



Structured Products In the Aftermath of Lehman Brothers

In a previous working paper, we illustrated the two general types of equity-linked structured products sold to retail investors in the United States – principal protected notes and enhanced yield-notes. By way of examples of our general thesis that retail structured products were over-priced at their initial offering, we reported on the valuation of Merrill Lynch's 7-Year S&P 500 MITTS® issued on August 30, 2002, JP Morgan's 5-Year Capped Quarterly Observation Notes linked to the S&P 500 issued on June 22, 2004 and Citigroup's 3-Year, Intel-linked TARGETS® issued on February 15, 2005.

Our 2006 working paper on structured products has been joined by work from other authors demonstrating that structured products sold to retail investors in initial public offerings were extraordinarily poor investments.¹ In this paper, we review recent literature and market events and extend our previous work to document the systematic over-pricing of a particular type of equity-linked structured product – reverse convertible notes. We also present an analysis of the Lehman Brothers structured products program because it illustrated the primary risk in retail structured products – credit risk – to devastating effect.

I. Introduction

Structured products have been issued by brokerage firms since the 1980s. Initially sold to institutional investors they increasingly found their way into retail investors accounts since 2006.² Investors purchase structured products in initial offerings. While some structured products are listed, they are very thinly traded. The payment of structured products is derived from the performance of various underlying assets, such as stocks, an index, a commodity, interest rates, foreign currencies, or a combination thereof.³ Because of their complex features, structured products embrace various risks such as credit risk, liquidity risk, call risk, interest rate risk, foreign exchange rate risk, yield curve risk, volatility risk, etc.

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¹ See “Are Structured Products Suitable for Retail Investors?” December 15, 2006, slightly revised May 1, 2007, available at www.SLCG.com.

² “An Arcane Investment Hits Main Street: Wall Street Pushes Complex ‘Structured Products’, Long Aimed at Institutions, to Individuals,” WSJ, June 21, 2006 reported that in 2006, out of 1400 structured products for U.S. individual investors, nearly 650 of which were launched in 2006.

³ The SEC defines structured products as

“securities whose cash flow characteristics depend upon one or more indices or that have embedded forwards or options or securities where an investor’s investment return and the issuer’s payment obligations are contingent on, or highly sensitive to, changes in the value of underlying assets, indices, interest rates or cash flows.”

See SEC Rule 434 (Prospectus Delivery Requirements in Firm Commitment Underwritten Offerings of Securities for Cash), available at <http://www.sec.gov/rules/final/prosdel.txt>.

Our prior work showed that retail structured products were poor investments because they were significantly overpriced at the offerings and were at best thinly traded thereafter. The overpricing of these products is in part attributable to the fact investors were exposed to the credit risk of the issuing brokerage firms without adequate compensation. Overpriced structured products survived in the marketplace because structured products' opaqueness obscured their true risks and costs and the high fees earned by underwriters and salespersons. The potential for high fees and commissions created strong incentives to develop and sell ever more complex variants of these inferior investments.

Since first distributing our research in December 2006 we, and other academics and practitioners, have continued our research, and regulators have taken notice.⁴ This paper reports our most recent research on a particular type of equity-linked structured product – reverse convertible notes. We conclude that reverse convertible notes sold to retail investors in initial public offerings were dominated by other readily available investments and so should have been recognized as *per se* unsuitable for any investor.⁵

We present a brief history of the structured products program at Lehman Brothers and illustrate many of our points with Lehman structured products examples. The spectacular failure of Lehman brothers in September 2008 left investors holding more than \$18.6 billion face value of what had been previously sold as low risk investments but which were now worthless.⁶ The Lehman experience is especially instructive of the opportunity for mischief presented by financial engineering; faced with increasing borrowing costs Lehman stepped up its issuance of structured products where its credit risk would not be priced into the debt. The harm thereby inflicted on retail investors was a direct transfer from unsophisticated retail investors to Lehman and UBS which co-underwrote much of the Lehman Brothers structured product issuance. This transfer from retail investors was only possible because Lehman and UBS made the structured products increasingly complex and opaque.

II. Principal Protected Notes

A. General Design

Principal protected notes provide for the return of principal and the payment of additional amounts to investors contingent on the value of pre-specified stocks, stock indexes, interest rates, exchange rates, commodities or other assets or baskets of assets at maturity.⁷ In general, if the underlying asset or assets has a positive return at the note's maturity, the note pays investors principal plus a positive return. If the underlying asset has a zero or negative return at the bond's maturity, the note generally pays only principal to the investor.

⁴ See NASD Notice to Members 05-59 - September 2005, NASD Provides Guidance Concerning the Sale of Structured Products available at <http://www.finra.org/Industry/Regulation/Notices/2005/P014998>.

⁵ See "An Arcane Investment Hits Main Street: Wall Street Pushes Complex 'Structured Products,' Long Aimed at Institutions, to Individuals" *Wall Street Journal* June 21, 2006, D1 and "Guaranteed to Go Up" *Forbes* November 27, 2006, p. 79-80.

⁶ Of the \$18.6 billion, \$8.1 billion was issued in US dollar-denominated notes. The data is from Bloomberg.

⁷ These products generally repay principal at maturity, although they may pay less than 100% (called "partial principal protection") in some circumstances.

Lehman Brothers issued a staggering assortment of principal protected notes, such as “100% Principal Protected Absolute Return Barrier Notes Linked to a Basket of Global Indices”, “Principal Protected Note with Enhanced Participation linked to a Basket of Commodities”, “Return Optimization Securities with Partial Protection Linked to a Portfolio of Common Stocks”, “100% Principal Protected Notes Linked to the S&P 500 Index”, and “100% Principal Protected Notes Linked to an Asian Currency Basket.”

The “Principal Protected” label is misused to market structured products which claim to guarantee the return of principal.⁸ The principal in a principal protected note is typically “guaranteed” to exactly the same degree as the principal in an unsecured subordinated note is guaranteed. The terms “principal protected” and “guaranteed return of principal” were used in the marketing of structured products and not in the marketing of unsecured subordinated notes because, when combined with the superfluous complexity of the coupon payment formulas, they were effective at masking the substantial credit risk in structured products. More accurate risk disclosure would have stated that repayment of any amount at maturity was contingent on the continued viability of the issuing brokerage firms and that any additional payments beyond the return of principal carried the additional risks of the assets to which those payments were linked.

Because principal protected notes purported to guarantee principal, they were easy to market to investors seeking low risk investments. In fact, many individuals who invested in principal protected notes were close to or already in retirement and wanted to invest conservatively in “risk-free” investments. However, investors in structured products bear not only the risk of the underlying asset, but also the credit risk of the issuing brokerage firm. If the issuing brokerage becomes insolvent before the note is repaid, investors may not recover any of their investment.⁹ The misleading name of the “100% Principal Protection Notes” makes it easy to neglect the credit risk and liquidity risk inherent in these notes.

B. Stock and Stock Index Products

The simplest principal protected notes had payoffs at maturity which were very similar to the payoffs to a combination of a note and a call option maturing at the same time as the structured product. We illustrate this simplest of structures with a Lehman Brothers product linked to a common basket of stocks – the S&P 500 Index.

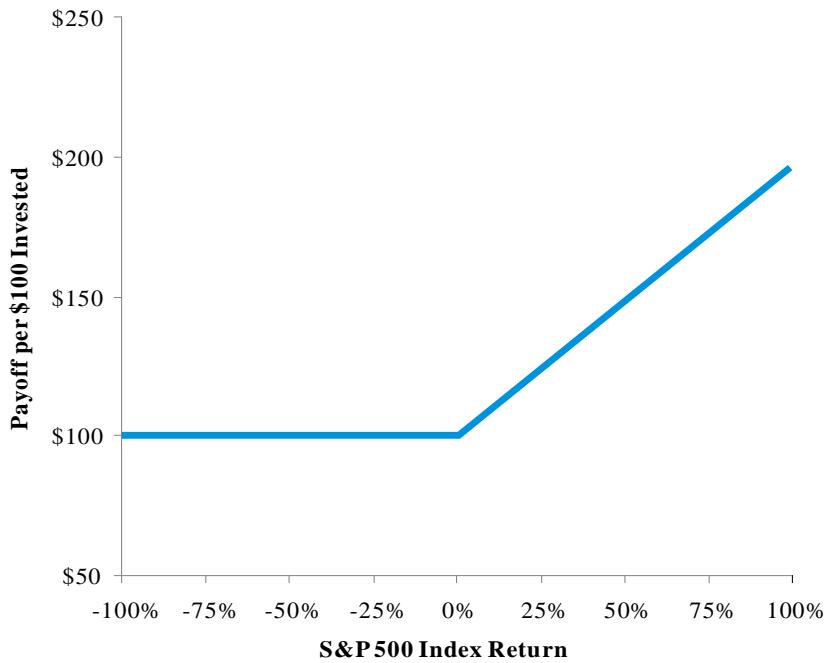
Lehman Brothers issued “100% Principal Protected Notes Linked to the S&P 500 Index” (CUSIP: 5252M0GW1) on August 1, 2008 with a maturity of August 6, 2011. At the note’s maturity, if the S&P 500 Index closed higher than the initial level on issue date, i.e., had a capital gain, – and Lehman Brothers was solvent – the investor was to receive the face value of the note plus an additional amount equal to the index price appreciation. If at maturity the index closed

⁸ CDO issuers took the abuse of language to nearly unfathomable extremes when they attached thin strips of long maturity Treasury securities to the equity tranche in CDOs and marketed the resulting combined security as a Principal Protected Note.

⁹ Lehman Brothers structured products are senior unsecured obligations of Lehman Brothers. Some Lehman Brothers structured products were trading for less than 10 cents on the dollar in November 2008 after Lehman filed for bankruptcy on September 15, 2008. See “Another ‘Safe’ Bet Leaves Many Burned”, *Wall Street Journal*, November 11, 2008.

below the index level on the offering date, the investor was to receive only the face value of the note. **Figure 1** shows the payoff diagram for a \$100 investment in this principal protected note.

Figure 1: Payoff diagram for \$100 invested in “100% Principal Protected Notes Linked to the S&P 500 Index.” The S&P 500 index level on the issue date was 1,260. The maturity payoffs are the same as investing in a combination of a zero-coupon Lehman note and a call option with strike price of 1,260, or a 0% return.



This example principal protected note has payoffs which are virtually identical to an investment in a three-year, zero-coupon \$100 face-value unsecured subordinated note issued by Lehman Brothers and a three-year at-the-money S&P 500 Index call option issued on August 1, 2008. Because such a note and call option can be easily valued and their payoffs replicate the payoffs to the structured product, they provide a straightforward measure of the value of the structured product. The \$100 zero-coupon Lehman note was worth \$78.13 and Lehman’s unsecured promise to deliver the payoff to the three year at-the-money index call option was worth \$11.14. Together these values imply that this structured product was worth only \$89.27 per \$100 when it was issued on August 1, 2008.¹⁰

C. Interest Rate Structure Products

Some principal protected notes, branded by Lehman as Steepeners, Spread Range Accrual Notes and Range Notes, paid coupons linked to interest rates. These products had maturities as long as 30 years and were usually callable at par on any interest payment date after a brief non-callable period.

Steepeners promised a high fixed coupon for an introductory period, after which they pay a floating coupon rate equal to a multiple of the spread between the yield on a long maturity

¹⁰ Whenever we report valuations throughout the paper we are essentially performing this same calculation. That is, our valuations of structured products involves valuing combinations of stocks, bonds and options which replicate or exceed the payoffs of the structured product in every possible state of the world at maturity.

reference bond and the yield on a short maturity reference bond subject to a minimum of 0% coupon rate, paying more interest the steeper the yield curve on coupon determination dates.

Spread Range Accrual Notes promised an annualized coupon rate each quarter equal to a fixed interest rate multiplied by an “interest accrual factor” equal to the percentage of days in the preceding quarter that a particular relationship between two interest rates held. For example, the “interest accrual factor” might be defined as the percentage of days during a quarter when the 30-year constant maturity swap (“CMS”) rate is greater than the 2-year CMS rate.

A Range Note is similar to a Spread Range Accrual Note, but defines the “interest rate accrual factor” as the percentage of days in the preceding quarter that a reference interest rate satisfied a particular condition. For example, a Range Note might define the “interest rate accrual factor” as the percentage of days in a quarter when the 6-month U.S. LIBOR is greater than 0% and less than 7%.

We illustrate the payoffs of an interest rate structured product with a Lehman Brothers Steepener Note (CUSIP: 52517PZ38), issued on June 7, 2007 with a maturity of 15 years. The note initially pays an 11% annual coupon rate quarterly and is not callable during the first two years. Thereafter the note may be called by Lehman Brothers on any coupon payment date at par.¹¹ If the note is not called, the floating coupon rate is calculated as 50 times the excess, if any, of the 30-year CMS rate over the 15-year CMS rate on the coupon determination dates.

Without the embedded call option, this Steepener note would be an attractive investment. From September 1992 to June 2007, the historical average spread between 30-year CMS rate and 10-year CMS rate was 0.4168%. Were this average spread to persist during the life of the Steepener, the average coupon rate would be over 20%. However, the value of Lehman’s option to call the bond is critical to the valuation of this Steepener. Using Bloomberg’s CMS spread model to compute the value of this product, we determined that the Steepener would appear to be worth \$124.53 per \$100 at the initial offering if we ignore Lehman’s option to call the note. The cost to investors of the embedded short call option is an extraordinarily high 41.48% of the face value and so the product’s value on the offering was, at most, \$83.05 per \$100.

As the example illustrates, interest rate structured products are subject to significant call risks. The call dates are periodic and the optimal exercise behavior is a complicated function of stochastic term structures of interest rates making it extremely difficult for even the most sophisticated investor to correctly evaluate the embedded call risk at the time of investment. Interest rate linked structured products expose investors to leveraged yield curve risk and volatility risk. Yield curve risk comes from the steepening or flattening of the spread between long-term and short-term interest rates. The volatility risk can either come from the fluctuation of interest rates spread, or from the interest rate evolution itself in the case of Range Notes.

Even this overstates the value of the Steepener and other callable structured products. In addition to the call option based on market interest rate volatilities, investors grant Lehman an

¹¹ This is an embedded Bermudan call option, referred to as a Bermudan call option because it is somewhere in between an American option which can be exercised at any time prior to expiration and a European option which can be exercised only at maturity.

option on Lehman Brothers credit risk. Lehman is more likely to call the Steepener if its credit quality has improved since the structured product was issued than it is to call the security if its credit quality has deteriorated. Thus investors are more likely to be left with the callable structured product the more its yield fails to compensate for Lehman's evolving credit risk.

D. Currency-Linked Structured Products

Some principal protected notes are linked to exchange rates or baskets of exchange rates. Examples include Lehman Brothers' "Foreign Exchange Basket Linked Notes", "Principal Protection Notes Linked to an Asian Currency Basket", and "Principal Protection Notes with Enhanced Participation Linked to a Latin American Currency Basket".

These currency-linked notes have payoffs which are a function of the appreciation or depreciation in a basket of foreign currencies relative to the U.S. dollar and typically mature in one to three years. At maturity, if the issuing brokerage firm is solvent the investor is repaid the face value of the note plus an amount equal to the weighted average return, if positive, on the basket of currencies multiplied by the leverage ratio; otherwise, the investor is repaid the note's face value.¹² These currency-linked structured products can be designed to generate positive returns if and only if there is depreciation in the specified basket of currencies.¹³

Currency-linked structured products are subject to currency risk, exchange-rate risk, volatility risk, political risk, interest rate risk, credit risk and liquidity risk. Currency risk, political risk and interest rate risk are related to the uncertainty of changes in the monetary policies of a country that may cause currency appreciation or depreciation.

On November 27, 2007, Lehman Brothers issued a "100% Principal Protected Notes Linked to An Asian Currency Basket" (CUSIP: 52520w333) that was to mature in two years. This note was linked to a basket of four Asian currencies: the Chinese Renminbi (CNY), Indonesian Rupiah (IDR), Indian Rupee (INR) and Philippine Peso (PHP). The basket return at maturity was defined as the sum of the equally-weighted average holding-period returns of the four currencies. The holding-period return of each reference currency is defined as the initial currency exchange rate on the issue date minus the final exchange rate on maturity date, divided by the initial exchange rate.¹⁴ If, at maturity, the basket return is positive, the note pays the face value plus an additional amount equal to 2.05 times the basket return. Otherwise, the investor receives only the note's face value.

This "100% Principal Protected Notes Linked to An Asian Currency Basket" can be valued as an unsecured Lehman note and Lehman's unsecured promise to deliver the payoffs to a set of currency options. Using standard valuation methods we determined it was worth \$89.39 per \$100 when it was issued on November 27, 2007.

¹² The calculation of basket returns is specified in the prospectus. It is usually an equal weighting among the reference currencies. If the note is designed for capitalizing the depreciation in foreign currencies, the return each reference currency is defined as the initial exchange rate minus the settlement exchange rate, then divided by the initial exchange rate.

¹³ There is usually no downside protection if the leverage ratio is greater than 100% on the upside.

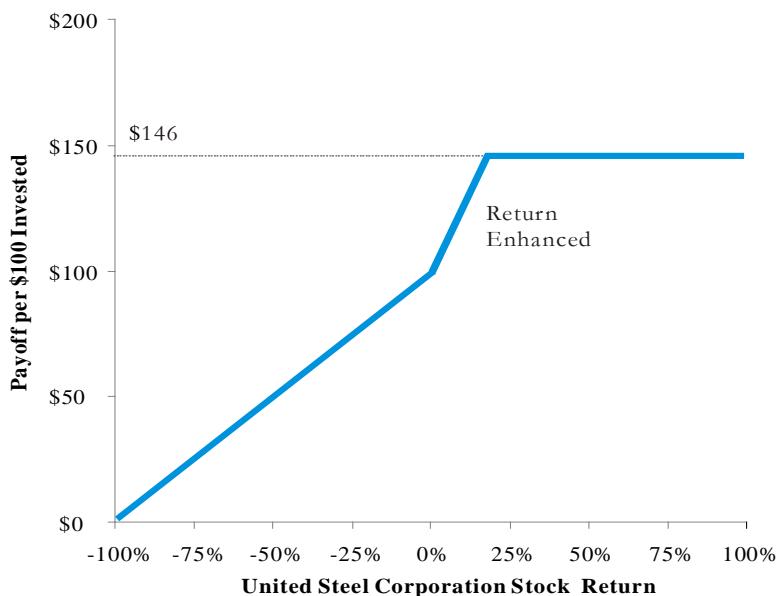
¹⁴ This note is designed to capitalize on the depreciation of Asian currencies relative to the U.S. dollar. In other words, the basket return will be positive if and only if some or all of the reference currencies depreciate in value in 2 years.

III. Enhance Yield / Enhanced Return Notes

Some structured products promised “enhanced yield” compared to conventional debt. Others leverage the returns to stocks or stock indices over some range. Both types of enhanced notes expose investors to the downside in the stock or stock index linked to them. The enhanced yield or return in part is compensation for the embedded option on the underlying security of the structured product.

Consider the “Return Enhanced Notes Linked to the Common Stock of United States Steel Corporation” (CUSIP: 524935DC4) issued on June 26, 2008 to mature in 13 months. If the closing price of the common stock of United States Steel Corporation (Ticker: X) at the note’s maturity exceeded the closing price on June 26, 2008, and Lehman was solvent, the investor was to receive the face value of the note plus an additional return, defined as the three times the capital appreciation in U.S. Steel’s stock price during the term of the note, subject to a maximum return of 46%. If the U.S. Steel stock price declined over the term of the note, investors suffered the same percentage capital loss applied to the face value of their investment in the notes. The payoff diagram is plotted in **Figure 2**.

Figure 2: Payoff diagram for \$100 invested in “Return Enhanced Notes Linked to the Common Stock of United States Steel Corporation (X)”. The structured note enhances the positive return of the United Steel Corp stock, while with an upper side limit 46%. The note is not principal protected – it bears the same negative return as the United Steel Corp stock.



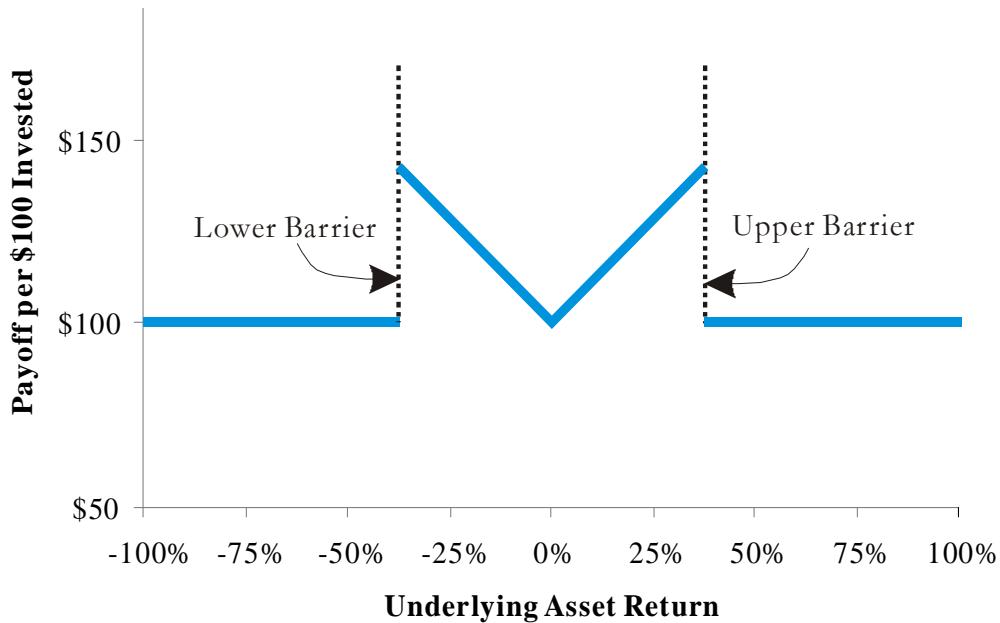
Payoffs to this Return Enhanced Note tied to U.S. Steel stock can be replicated with a \$100 face value, zero coupon Lehman Brothers unsecured 13-month note, three at the money call options on U.S. Steel, three short call options on U.S. Steel struck at 46% above the U.S. Steel closing price on the issue date and one short at the money put option – all expiring on the date the structured product matures. We valued this Return Enhanced Note and determined that it was worth \$88.48 per \$100 when it was offered on June 26, 2008.

IV. Absolute Barrier Notes

Some structured notes pay a coupon equal to the absolute value of the change in the value on some underlying asset during the term of the note. Consider the 100% Principal Protection Absolute Return Barrier Notes Linked to a Basket of Global Indices (Cusip: 52522L830) issued on April 1, 2008 with an 18-month maturity. The underlying assets, which the payoff of the note is linked to, are a basket of five securities: the S&P 500® Index (SPX), the Russell 2000® Index (RTY), the MSCI EAFE Index® (MXEA), the Dow Jones EURO STOXX 50® Index (SX5E) and the NASDAQ-100 Index® (NDX). The basket return is calculated as the weighted average of the index returns, where the weights for the indices (SPX, RTY, MXEA, SX5E and NDX) are 40%, 20%, 20%, 10% and 10%, respectively. **Figure 3** shows the payoff diagram.

If the basket's cumulative return is ever above or below the “absolute return barriers”, the investor will receive only the face value without any additional return at maturity. For this particular note, the absolute return barriers are [-20.66%, 20.66%]. If the basket return never goes above 20.66% or below -20.66% during the life of the note, at maturity investors will get back the face value of the note with an additional return equal to the absolute value of the holding period basket return. We have evaluated the product. It was worth \$94.7 per \$100 at issuance.

Figure 3: Payoff diagrams of the “100% Principal Protected Absolute Barrier Notes Linked to a Basket of Global Indices” If the basket's cumulative returns remain within the “barriers” every day during the term, the structured note repays the face value and the absolute value of the basket return at maturity. Otherwise the note repays only the face value.



V. Reverse Convertible Notes

Reverse convertible notes (also called reverse exchangeable notes) pay coupons like a traditional coupon bond, but at a higher rate than the prevailing market rate, ranging from 7% to 40% or more.¹⁵ The maturity of reserve convertible notes ranges from 3 months to 2 years. Unlike a traditional coupon bond that pays the face value at maturity, reverse convertible notes' payments at maturity are a contingent claim on the performance of the underlying asset, typically a stock. If, on the maturity date, the underlying asset's value is less than the asset's initial value on the issue date,¹⁶ the notes will be exchanged for shares of the underlying stock which can be worth significantly less than the face value of the note.

When an investor buys a reverse convertible note, she is at the same time selling a call or put option or some complex options to the issuer. She is obligated to buy shares of the underlying assets from the issuer at maturity, if the underlying asset has dropped significantly. The more volatile the underlying asset is, the higher the option cost to this product, hence the higher the required yield (coupon rate) of reverse convertible note. Consequently, the higher coupon rates in excess of the market rates are merely option premiums and interest on premiums paid by the bond issuer to the investors.

Reverse convertible notes' inflated stated coupon rates are a useful feature of in marketing these products to individual investors. In 2007, retail investors purchased \$8.5 billion in reverse convertible products, up by 81% from 2006.¹⁷ The coupon rates on reverse convertible notes issued by Lehman Brothers in 2008 ranged from 9% to 40%.

Academic literature has shown that reverse convertible securities are significantly overpriced when issued, and that the issuing brokerage firms make substantial profits over issuing cost. For example, Hernandez, Lee and Liu (2007) estimate the average profit in the \$45 billion reverse convertible notes market is 3% to 6% above issuing cost. Benet, Giannetti and Pissaris (2006) estimate the average actual coupon rates paid by issuers are 300-500 basis points lower than expected coupon rates. They also find that it is more profitable to issue reverse convertible notes linked to riskier stocks since the volatility risk is not fully compensated by higher coupon rates. Henderson and Pearson (2007) estimate that investors who purchased \$2 billion of reverse convertible notes from Morgan Stanley from 2001 to 2005 paid on average 8% more than the securities' true value.

Variants of reverse convertible bonds include "plain-vanilla reverse convertible bonds", "discount certificates", "knock-in reverse convertible bonds", and "knock-out reverse convertible bonds", differentiated by whether the bond has coupon payments and how the principal will be paid at maturity.¹⁸ Investors in "plain-vanilla" reverse convertible bonds do not receive the face value of the notes back at maturity if the underlying asset closes at a lower price than the initial

¹⁵ Reverse convertible notes pay monthly, quarterly or annual coupons.

¹⁶ This is a simple case for "plain-vanilla reverse convertible notes". For "knock-in reverse convertible notes" and "knock-out reverse convertible notes" the payment also depends on whether the underlying stock price crosses a pre-specified barrier level during the life of the note.

¹⁷ "Risky Strategy Lures Investors Seeking Yield", Wall Street Journal, March 26, 2008

¹⁸ Hernandez, Lee and Liu (2007) classify the reverse convertible notes into these four types.

issue-date price. Instead, the investor will receive the number of shares determined by dividing the face value of the note by the underlying stock's closing price on the issuing date and so will suffer the decline in the value of the underlying stock over the term of the note. If the stock closes at maturity above the closing stock price on the issue date, the investor receives the face value of the note. In a plain vanilla note, the investor is selling a put option on the underlying asset to the issuer. The effective put option¹⁹ has a strike price equal to the underlying asset's price on the issue date, and expires when the bond matures. "Discount certificates" are like the "plain-vanilla" convertible bonds, except that they do not pay interim coupons.

"Knock-in" reverse convertible bonds are similar to the "plain-vanilla" reverse convertible bonds except that investors in the "knock-ins" notes don't have the linked stock put to them unless the stock price has fallen below a threshold "trigger" price below the closing price of underlying stock on the issue date. If the underlying stock' price closes at maturity below the price on the issue date and the price of the underlying asset *ever* fell below the trigger price during the life of the structured product, the investor receives pre-specified shares of the underlying asset worth less than the face value of the note.²⁰ Otherwise, the investor receives the face value of the note. Effectively, the "knock-in" is a coupon bond embedded with an at-the-money "down-and-in" barrier put option. At the issue date, the investor is granting this put option to the issuer and is obligated to buy the underlying asset at maturity if the asset sinks in value and crosses below the trigger price.

"Knock-out" reverse convertible bonds specify a trigger price above the closing price of the underlying stock on the issue date. If, at the bond's maturity, the closing price of underlying asset is below the initial price and the underlying asset's price *never* rose above the trigger price during the life of the bond, the investor will receive shares of the underlying asset, equal in number to the face value of the structured product divided by the underlying stock's closing price on the structured products issue date, along with any accrued or unpaid coupon payments. Otherwise, the investor receives the face value of the note. Effectively, "knock-out" reverse convertible structured products are a coupon bond embedded with an "up-and-out" barrier put option.

We illustrate the payoffs to a knock-in reverse convertible note using an example issued by Lehman Brothers (CUSIP 524935AP8). The structured product, linked to the performance of Fannie Mae's common stock, was issued on April 25, 2008 to mature on October 30, 2008 (in 6 months) with an annualized coupon rate of 25%. The trigger price was \$18.558 or 60% of Fannie Mae's \$30.93 closing stock price on April 25, 2008.

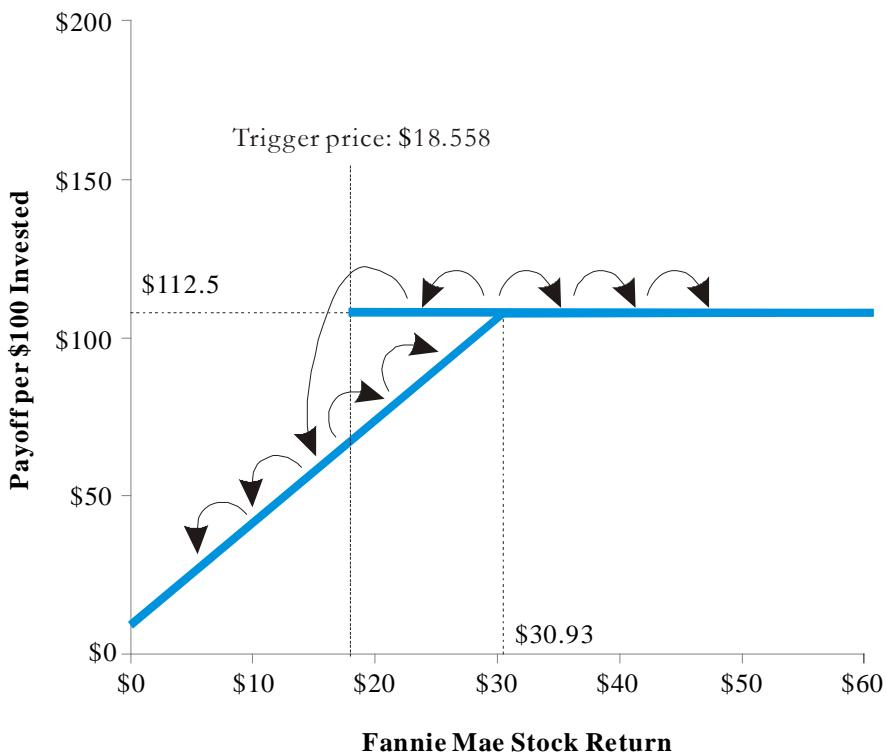
If Fannie Mae's stock price closed lower than \$30.93 on October 30, 2008, and the stock price had *ever* dropped below \$18.558 during the 6-month term of the note, investors were to receive 3.23 shares (\$100 principal/\$30.93 initial price) of Fannie Mae stock. For example,

¹⁹ No put option is actually written by investors or sold to the bond issuer. However, for ease of explanation we refer to the price of the bond's underlying asset on the bond's issue date as the "put option's exercise price" or "the exercise price."

²⁰ The number of shares equals the invested principal amount divided by the initial price of the underlying asset at issue date. At maturity the investor also receives any accrued or unpaid coupon payments.

assume Fannie Mae closed at \$10 on October 30, 2008. Investors would receive 3.23 shares of Fannie Mae stock on October 30, 2008 worth only \$32.30 plus a \$12.50 coupon payment at maturity resulting in a 55.2% loss because the closing price of Fannie Mae was below \$30.93 and the stock had dropped below \$18.558 prior to maturity.²¹ If instead the Fannie Mae stock price never drops below \$18.558 investors receive the face value of the note, with any accrued or unpaid coupon payments, regardless of the closing price of Fannie Mae at maturity date. Investors who bought this product effectively invested in an unsecured Lehman Brothers note and simultaneously granted a “down-and-in” barrier put option on Fannie Mae stock to the Lehman Brothers. **Figure 4** shows the final payoff diagrams for investing in this note.

Figure 4 Payoff diagrams for \$100 invested in “Knock-in Reverse convertible Notes Linked to the Common Stock of a Single Reference Stock Issuer - Fannie Mae.” Fannie Mae’s initial stock price was \$30.93. If Fannie Mae dropped below \$18.558 at least once during the life of the product, investors receive the lesser value of 3.23 shares of Fannie Mae stock or \$100 plus the coupon payment. If Fannie Mae never closed below \$18.558 during the term of the product the investor receives \$100 plus the coupon payment. The knock-in reverse convertible note is equivalent to an unsecured note and a short “down-and-in” barrier put option, with a strike price of \$30.93 and barrier price of \$18.558. This product is reminiscent of the board game, Snakes and Ladders.²²



Knock-in reverse convertible notes expose investors to much of the underlying stock’s downside risk but limits investors’ upside potential.²³ If the product is linked to a highly volatile

²¹ Usually coupon payments are made monthly, on a 30/360 base. In that case the present value of coupon payments will be less than \$12.5 with any positive discount rate.

²² Snakes and Ladders originated in India and was traveled through England. The game was renamed Chutes and Ladders and brought to the U.S.A in 1943 by Milton Bradley. www.en.wikipedia.org/wiki/Snakes_and_ladders

²³ Coupon payments serve mostly as option premiums.

stock, the issuing brokerage firm may promise a higher stated coupon to entice investors but the high coupon rates are merely partial compensation for the embedded put options. We valued this six month “Knock-in Reverse Exchangeable Notes Linked to the Common Stock of Fannie Mae” and determined it was worth \$95.74 per \$100 invested when it was issued on April 25, 2008. One interpretation of this low valuation (and the previous examples) is that Lehman Brothers only had to set aside \$95.74 on the issue date to meet the payment obligations under the product when it matured in six months. This difference could be interpreted as a gain on the issue date or as a reduction in Lehman’s borrowing costs under the structured product. As we will show next, Lehman appears to have used its issuance of structured products as a means to borrow at substantially below market interest rates from unsuspecting retail investors.

VI. Lehman Brothers Structured Products Program

Lehman Brothers Holding Company is a prime example of a brokerage firm that issued structured products to raise low cost financing. Lehman Brothers used structured products to obtain financing at lower rates than would have been available if the company had issued simple bonds instead. The structured products carried a lower implied yield not because the investments were safer than a simple bond, but because investors did not understand how badly overpriced the products were.

A. Background

Before filing for bankruptcy on September 15, 2008, Lehman Brothers was the fourth-largest investment bank in the U.S., after Goldman Sachs Group, Morgan Stanley and Merrill Lynch. Lehman experienced rapid expansion from 2003-2006 along with the booming U.S. economy. Lehman Brothers’ total revenue increased from \$17.29 billion in 2003 to \$46.71 billion in 2006. Net income increased from \$1.70 billion to \$4.01 billion over the same period, implying a compound annual growth rate of between 33% and 39%. By the November 30, 2006 fiscal year end, Lehman Brothers had approximately \$484.4 billion in debts, \$503.5 billion in total assets, and \$19.1 million in equity, resulting in a gross leverage ratio of 26.4 to 1.

The growth, however, came with increased risk. On November 30, 2006, Lehman Brothers had approximately \$57.73 billion in mortgage-related assets, equivalent to 300% of total equity. Of the \$57.73 billion in mortgage-related assets, \$15.93 billion was either subprime quality or was the interest Lehman had retained in mortgage-backed securities it issued (generally the most subordinated tranche of the security). In other words, by the end of 2006 Lehman had 83% of its equity tied up in extremely risky mortgage-related assets.

B. Rising Credit Risks

Lehman’s mortgage-related assets continued to grow during 2007 and 2008. During fiscal 2007, Lehman’s mortgage-related assets jumped from \$57.73 billion to \$89.11 billion, representing 25.5% and 28.5% of total financial instruments owned in 2006 and 2007, respectively. Of the \$89.11 billion mortgage-related assets in 2007, approximately 46.5% had been repackaged into complex asset-backed securities. As of November 30, 2007, Lehman had \$17.31 billion in either subprime holdings or retained interest in securitizations, and only \$22.49

billion in total equity.²⁴ In other words, after writing down its mortgage assets by \$4.2 billion in 2007, Lehman still had 77% of its equity tied up in extremely risky assets. By May 31, 2008, 26.9% of Lehman's financial instruments were still mortgage-related, 50% of which had been repackaged into complex asset-backed securities.

Lehman Brother's large mortgage holdings—especially subprime mortgage holdings—and investments in the equity tranches of asset-backed securities caused major financial trouble for Lehman. In the fourth quarter of 2007, Lehman took a \$3.5 billion write-down in mortgage assets, followed by another \$4.7 billion mark-to-market loss in the first quarter of 2008. As a result of its large write-downs and additional unrecognized losses, Lehman had to raise funds from other sources to keep the impaired securities afloat and to maintain liquidity.

Figure 5 plots Lehman Brothers' split-adjusted stock price from January 1, 2006 to September 15, 2008. Lehman's stock price decline - from \$78.12 on December 29, 2006 to \$19.12 on June 30, 2008 reflected an increasingly pessimistic assessment of Lehman's viability.

Figure 5: Lehman Brothers' Split-adjusted Stock Price, January 1, 2006 – September 15, 2008. Lehman's stock price fell almost continuously throughout 2007 and 2008. The steady decline in Lehman's stock price reflected the market's increasingly pessimistic assessment of Lehman's long run viability.

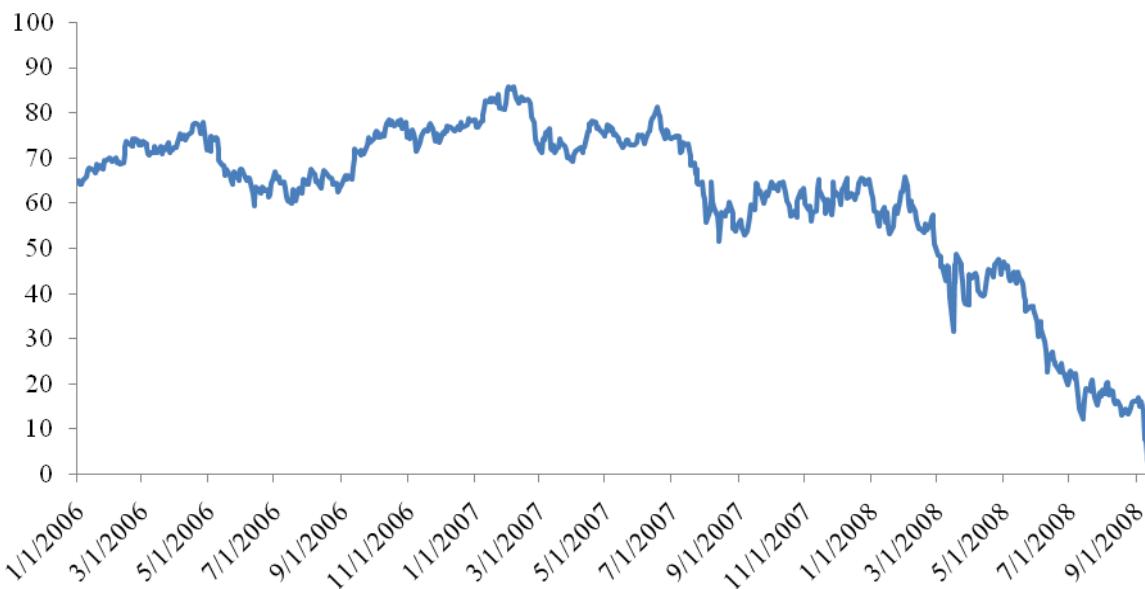


Figure 6 plots Lehman Brothers' implied stock price volatility against the implied volatilities of the other big five brokerage firms from January 1, 2006 through September 15, 2008. This data indicates that the sophisticated investors realized that the investment banking industry had become much riskier than in recent years as early as July 2007. In the days before Bear Stearns was bought by JPMorgan, the implied volatility of both Bear Stearns and Lehman

²⁴ Lehman wrote off \$700 million of mortgage-related assets in the third quarter and another \$3.5 billion in the fourth quarter. After being netted against various gains—including gains from hedging the risky assets—Lehman had a net write-off of \$1.53 billion for fiscal 2007.

Brothers doubled, making their implied volatilities almost four times larger than they were just one year earlier. After Bear Stearns was bought out on March 17, 2008, Lehman Brothers' implied volatility continued to increase relative to Lehman's peer group, spiking with speculation in July 2008 that the U.S. government would bail out Fannie Mae and Freddie Mac, and spiking again in the days before Lehman filed for bankruptcy.

Figure 6: Implied Stock Price Volatility. The graph shows the 12-month call option implied volatility for Lehman Brothers and four competitors: Goldman Sachs, Morgan Stanley, Merrill Lynch, and Bear Stearns. The spike in volatility in March 2008 is related to the collapse of Bear Stearns; the spike in July 2008 is related to speculation that the U.S. government would take over Fannie Mae and Freddie Mac.

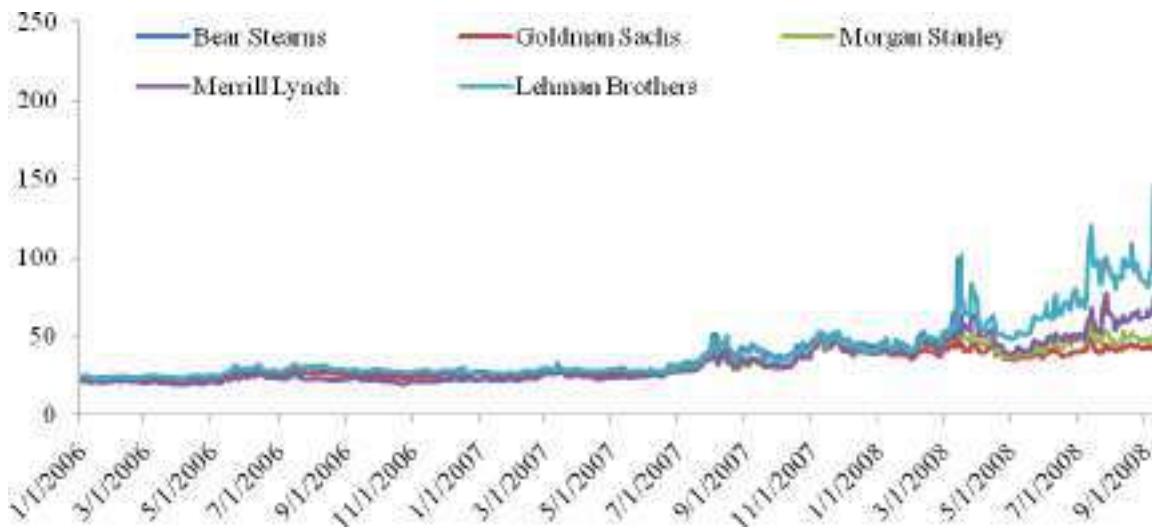


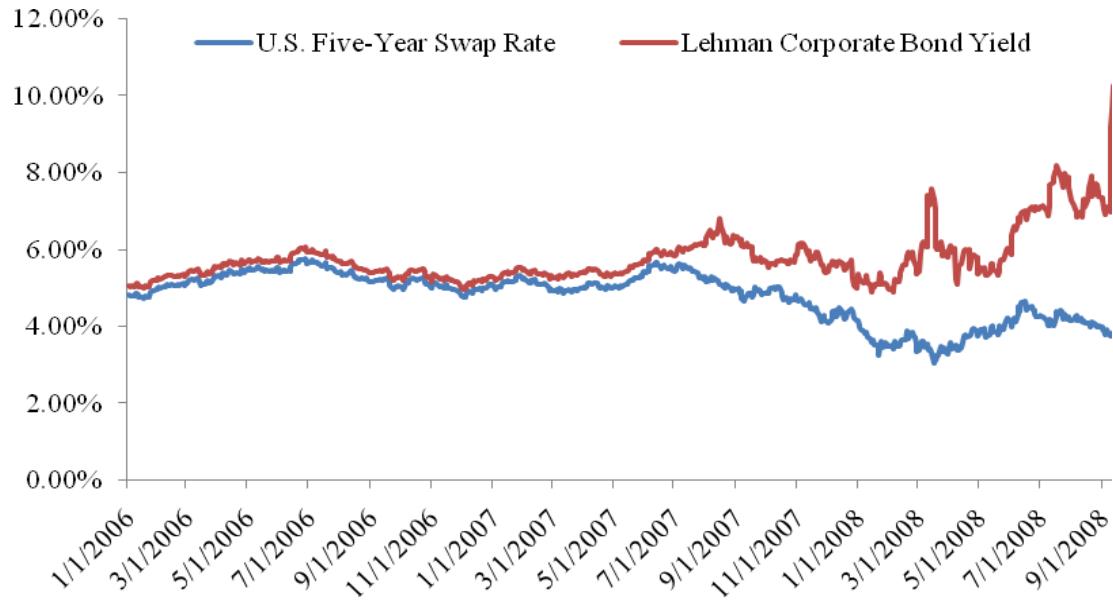
Figure 7 plots Lehman's 5-year unsecured corporate bond yield against the U.S. 5-year swap rate. The corporate bond yield is calculated by adding the 5-year Credit Default Swap (CDS) spread and the U.S. 5-year swap rate.²⁵ Through February 2007 (the end of Lehman's first quarter), the credit spreads on Lehman and the other four large brokerage firms (not shown) were approximately 20 basis points. From March 2007 on, Lehman's CDS spread rose above its competitors' spreads as Lehman's financial performance worsened. Lehman's five-year credit default swap, which priced the risk that Lehman would default on its loans within the next five years, increased from an average of approximately 24 basis points (i.e., 0.24%) in fiscal 2006 to an average of 35 basis points in the second quarter of 2007.²⁶ By the end of the third quarter the credit default swap spread on Lehman debt was approximately 130 basis points. Put in different terms, the market thought that Lehman's risk of defaulting on its loans in the next five years increased more than 500% during the second and third quarters of 2007. By the end of

²⁵ We assume the CDS spread is a credit insurance premium reflecting the company's credit risk.

²⁶ We use weekly averages as our base observation for credit default swaps to reduce the noise of single days. Also, the Q1 2007 average is approximately equivalent to the fiscal 2006 average. The average for the period January 1, 2006–February 28, 2007 is 23.5 basis points.

November 2007 (Lehman's fiscal year end), Lehman's CDS spread was approximately 150 basis points, almost double the spread on Goldman Sachs' debt.

Figure 7: Lehman 5Y Corporate Bond Yield and U.S. 5Y Swap Rate. Lehman's Corporate Bond Yield is estimated by adding Lehman's five-year credit default swap spread to the U.S. five-year swap rate.



As Lehman's credit risk rose, it became increasingly costly for the company to issue debt. **Figure 7** indicates that new corporate bonds issued by Lehman Brothers would have had to pay 5.40% in November 2007, more than the 5.14% (5.21%) long-term weighted-average interest rate Lehman paid in 2005 (2006), and more than the 4.94% paid by Goldman Sachs in November 2007 or the 5.18% paid by Morgan Stanley.

Issuing additional structured products was one alternative to equity and debt issuance available to Lehman. Structured products had several advantages over simple bonds. Because structured products could be designed with complex payoff structures, Lehman could make it virtually impossible for retail investors to even roughly determine what the value the products were and what the expected returns were. Structured products could be designed with high stated or apparent yields but with extremely low expected yields. These extremely low expected yields compared to Lehman's cost of transparent borrowing provided the spread necessary to pay substantial underwriting spreads and commissions, making it easy to sell the inferior products to unsophisticated investors. In response to these incentives Lehman issued and sold approximately 1,300 structured products in 2007-2008, far more than in previous two-year periods, ultimately raising \$19.2 billion at below market interest rates. See **Figure 8** and **Figure 9**.

Figure 8: Number of Structured Products Issued by Lehman Brothers from January 2006 through September 2008. Faced with increased transparent borrowing costs, Lehman ramped up its issuance of structured products.

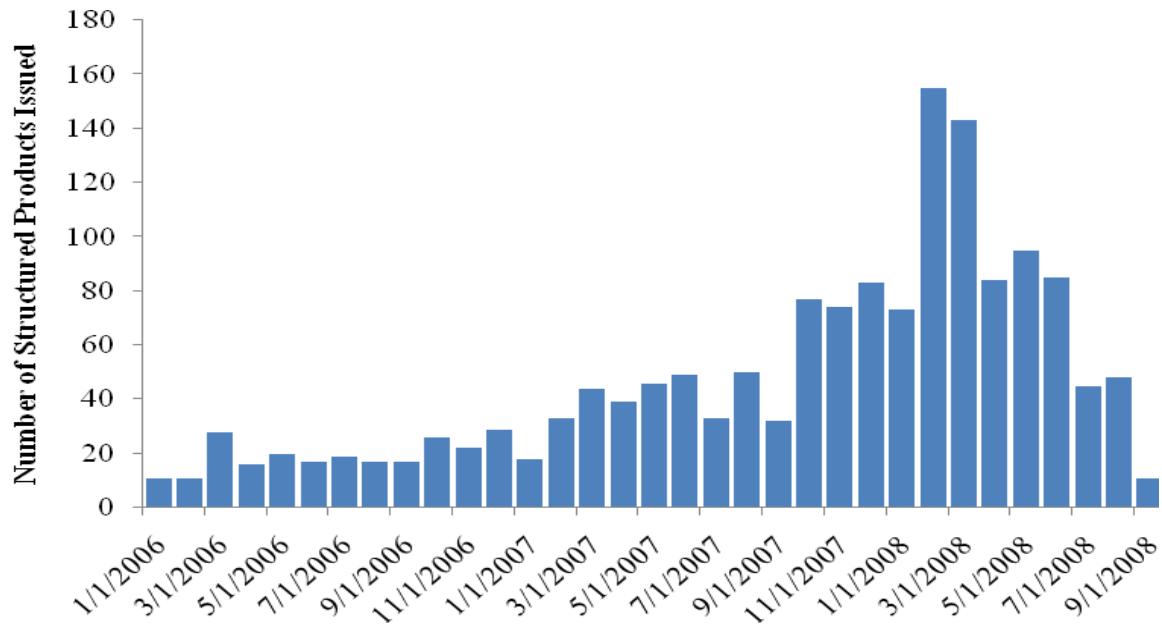
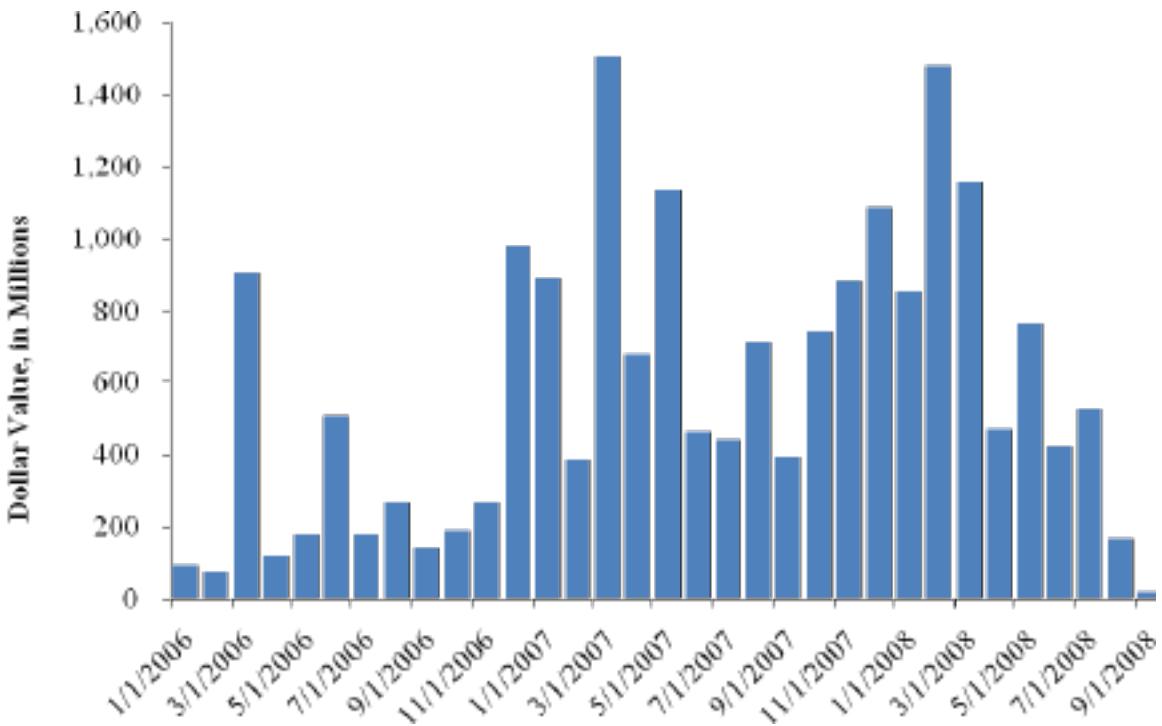


Figure 9: Dollar Value of Structured Products Issued by Lehman Brothers from January 2006 through September 2008. The dollar value of new issues also increased but less dramatically than the number of issues.



VII. Implied Yields / Borrowing Costs

One way to evaluate Lehman Brothers' structured products program is to value individual products when they are offered. We have provided several examples of this approach in the discussion above. Another approach is to evaluate the program is to estimate the implied yield on the structured products when offered. This is an estimate of the returns investors might earn comparable to the initial yield on a bond. It is also an estimate before issuance costs of Lehman's implied funding costs.

We have taken a large sample of Lehman's structured products including 78 reverse convertible notes and 16 principal protected notes and estimated the implied yield for each note on the dates they were issued. The implied yield is defined as the discount rate that makes the present value of the future cash flows equal to the face value of the note. **Figure 10** plots the implied yields for all 94 securities, along with the 5 year U.S. swap rate and Lehman Brothers' corporate bond yield.

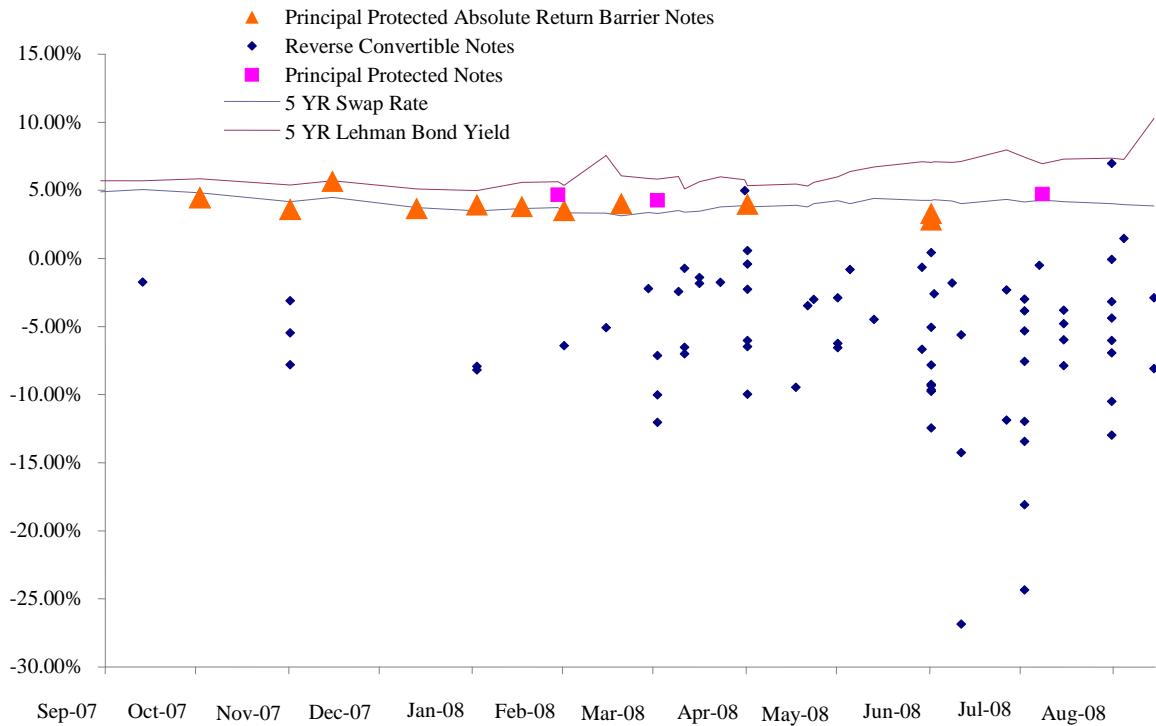
Figure 10 highlights several interesting points about Lehman's structured notes program.

First, none of the 94 structured products have implied yields greater than Lehman Brothers' corporate bond yield. That is, Lehman issued unsecured notes and bonds with low effective yields to unsophisticated retail investors.

Second, 13 of the 16 principal protected notes have implied yields very close to the risk-free rate. This is striking because the principal protection notes were unsecured. If Lehman Brothers declared bankruptcy, the holders of the principal protection notes would – and did – suffer substantial losses to their principal. In short, investors were earning the risk-free rate on an investment that carried a significant amount of default risk. Even if the principal had truly been 100% guaranteed, it is interesting that the notes earned only the risk-free rate. Because the risk-free principal could be expected to earn the risk-free rate, the failure of the implied yields to exceed the risk-free rate means that the intricate return schemes presented in the notes did not even provide compensation for exposure to the linked stocks, stock indexes, interest rates, currencies, commodities and other assets.

Third, 76 of the 78 reverse convertible notes have implied yields less than the risk-free rate, and 73 of the 78 notes have negative implied yields. A negative implied yield means the investor can expect to lose money. Our valuations coincide with the result in Henderson and Pearson (2007) – the average present value of the 78 reverse convertible notes is \$9.32/\$10.

Figure 10: Implied Yields of Lehman Structured Products. We plot the implied yields for 94 Lehman structured products along with the 5 year U.S. swap rate and 5 year Lehman unsecured bond yields. Principal protected notes had implied yields roughly equal to the risk free rate of return despite the significant market, liquidity and credit risks. The reverse convertible products were even worse. They had negative expected returns.



VIII. Conclusion

Consistent with our prior research into equity-linked notes, we find that reverse convertibles and notes linked to interest rates, currencies and commodities sold to retail investors in the United States were dominated by other readily available investments and so should have been recognized as *per se* unsuitable for any investor.

Overpriced structured products survived in the marketplace because their opaqueness obscured the true risks and costs and the high fees extracted by underwriters and salespersons. The inferiority of these products compared to other investments is in part attributable to the credit risk of the issuing brokerage firms.

Faced with increasing borrowing costs Lehman stepped up its issuance of structured products. This allowed Lehman to borrow billions of dollars from retail investors without compensating investors for its high and escalating credit risk. The harm thereby inflicted on investors was a direct transfer from unsophisticated retail investors to Lehman and UBS.

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