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Computing Yields on Enhanced CDs

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In this paper, we seek to provide a framework for comparing certificates of deposit (CD) products that vary in their features. There are now fixed-rate CDs with no early withdrawal penalties as well as floating-rate CDs with guaranteed floors. With the model developed here, we examine the required change in the effective annual rate required in basis points to make CD products with embedded derivatives (called enhanced CDs) comparable with the standard CD products (ones with large early withdrawal penalties). This framework is beneficial for both retail customers seeking to make rational comparisons and bank executives seeking to provide optimal liability products and seeking to manage the resulting interest rate risk.

I. INTRODUCTION

The purpose of this paper is to provide a general framework for comparing CD products with embedded options. The objective here is to move toward a methodology that would comply with the general intent of the Truth in Savings Act of 1991. Section 262 (b) states that the purpose of this act is:

> ... to require the clear and uniform disclosure of
> (1) the rates of interest which are payable on deposit accounts by depository institutions; and
> (2) the fees that are assessable against deposit accounts, so that *consumers can make a meaningful comparison between competing claims* (emphasis added) of depository institutions with regard to deposit accounts.

Thus, we seek to provide a mechanism for comparing enhanced CD products. Specifically, we build upon the "Annual Percentage Yield" (APY) legal concept contained in the Truth in Savings Act. Our results are presented, however, in "effective annual rate" (EAR) form which is more appropriate. That is, we demonstrate how to compute the APY and EAR for enhanced CDs. This framework will be useful for both depositors and bankers. Depositors will find this useful for comparing CD products, and bankers will be able to use the framework to make more informed decisions on which products to offer.

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Retail banking is undergoing dramatic change. There is the mentality that CDs are a rather mundane source of bank funding. This mentality is best captured by the following quote from Chet Currier (1987, p. 39):

> No matter how it is structured, a CD is fundamentally a simple proposition—a loan of money by the buyer to a bank or savings institution for a specified period of time, in return for interest on that money.

This view of CDs has cost the banks market share. However, recent changes have somewhat revived the CD market. In an article entitled, "Yields on CDs Lag Behind Rate Increase," which appeared in the *Wall Street Journal* (1996, pp. C1, C15), Lynn Asinof reported:

> Indeed, people today have some $925 billion in small-denomination CDs, according to Federal Reserve Board figures. Although that is far less than in 1991, when CD assets topped out at over $1.1 trillion, it is up significantly from 1994, when assets dropped well below $800 billion.

This *Wall Street Journal* article goes on to illustrate how banks are attempting to revive this market:

> At the same time, some banks are promoting CD deals aimed at encouraging the creation of additional banking relationships or attracting larger deposits.... Hibernia National Bank, New Orleans, offers a two-year CD with the one-time option of bumping the rate up if interest rates rise. (p. C15)

In this paper, we provide a methodology for comparing Hibernia National Bank's offer to other two-year CD products.

With deregulation of the banking industry coupled with historically low interest rates in the early 1990s, retail banks began offering a variety of incentives to keep funds as well as attract new funds. One of the more esoteric offerings is the World Soccer CD that would double the interest rate if the United States won the World Soccer Cup (Peterson Bank, 1994). The retail bank, Peterson Bank in Chicago, actually purchased an insurance policy against the risk. Admittedly, the main purpose was to gain publicity—which it did, receiving notice on the front pages of *The Wall Street Journal* and *USA Today*. There are health-care CDs that allow money to be withdrawn with no early withdrawal penalty if funds are used for health-care expenses (O'Connell, 1994) and even a "Hunter's Special" that pays a Weatherby Mark V Deluxe rifle instead of cash interest (Farnham, 1994).

The primary motivation for these products is marketing. However, many retail banks are now routinely offering CDs with features such as no early withdrawal penalty, the ability to add to the original deposit, and a variable rate with a guaranteed floor. For example, the Bank Leumi Trust's Triple Choice Time Deposit CD is a two-year CD that allows depositors to add funds in the first year, make one withdrawal (up to 50%), and obtain an upward rate reset once during the term of the CD at the depositor's discretion (O'Connell, 1994). SouthTrust Bank offers a two-year CD that has a guaranteed floor rate, which floats with the 13-week Treasury bill, allows one early withdrawal at no penalty, and permits depositors to add to the CD at any time. This product was advertised as the "Maximum Advantage two-year CD Account."

Certificate of deposits are an important source of bank funding. A survey of small banks in the southeast United States revealed that CDs represented an average of 45% of

the total assets and ranged from a low of 32% to a high of 61%. Clearly, it is essential that liability managers at banks understand the ramifications of embedding derivatives in their CD products. Also, bank customers need to be aware of the opportunities these new products provide.

II. Literature Review

Academic research related to CDs focus primarily on the role of government guarantees. For example, Cook and Spellman (1994) develop a theoretical model for CD rates related to the risk of default by the bank as well as third party government guarantees. They find empirical evidence around the collapse of the Federal Savings and Loan Insurance Corporation that these risks were adequately priced. Cooperman, Lee and Wolfe (1992) and Cook and Spellman (1991) provide further research in this area.

A second strand of academic research attempts to identify the factors driving changes in CD rates. For example, Fraser (1995) uses principal components analysis to ascertain that Treasury bill rate changes effect CD yields in the United Kingdom. In the United States, Knez, Litterman and Scheinkman (1994) use a factor approach to identify that 86% of the variation in money market returns are explained by three factors, and a four factor model explains 90% of this variation. Using cointegration analysis based on an error correction model, Fung and Isberg (1992) document a causal relationship where U.S. markets influence international markets in the 1981-1983 period. However, from 1984 to 1988, this causality seemed to reverse itself.

The academic research related to valuing interest rate contingent claims is vast. The seminal paper by Black and Scholes (1973) on option pricing also addressed bond valuation. Two surveys of this vast literature include Courtadon (1993) and Ho (1995). Tuckman (1995) offers more details on analytical techniques. In this paper, we seek to merge the recent advances in interest rate contingent claims valuation with the enhanced CD products.

III. CD Valuation

In developing a CD valuation model that incorporates embedded derivatives, several issues must be addressed. First, the value of the exotic option will increase as the maturity of the CD is lengthened. Even the most enhanced product will not be associated with much risk if the maturity is only three months. However, some CDs have very long maturities. The Hunter's Special mentioned above had a nine-year maturity.

Second, the ability to early withdrawal is actually an option held by the depositor to put the CD back to the bank. The depositor has the option of selling the CD to the bank at a price less than its "market value." What sort of early withdrawal penalty is appropriated for bankers and depositors alike? As some banks are dropping the early withdrawal penalty altogether, how much reduction in yield should they demand in return?

Third, the ability to reset the interest rate and the timing of this ability need to be addressed. For example, some two-year CD products allow depositors to reset the interest

rate higher during the first 10 days of the second year. Other two-year CD products allow depositors to reset the interest rate at any time during the two-year period. Still other two-year CD products automatically reset the interest rate during the life of the CD. Some framework is needed to convert these various alternatives into tangible APYs or EARs for comparative purposes.

Fourth, most floating-rate CDs provide a floor on interest rates while some have caps. The market value of a floating-rate CD with an embedded option (cap or floor) is equal to the value of a floating-rate CD with no option minus the value of the cap or plus the value of the floor. Fifth, some CDs allow depositors to add additional funds to the CD during its life. Finally, the standard adjustments for compounding method and payment frequency must be made.

The comparison of enhanced CDs with standard instruments follows a two-step procedure. First, the current value will be estimated for both the enhanced CD and the standard CD using the same reference interest rate (see the Appendix for a sketch of how this would be accomplished). Second, the price differential between these two CDs will be used to establish the EAR or APY for the enhanced CD.

Once the value of the enhanced CD is established, we can estimate either the effective annual rate (EAR) or the annual percentage yield (APY). The EAR is the appropriate interest rate if it were compounded only once a year. The APY is the per period interest rate multiplied by the number of periods in a year.

It is important to emphasize at this point that our objective is one of assessing relative value. That is, what is the value of the enhanced CD relative to a standard CD whose value we are assumed to know? Because there is no secondary market in enhanced CDs, it is impossible to use a direct market comparable valuation approach. It is standard practice in the derivatives markets to value off-market instruments using some valuation methodology calibrated to at-market instruments. Here we assume the current standard CD trades at par, even though there is obviously profit to the bank, because our focus is on relative value. Currently, bank CD rates are highly correlated with LIBOR rates. The only unobserved parameter is volatility and it can be approximated from the appropriate interest rate derivative market, such as caps, floors, and swaption markets.

It is not uncommon to determine the value of a financial security that has no liquidity. For example, FASB is presently assessing what to do with the fair value of executive stock options even though they are nonmarketable, require vesting, and so forth. There is a whole industry related to business valuation, where many times there are no direct market comparables. In derivative markets, standard practice is to rely on valuation models that have been appropriately calibrated. In the end, bankers and depositors must assess the validity of the valuation model and the inputs used.

The depositor must carefully examine the enhanced features of these CDs and determine whether the enhanced features are sufficiently beneficial to offset the loss in yield. One approach would be for the depositors to assign a price to the enhanced features based on their preferences. This depositor specific price would be used to establish an adjusted EAR or APY.

Suppose the standard two-year, fixed-rate CD is quoted at 5% (EAR_s, where s denotes the "standard CD"). A banker is considering offering another comparable CD product with a low early withdrawal penalty (say 14-day penalty rather than 182-day), and this lower early withdrawal penalty resulted in an enhanced CD value of 100.20% of par based on an acceptable valuation model that has been appropriately calibrated (denote this value as

EnCDValue; hence, depositors place a 20 basis point value on the lower early withdrawal penalty), then the EAR for this enhanced CD (EAR_n) would be computed as follows:

$$EnCDValue = Par(1 + AnnualPremRate)^{t/365}, \tag{1}$$

or

$$AnnualPremRate = \left(\frac{EnCDValue}{Par}\right)^{365/t} - 1. \tag{2}$$

Thus,

$$\begin{gathered} EAR_n = 100(EAR_s + AnnualPremRate) \\ EAR_n = 100\left[0.05 + \left\{\left(\frac{100.20}{100.0}\right)^{365/730} - 1\right\}\right] = 100[0.05 + \{0.001\}] = 5.1\%, \end{gathered} \tag{3}$$

where t is the number of days in the deposit. In this case, the lower early withdrawal penalty benefits depositors at an EAR of 10 basis points per year.

A similar analysis could be conducted using APY. Based on the data above, the periodic APY (APY_p) of the regular CD would be expressed as:

$$APY_p = (1 + EAR)^{1/n}, \tag{4}$$

where n is the number of compounding periods per year. If we assume quarterly compounding, we have a periodic APY of:

$$APY_p = (1 + 0.05)^{1/4} - 1 = 0.012272 = 1.2272\%. \tag{5}$$

The annualized APY for the standard CD (APY_s) is:

$$APY_s = 0.012272 \times n = 0.012272 \times 4 = 4.9089\%. \tag{6}$$

For the enhanced CD, we have:

$$\begin{gathered} APY_n = 100\left[APY_s + \left\{\frac{ExCDValue}{Par} - 1\right\} \times \left(\frac{365}{t}\right)\right] \\ APY_n = 100\left[0.049089 + \left\{\frac{100.20}{100.0} - 1\right\} \times \left(\frac{365}{730}\right)\right] = 5.0089\%. \end{gathered} \tag{7}$$

The EAR_n is equal to the standard EAR plus an adjustment reflecting the added value of the embedded options. Hence, there are two factors impacting EAR, the current CD rate reflected in EAR_s, plus the value of the embedded option. This additional factor causes some standard pricing relationships to no longer hold. For example, we could observe a higher EAR_n and a higher market value of the enhanced product (*EnCDValue*), due to increased volatility in the market.

We turn now to examine some of the general implications of this model.

IV. CD Valuation Model Implications

In the examples and illustrations that follow, we assume a 5% flat term structure. The recombining binomial lattice used here is easily adapted to nonflat term structures. Thus, fixed-rate CDs with large early withdrawal penalties and floating-rate CDs with no floors or caps will both be valued at par.

Suppose yield volatility is known to be 15%. How could we compare the following two-year CD products?

A) Standard Fixed-Rate CD (large early withdrawal penalty)

B) Standard Floating-Rate CD (no floor or cap)

C) Enhanced Fixed-Rate CD (only 7-day early withdrawal penalty)

D) Enhanced Floating-Rate CD (a guaranteed 5% EAR floor)

Clearly, product C is preferable to A because of the limited early withdrawal penalty and product D is preferable to B because of the guaranteed floor rate. Thus, we know the EAR will be higher for products C and D. What is less clear is the comparability of products C and D. Some depositors will have a strong preference for C and others for D depending in part on depositors' perceived liquidity needs and expectations regarding future interest rates. Using the binomial approach to valuation, we find the EAR of both C and D to be approximately equal at 5.24%. Hence, the ability to put back a fixed-rate CD with only a seven-day penalty is roughly equivalent to holding a floating-rate CD with a guaranteed floor of 5%. These enhanced features are worth roughly 24 basis points each.

It is important to emphasize that the individual depositor will select from these products based on their own preferences. Thus, the depositors will select a pure floating-rate CD if they have a strong view that interest rates are going to rise. Uncertainty regarding this view will perhaps drive depositors to prefer a floating-rate CD with a floor. Similarly, a depositor with no liquidity needs and a strong preference for a fixed rate would select a fixed-rate CD with heavy early withdrawal penalties. However, a fixed-rate depositor with some liquidity needs may select a fixed-rate CD with limited early withdrawal penalties.

Figure 1a illustrates in basis points the additional value of reducing the early withdrawal penalty on fixed-rate, one-year CDs under various volatility assumptions. The lower the early withdrawal penalty, the greater the value in basis points. Also, the higher the volatility, the greater the value in basis points. Figure 1b illustrates the same pattern with greater magnitude for two-year CDs. Thus, a depositor seeking to reduce the early withdrawal penalty must be willing to pay the increased embedded option value. Specifically, they must be willing to accept a lower stated rate.

Figure 2a illustrates in basis points the additional value of providing guaranteed floors on floating rate, one-year CDs. We see the higher the guaranteed floor, the greater the value in basis points. Higher volatility makes the impact of a floor even greater. Figure 2b illustrates that for two-year CD products the value of the floor is even greater (but clearly the value is not double).

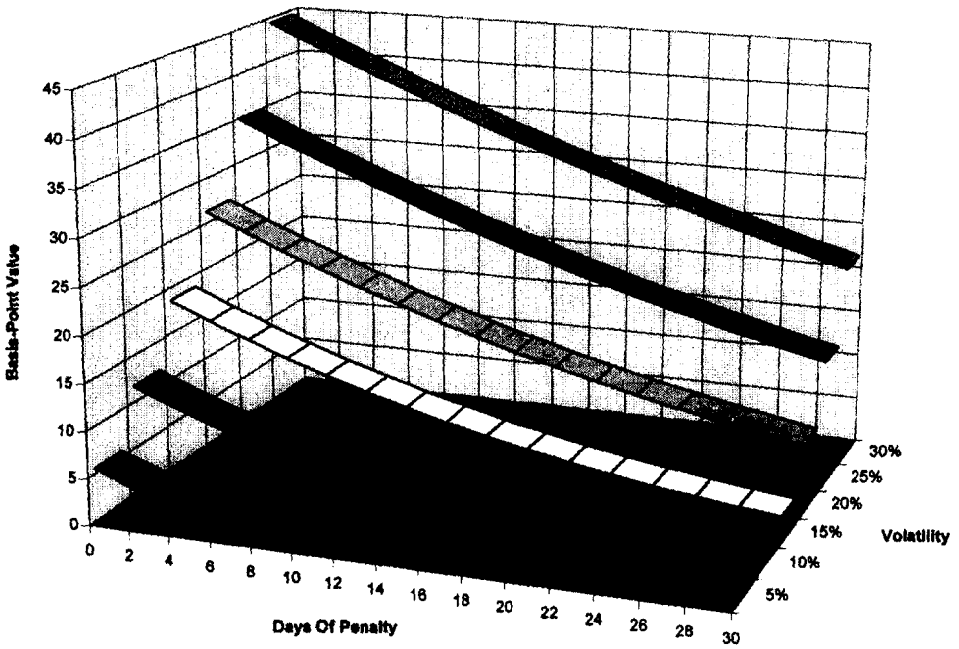

Figure 1a. Impact of Early Withdrawal Penalty on EAR One-Year CDs

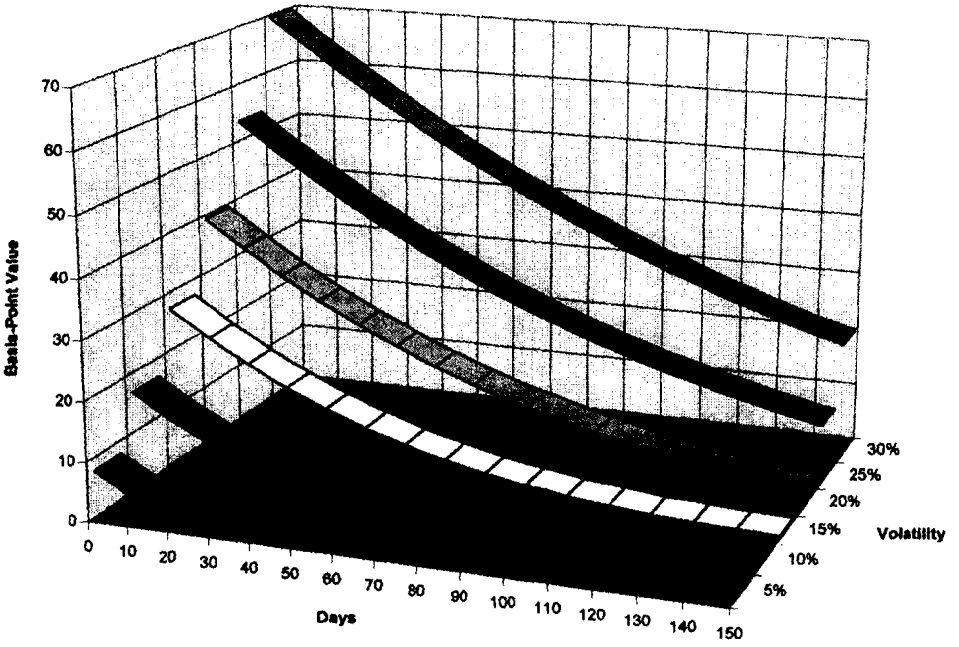

Figure 1b. Impact of Early Withdrawal Penalty on EAR Two-Year CDs

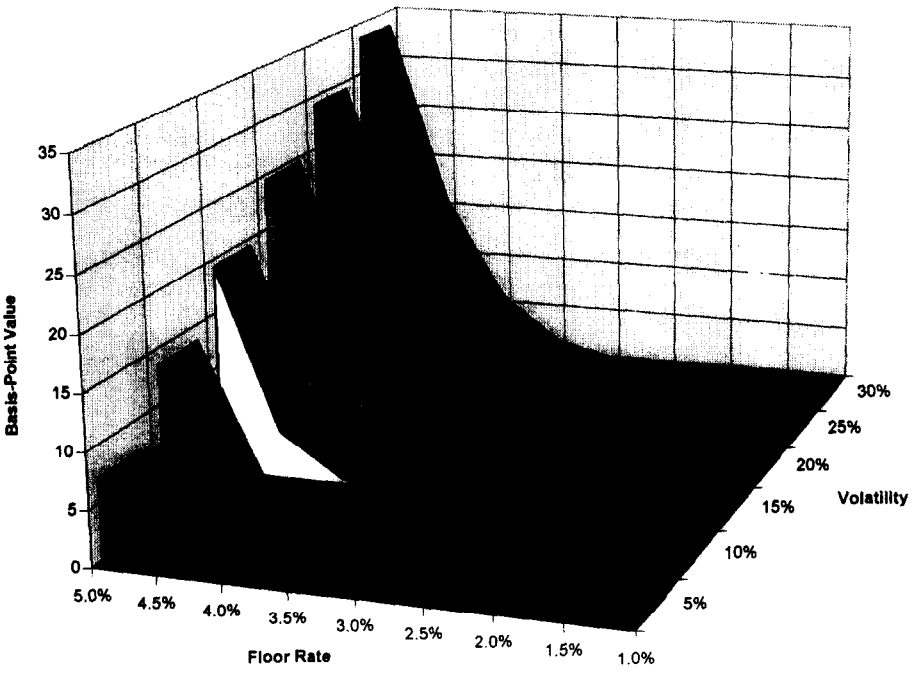

Figure 2a. Impact of Floor on EAR One-Year CDs

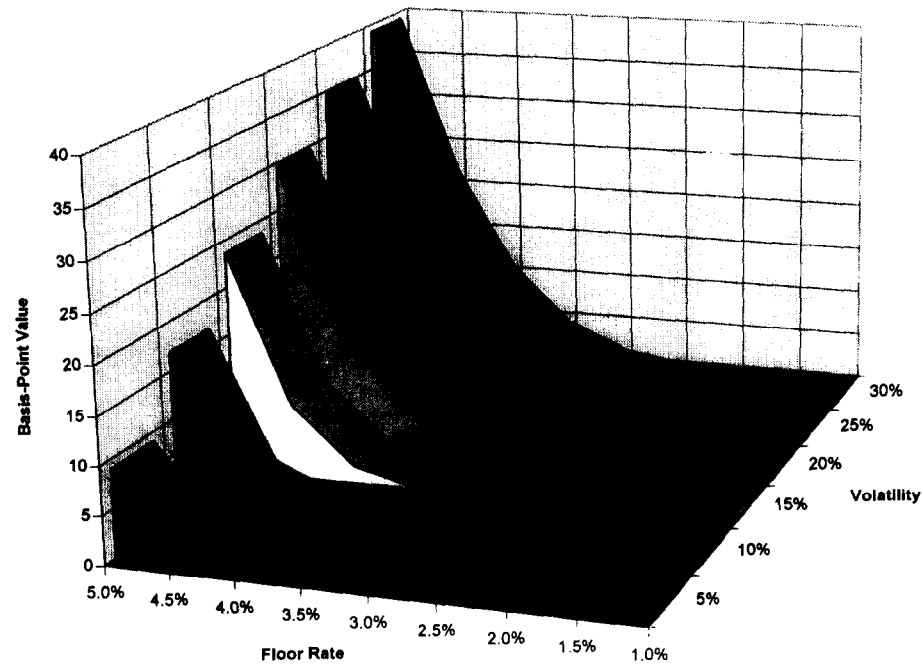

Figure 2b. Impact of Floor on EAR Two-Year CDs

Depositor preferences will determine which enhanced CD product they prefer. A valuation model such as the one presented here would be beneficial in assisting depositors in sorting out their choices. As the CD product offerings increase, depositors will need to clearly understand the relative value trade-offs.

V. Applying this Model in Practice

Thus far we have observed that embedded options in CD products are valuable and should be appropriately addressed when offering or buying new CD products. Specifically, a lower early withdrawal penalty is valuable to the fixed rate CD depositor and hence will translate into a higher option-adjusted EAR or APY than the standard CD paying the same fixed rate. A floating rate CD with a guaranteed floor will have a higher option-adjusted EAR or APY when compared to a floating rate CD with no floor.

Does the higher EAR or APY mean bankers should avoid offering enhanced CDs? Of course not. Each depositor is unique and has different preferences and beliefs regarding the future course of interest rates. A depositor who believes interest rates will rise shortly will not be interested in a fixed rate CD with large early withdrawal penalties. A depositor that is uncertain about their liquidity needs will avoid CDs with heavy early withdrawal penalties.

The banker's objective should be to offer appropriately priced CDs that allow for product differentiation which results in a competitive advantage over banks offering standard products. Brooks and White (1996) focus on the marketing aspects of enhanced CD products. The depositors objective should be to select the appropriate CD products best suited for them. For illustrative purposes, suppose there are two banks in a given market, Stoic Bank and Modern Bank.

At two-year maturities, the Stoic Bank offers a fixed rate CD at 5% with 182-day early withdrawal penalty. The Modern Bank also has a similar CD but would like to expand its offering to attract other depositors. For simplicity, assume the yield curve is flat and CD rate volatility is 10% (about normal). The Modern Bank decides to offer a menu of products at the two-year maturities as follows (See Table 1).

The problem is establishing the appropriate rate for products 3 and 4. Using the valuation model, we find the annual premium rate of the embedded options are 0.167% for product 3 and 0.168% for product 4. Thus, the appropriate EAR for product 3 is roughly 4.833% (5% – 0.167%) and for product 4 is 4.832% (5% – 0.168%). However, some depositors will have strong preferences for products 3 or 4 and will be willing to accept even lower rates.

TABLE 1
Modern Bank Products at 2-Year Maturities

Product	*Type*	EAR_n	EAR_s	*Annual Premium Rate*
1	Fixed Rate CD	5%	5%	0%
2	Floating-Rate CD	5%	5%	0%
3	Fixed Rate CD, No EWP	?	5%	0.167%
4	Floating-Rate CD, 5% Floor	?	5%	0.168%

Note: * EWP denotes early withdrawal penalty.

The benefits to the bank of attracting new depositors and gaining market share may well offset the additional administrative costs. The administrative costs should be minimal because the marketing channels have already been established. Offering enhanced CDs requires bankers to have a good grasp of their interest rate risk. Alternatively, one benefit of good asset/liability management is the ability to comfortably offer new deposit products.

The benefits to the depositor of expanded CD offerings may well offset the additional education costs involved in understanding the relative trade-offs. Depositors must take the time and effort to clearly understand and assess the different features of these new CD products.

One cost of offering enhanced CDs is increasing a bank's interest rate risk. The embedded options will typically be used against the bank at a time when it is disadvantageous to them. For example, depositors will early withdraw when rates go higher causing the bank to lose lower cost of funds. The resulting interest rate risk can be effectively managed, if necessary, with over-the-counter derivative products such as interest rate caps and floors.

One benefit of conducting this type of analysis is the ability to compute an option-adjusted net interest spread (or margin). In the illustration above, it would appear as if the Modern Bank had a higher net interest rate spread if no adjustments were made to the quoted EAR or APY. That is, the Modern Bank would be issuing deposits at 4.833% and 4.832% as opposed to 5%. Appropriately managed, enhanced CDs are an effective way to expand market share and profitability.

In the same way depositors must understand that even though they receive a lower stated yield on enhanced CDs, they are receiving valuable options. These options increase flexibility which, at times, would be extremely valuable to depositors.

One interesting issue is the failure of depositors to behave rationally. Anecdotal evidence from a few bankers suggests that depositors will fail to exercise valuable options embedded in CD products. For example, liquidity considerations will cause some depositors to abandon valuable embedded options. Hence, one interesting benefit to banks is offering appropriately priced embedded options and receiving the benefit of depositors lack of optimal exercise. For example, a bank offered a two-year CD product with the option to set the rate higher for a few weeks after the first year if one-year CD rates had risen after a year. This product was offered in late 1993. In late 1994 a significant percentage of CD customers failed to exercise their right to reset the interest rate higher even though rates had risen significantly. Interestingly, this suggests that two CD products—one that resets upward automatically and one that requires the depositor to request the higher rate—will have different values to the bank.

VI. Concluding Comments

In summary, we examined the relative pricing of enhanced CD products. The objective was to provide a mechanism to facilitate comparison of vastly different CD products. Further insights could be obtained if empirical evidence is gathered from banks that offer these products. This research is vital for bankers in their management of the resulting interest rate risk of enhanced CD offerings. For example, a five-year CD with no early withdrawal penalty will have risk characteristics that are dramatically different from those of a five-year CD with a high early withdrawal penalty. Without a viable method to evaluate their enhanced CD products, bankers cannot assess the interest rate risk of their institutions.

Depositors must realize that there is more than two dimensions (yield and maturity) when analyzing various CD products. Depositors are accustomed to choosing a maturity but now must assess the type of rate, fixed or floating, and the value they place on liquidity. If nothing else, CDs are no longer a mundane security.

APPENDIX

A Sketch of Valuing the Enhanced CD

We use the following notations:

- P_0 Current Value of CD;
- T Maturity of CD in years;
- $r(s)$ Reference interest rate at time s;
- $c(s)$ Ceiling interest rate at time s;
- $f(s)$ Floor interest rate at time s;
- $C_t(r(t))$ Periodic interest rate (or coupon) paid for the CD;
- D_t Appropriate deposit amount upon which to compute interest payment;
- $I_t(R)$ Indicator function based on whether the CD can be reset (denoted by R);
- $P_{c,t}$ Price of CD at t based on the ceiling rate, c;
- $P_{f,t}$ Price of CD at t based on the floor rate, f;
- $P_{m,t}$ Price of the CD at t based on the current market interest rate, $r(t)$;
- DP_t Dollar interest penalty at t for early withdrawal; and
- AI_t Accrued interest since last interest payment (accrued at the appropriate interest rate).

The model developed here is based on the following major assumptions:

1. The reference interest rate follows a multiplicative binomial process that converges to a bivariate lognormal density as the time step tends to zero;
2. The appropriate discount rate is the reference interest rate; and
3. Markets are complete and riskless arbitrage opportunities do not exist.

This analysis could easily be adjusted to handle a discount rate at a fixed spread to the reference interest rate. For example, the reference interest rate may be 13-week Treasury bills and the appropriate discount rate is approximately 50 basis point under 13-week bills.

Using standard present value arguments and rational behavior by depositors, we can value the CD as follows:

$$P_0 = \int_0^T e^{-\int_0^t r(s)ds} [D_t min(C_t(c(t)), max(C_t(f(t)), C_t(r(t))))$$

$$+ I_t([R])\{max(D_t - DP_t + AI_t, min(P_{c,t}, max(P_{f,t}, P_{m,t})))\}]dt.$$

This CD valuation model is implemented using a standard recombining binomial lattice. This binomial method applied to interest rate securities is known to be slightly biased (e.g., see Windas, 1993). We adjust for this bias to make the standard CD product value at par whether it is a fixed-rate CD or a floating-rate CD.

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