion Price, which could result in a total loss of your initial investment.
- You cannot tolerate receiving shares of the Reference Underlying at maturity that are worth less than your initial investment or may have no value at all.
- You seek an investment that participates in the full appreciation in the price of the Reference Underlying or that has unlimited return potential.
- You are not willing to accept the risks of owning equities in general and the Reference Underlying in particular.
- You cannot tolerate fluctuations in the price of the Notes prior to maturity that may be similar to or exceed the downside price fluctuations of the Reference Underlying.
- You are not willing to invest in the Notes based on the Coupon Rate set forth on the cover of this pricing supplement.
- You are unable or unwilling to hold the Notes to maturity, a term of approximately 6 months, and seek an investment for which there will be an active secondary market.
- You are not willing or are unable to assume the credit risk associated with Deutsche Bank AG, as Issuer of the Notes for all payments on the Notes, including any repayment of your initial investment at maturity.

Figure C.2: Investor suitability section of product prospectus

Table C.1: Example of Plain Vanilla Product

The table presents an example of a product with no exotic feature, its payoff description, translation into a mathematical formula, and decomposition into a bond and an option. Prices of the underlying are normalized to 1 at issuance.

Panel A: Product characteristics

Name	Airbag Yield Optimization Notes
Issuer	UBS
CUSIP	90272G254
Volume	\$0.35 million
Year	2014
Term	12 months
Headline rate	5.22%
Underlying	Apple
Payoff description	This is an income product linked to the share of Apple. The product offers a coupon of 5.22% p.a., paid monthly throughout the investment period. At maturity, the product offers a capital return of 100%, if the final share level does not fall by more than 5% from its initial level. Otherwise the capital return equals 100%, minus 1.0526% for every 1% fall in excess of the initial 5% fall, paid in shares.

Panel B: Payoff translation and decomposition

Translated formula

$$P_T = \begin{cases} 1 & \text{if } S_T \geq 0.95 \\ 1 - 1.0526(0.95 - S_T) & \text{otherwise} \end{cases}$$

$$P_m = 0.522 \times \Delta t \quad \text{for monthly observation dates } m = 1, \ldots, M$$

Decomposition

Long bond, 5.22% monthly coupon

Short 1.0526× put, $K = 0.95$

Table C.2: Example of Product with Binary Feature

The table presents an example of a product with a binary feature, its payoff description, translation into a mathematical formula, and decomposition into a series of conditional options. Prices of the underlying are normalized to 1 at issuance.

Panel A: Product characteristics

Name	Trigger Yield Optimization Notes
Issuer	Barclays Bank
CUSIP	06741K361
Volume	\$7.21 million
Year	2011
Term	6 months
Headline rate	9.93%
Underlying	Nabors Industries
Payoff description	This is an income product linked to the share of Nabors Industries. The product offers a coupon of 9.93% p.a., paid monthly throughout the investment period. At maturity, the product offers a capital return of 100%, if the final share level does not fall by more than 25% from its initial level. Otherwise the capital return equals 100%, minus 1% for every 1% fall, paid in shares.

Panel B: Payoff translation and decomposition

Translated formula

$$P_T = \begin{cases} 1 & \text{if } S_T \geq 0.75 \\ S_T & \text{otherwise} \end{cases}$$

$$P_m = 0.993 \times \Delta t \quad \text{for monthly observation dates } m = 1, \ldots, M$$

Decomposition

Long bond, 9.93% monthly coupon

Short cash-or-nothing put, $K = 0.75, Q = 1$

Long asset-or-nothing put, $K = 0.75$

Table C.3: Example of Product with Knock-Out Feature

The table presents an example of a product that can terminate early, its payoff description, translation into a mathematical formula, and decomposition into a series of conditional options. Prices of the underlying are normalized to 1 at issuance. *Maximum term* is the maximum maturity if the product does not terminate early. *Expected term* is estimated under the risk-neutral probabilities of termination on each observation date. *Effective term* is calculated by evaluating the conditions for early termination on each observation date.

Panel A: Product characteristics

Name	Trigger Phoenix Autocallable Notes
Issuer	RBC
CUSIP	78010UZA8
Volume	\$0.5 million
Year	2014
Maximum term	18 months
Expected term	5 months
Effective term	3 months
Headline rate	13.8%
Underlying	Facebook
Payoff description	This is an income product linked to the share of Facebook. The product offers a coupon of 13.8% p.a., paid quarterly, if the share level does not fall by 30% or more from its initial level on the applicable quarterly observation date. Otherwise, no coupon is paid for that observation period. The product can terminate early on any quarterly observation date if the share level is greater than or equal to its initial level. In that case, the product terminates with a payout equal to 100% of the capital plus the coupon. At maturity, the product offers a capital return of 100%, if the final share level does not fall by 30% or more from its initial level. Otherwise the capital return equals 100%, minus 1% for every 1% fall, paid in cash or shares.

Panel B: Payoff translation and decomposition

Translated formula

$$P_T = \begin{cases} 1 & \text{if } S_n < 1, \forall n = 1, \ldots, M-1 \text{ and } S_T > 0.7 \\ S_T & \text{if } S_n < 1, \forall n = 1, \ldots, M-1 \text{ and } S_T \leq 0.7 \\ 0 & \text{otherwise} \end{cases}$$

$$P_m = \begin{cases} 1 + 0.138 \times \Delta t & \text{if } S_n < 1, \forall n = 1, \ldots, m-1 \text{ and } S_m \geq 1 \\ 0.138 \times \Delta t & \text{if } S_n < 1, \forall n = 1, \ldots, m-1,\ S_m > 0.7 \text{ and } S_m < 1 \\ 0 & \text{otherwise} \end{cases}$$

Decomposition

Long series of conditional cash-or-nothing calls for quarterly observation dates $m = 1, \ldots, M-1$, $Q_m = 1 | S_n < 1, \forall n = 1, \ldots, m-1$ and $S_m \geq 1$

Long series of conditional cash-or-nothing calls for quarterly observation dates $m = 1, \ldots, M$, $Q_m = 0.138 \times \Delta t | S_n < 1, \forall n = 1, \ldots, m-1$ and $S_m > 0.7$

Long conditional cash-or-nothing call $K = 0.7, Q_M = 1 | S_n < 1, \forall n = 1, \ldots, M-1$

Long conditional asset-or-nothing put $K = 0.7 | S_n < 1, \forall n = 1, \ldots, M-1$

Table C.4: Margins, Expected Returns, and Ex-Post Returns for a Sample of 100 Products

The table reports estimated values and ex-post returns for a sample of 100 products—10 products with median volume in each year. *Margins* are estimated using the pricing model described in Section 4 and are not adjusted for the credit risk of the issuer. To estimate the expected returns, I assume the expected excess return on the underlying equals $\mu - r = \hat{\beta} \times 6\%$ *p.a.* *Product return* is the sum of the payoff at maturity and the coupon payments rolled over at the risk-free rate until maturity. *Abnormal return* is the difference between product return and benchmark return—the cumulative return of delta equivalent daily adjusted positions in the underlying equity and risk-free rate over the term of the product. *Expected term* (in months) is estimated using the risk-neutral probabilities of early termination.

					Holding Period Returns		
Issue month	Issuer	Underlying	Expected term	Margin	Expected	Product	Abnormal
2006-10	JPMorgan Chase	AMR	6	3.4	3.5	10.1	-2.1
2006-6	ABN Amro Bank	Wal-Mart	12	2.4	4.1	8.5	-0.5
2006-9	ABN Amro Bank	Apple	12	4.8	3.0	11.2	-2.4
2006-9	JPMorgan Chase	NaborsIndustries	12	3.3	3.4	10.2	0.7
2006-11	JPMorgan Chase	JetBlueAirways	12	3.0	1.8	-33.2	-11.1
2006-11	JPMorgan Chase	JoyGlobal	12	4.0	5.2	15.3	-1.7
2006-6	ABN Amro Bank	ValeroEnergy	12	3.6	3.2	12.5	2.8
2006-11	Credit Suisse	RedHat	6	2.7	1.9	8.7	-4.3
2006-11	JPMorgan Chase	AtherosCommunications	12	4.9	9.3	19.0	2.7
2006-12	ABN Amro Bank	GeneralMotors	12	2.4	4.9	14.3	-4.4
2007-8	ABN Amro Bank	CSX	6	3.7	-0.2	-7.1	-4.0
2007-12	ABN Amro Bank	FannieMae	3	3.7	-2.3	-8.0	-12.1
2007-8	RBC	GeneralMotors	3	4.2	-2.5	3.1	-5.1
2007-6	RBC	TitaniumMetals	6	3.8	-0.5	7.3	-3.4
2007-11	JPMorgan Chase	GoldmanSachs	6	4.3	-0.8	7.5	-3.5
2007-6	RBC	GeneralMotors	6	2.9	0.9	-19.2	-3.1
2007-10	RBC	Bowater	3	3.6	-1.8	-37.1	-7.5
2007-4	RBC	eBay	6	2.2	1.8	6.2	0.0
2007-11	JPMorgan Chase	Schlumberger	12	3.3	2.4	-35.8	-15.0
2007-7	JPMorgan Chase	Deere&Company	12	6.0	1.6	10.2	-7.9

Table C.4: Margins, Expected Returns, and Ex-Post Returns for a Sample of 100 Products, cont.

					Holding Period Returns		
Issue month	Issuer	Underlying	Expected term	Margin	Expected	Product	Abnormal
2008-7	JPMorgan Chase	PeabodyEnergy	3	4.5	-3.1	-51.3	-7.6
2008-5	HSBC Bank	ValeroEnergy	6	5.4	-3.2	-57.0	-8.7
2008-8	RBC	FreeportMcMoran	3	3.4	-2.1	-70.0	-10.2
2008-2	RBC	AT&T	12	4.6	0.0	-21.3	-0.9
2008-4	HSBC Bank	ValeroEnergy	12	2.2	1.3	-48.7	-2.6
2008-2	RBC	Apple	3	2.2	-0.6	3.7	-3.9
2008-10	ABN Amro Bank	Apache	3	6.5	-5.9	3.2	-8.8
2008-8	ABN Amro Bank	TransoceanSedco	12	3.2	1.2	-30.0	-12.0
2008-9	Barclays Bank	Monsanto	3	4.1	-3.0	-20.2	-7.1
2008-5	Barclays Bank	FlextronicsInternational	6	5.1	-2.3	-73.8	-8.2
2009-11	RBC	LincolnNational	3	0.6	0.7	5.2	1.6
2009-10	ABN Amro Bank	UnitedStatesSteel	3	1.4	-0.1	3.7	-2.4
2009-6	JPMorgan Chase	JamesRiverCoal	3	6.8	-5.7	6.3	-0.3
2009-3	JPMorgan Chase	GoldmanSachs	3	-1.0	1.4	5.2	2.1
2009-7	RBC	WellsFargo	3	3.8	-2.9	6.6	0.4
2009-11	RBC	KeyCorp	3	2.3	-2.0	6.2	-0.1
2009-8	RBC	BankofAmerica	3	3.5	-2.1	4.2	-1.4
2009-11	RBC	AlleghenyTechnologies	3	2.1	-1.0	4.6	-1.1
2009-9	ABN Amro Bank	Alcoa	6	5.0	-2.5	9.2	-1.3
2009-4	ABN Amro Bank	AKSteel	3	7.5	-5.6	7.3	-7.9
2010-7	Barclays Bank	MetLife	6	4.2	-1.9	5.2	0.2
2010-4	Barclays Bank	DiscoverFinancialServices	12	6.8	-2.6	9.2	-4.7
2010-4	Barclays Bank	MorganStanley	12	7.3	-3.9	-5.6	-13.4
2010-4	Barclays Bank	Patterson-UTIEnergy	6	5.7	-3.8	5.6	-4.2
2010-4	Barclays Bank	ZionsBancorporation	12	10.7	-8.5	-2.2	-8.9
2010-11	UBS	Intel	12	4.2	-1.3	8.1	-1.8
2010-5	Barclays Bank	LeapWireless	6	8.8	-6.7	-22.2	-2.7
2010-4	Barclays Bank	RowanCompanies	12	6.6	-2.4	9.5	-3.7
2010-4	Barclays Bank	ForestOil	6	7.0	-5.0	5.3	-3.5
2010-5	Barclays Bank	CirrusLogic	18	8.7	-5.2	24.2	-1.9

Table C.4: Margins, Expected Returns, and Ex-Post Returns for a Sample of 100 Products, cont.

					Holding Period Returns		
Issue month	Issuer	Underlying	Expected term	Margin	Expected	Product	Abnormal
2011-11	Deutsche Bank	StateStreet	12	6.8	-3.6	11.0	2.5
2011-11	JPMorgan Chase	Schlumberger	6	5.7	-4.0	6.9	-0.2
2011-9	UBS	Apple	6	4.9	-3.3	6.0	-0.1
2011-11	UBS	Ford	7	-0.5	4.5	5.5	-0.5
2011-10	RBC	GeneralElectric	3	0.3	0.6	3.9	-1.5
2011-11	Bank of Montreal	Apple	6	1.8	-0.4	6.5	1.5
2011-9	UBS	Halliburton	12	6.1	-2.9	11.0	7.2
2011-1	JPMorgan Chase	PeabodyEnergy	6	3.6	-1.9	5.0	-1.6
2011-4	RBC	LasVegasSands	3	3.3	-1.1	3.4	0.0
2011-4	Bank of Montreal	NVIDIA	3	3.2	-2.2	-19.8	-1.7
2012-3	Bank of Montreal	AKSteel	3	2.2	-1.0	-28.8	4.0
2012-10	RBC	JoyGlobal	3	3.9	-2.7	3.1	-0.7
2012-8	Barclays Bank	Expedia	6	4.4	-2.4	5.6	-4.0
2012-6	UBS	Caterpillar	12	6.8	-2.5	8.5	2.9
2012-12	UBS	FreeportMcMoran	12	5.2	-0.7	8.1	-2.5
2012-2	UBS	WeatherfordInternational	7	5.0	-2.3	8.1	9.2
2012-1	UBS	Cummins	12	5.6	-1.3	8.1	-1.1
2012-12	UBS	Citigroup	7	3.7	-0.3	2.0	-2.9
2012-2	JPMorgan Chase	Cummins	6	4.1	-1.7	-15.4	0.9
2012-5	RBC	PeabodyEnergy	3	3.6	-2.8	3.8	-6.1
2013-9	RBC	Netflix	3	3.8	-3.3	3.2	-3.0
2013-12	RBC	CliffsNaturalResources	3	4.3	-3.1	3.7	13.4
2013-4	RBC	PeabodyEnergy	3	3.6	-2.7	-19.9	-4.6
2013-11	RBC	RedHat	3	1.8	-1.2	2.5	-3.1
2013-12	UBS	PulteGroup	7	2.3	0.2	3.4	-1.5
2013-8	UBS	MarvellTechnology	7	2.9	-1.0	5.3	1.4
2013-8	UBS	PulteGroup	7	3.4	-1.2	4.2	-0.9
2013-3	JPMorgan Chase	BankofAmerica	12	4.2	1.0	7.5	-0.9
2013-4	UBS	VMWare	7	1.6	0.6	4.1	-5.2
2013-8	JPMorgan Chase	Whirlpool	12	3.5	1.3	9.5	-1.1

Table C.4: Margins, Expected Returns, and Ex-Post Returns for a Sample of 100 Products, cont.

					Holding Period Returns		
Issue month	Issuer	Underlying	Expected term	Margin	Expected	Product	Abnormal
2014-9	RBC	Apple	18	4.3	-0.6	10.1	-4.7
2014-8	UBS	Medivation	9	-0.3	1.9	4.3	-1.6
2014-11	UBS	GenworthFinancial	12	7.2	-3.1	-35.5	0.0
2014-1	UBS	Yahoo	7	2.9	-1.8	10.0	2.4
2014-2	RBC	TeslaMotors	3	4.9	-4.6	3.9	-1.6
2014-8	UBS	Salesforce	12	4.7	-2.1	8.1	-3.3
2014-2	RBC	KBHome	3	3.6	-2.4	2.3	3.4
2014-6	UBS	Expedia	12	4.1	-1.4	8.7	-3.4
2014-1	UBS	Tesoro	9	3.1	-0.6	2.7	2.3
2014-2	UBS	LasVegasSands	12	4.6	2.2	-18.3	-1.3
2015-1	UBS	Linkedin	7	3.9	-1.8	3.3	-2.0
2015-6	UBS	UnitedStatesSteel	9	8.5	-5.5	-28.1	-13.4
2015-8	UBS	Salesforce	6	3.3	-1.8	5.5	-7.0
2015-4	UBS	Apple	12	4.6	-2.6	4.8	-1.9
2015-1	UBS	Facebook	4	2.3	-1.3	0.7	-1.4
2015-2	UBS	FreeportMcMoran	12	6.5	-1.5	-52.9	-4.6
2015-2	UBS	Amgen	12	5.0	-3.5	5.5	-3.0
2015-2	UBS	MicronTechnology	7	2.3	0.0	-63.6	-21.1
2015-4	UBS	TataMotor	12	4.8	-0.6	-29.3	-2.1
2015-3	UBS	WynnResorts	12	4.8	-1.2	-20.4	-10.6